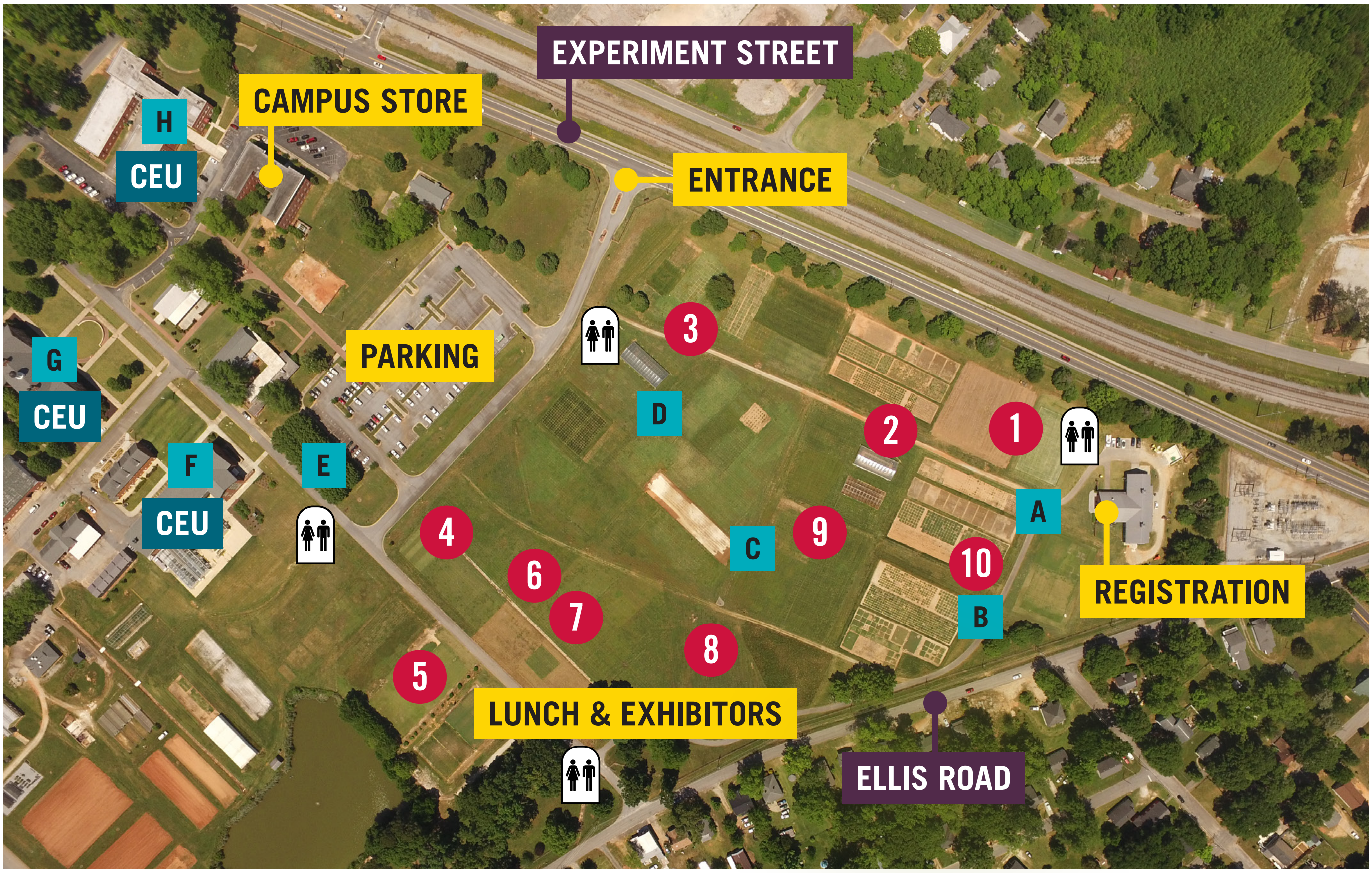
Turfgrass Research FIELD DAY

ONE DAY, ACRES OF INFORMATION

Wednesday, August 3, 2022 | UGA Griffin Campus

MAP and Field Day TOUR STOPS



Guided morning tour stops: 1–10

Self-guided afternoon tour venues: A–H

Restrooms

CEU Continuing Education Certification (CEU) credits for pesticide recertification will be available at three locations, no earlier than 2:15 p.m.:
Stop F — Turfgrass Research and Education Center
Stop G — Student Learning Center
Stop H — Stuckey Building

Today only, Field Day attendees can receive a 10% discount at the UGA Bookstore.

2022 UGA Turfgrass Research Field Day PROGRAM

WEDNESDAY, AUGUST 3

8 to 8:45 a.m. **REGISTRATION**

8:50 to 9:15 a.m. **INTRODUCTION**

Welcome – *Clint Waltz*

UGA Griffin Campus Welcome – *David Buntin*

9:15 to 11:30 a.m. **GUIDED RESEARCH TOUR**

1. Research Facilities Enhancement — *G. Henry*
2. Water Requirements for Turfgrasses with Improved Drought Performance — *D. Jespersen*
3. Refreshment stop
4. Evaluation of Mowing Frequency for Lawn Health and Performance — *C. Waltz*
5. Sustainably Managing Turfgrass Diseases with Nanobubble Technology and Biofungicides — *B. Bahri*
   Turf Disease Management: Fungicide Round-up — *A. Martinez-Espinoza*
6. Updates on Fall Armyworm and Rhodesgrass Mealybug Research in Turfgrass — *S. Joseph*
7. Role of Pollinators in Centipedegrass — *S. Joseph*
8. Evaluation of Fall Herbicide Programs for Annual Bluegrass Control in Bermudagrass — *P. McCullough*
9. Development of Recommendations for an Herbicide-Resistant Turfgrass System — *P. Raymer*
10. Computer Vision-Based Weed Mapping — *J. Zhang*

11:30 a.m. to 1 p.m. **TURFGRASS EQUIPMENT AND PRODUCT EXHIBITS**

11:30 a.m. to 1:15 p.m. **LUNCH**

1:15 to 2:30 p.m. **SELF-GUIDED RESEARCH TOUR**

A. Sustainably Managing Dollar Spot with UV-C Light Technology — *B. Bahri*
B. Past, Present, and Future of Golf Course Putting Greens Grasses from Tifton — *B. Schwartz*
C. Problem Weed Control and New Turfgrass Herbicides — *P. McCullough*
D. Water Efficiency Improvements in Warm-Season Turfgrasses — *C. Waltz*
E. Turfgrass Response to Shaded Conditions — *P. Raymer*
F. Diagnosing Turfgrass Disease — *A. Martinez-Espinoza*
G. Graduate Student Research — *Students and D. Jespersen*
H. Extension in Urban Ag — *G. Huber*

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Research and Education Contributors

The turfgrass research and education program at the University of Georgia is supported by state and federal funding and various entities of the turfgrass industry. Without the active direct and indirect support of the turfgrass industry, our research and education efforts would be severely curtailed. We wish to thank the various contributors who, in recent years, have helped the turfgrass industry by supporting our research and education programs:

Air2G2
Akins Feed and Seed
A.M. Buckler & Associates, Inc.
Amvac Chemicals
Aquatrols
Aqua-Yield
Atlanta Athletic Club
Atlanta Braves
Atlanta Country Club
Augusta National Golf Club
Barenbrug
BASF
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Beck's Turf
Bernhard and Company
Bethel Farms
Bricko Farms
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Butler Sand
Buy Sod
Carolina Fresh Farms
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Evergreen Turf Farms
Ewing Irrigation
FMC
Foothills Compost
Foskey Turf Farm
Georgia Agribusiness Council
Georgia Agriculture
Georgia Certified Landscape Professionals
Georgia Crop Improvement Association
Georgia Golf Course Superintendents Assn.
Georgia Golf Environmental Foundation
Georgia Master Gardeners
Georgia PGA
Georgia Recreation and Park Assn.
Georgia Seed Development Commission
Georgia State Golf Association
Georgia Turfgrass Foundation Trust
Gold Mine Golf Inc.
Golf Agronomics
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Green Tee Golf Inc.
Greenville Turf and Tractor
Griffin City Golf Course
GrupoInesta
Harrell's
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Helena Chemical
Howard Fertilizer and Chemical Co.
Intermountain Golf Course Superintendents Assn.
Irrigation Consultant Services
ISK BioSciences
Jacklin Seed
Jacobsen
Jekyll Island Club
Jenco Golf Cart
Jerry Pate Turf & Irrigation
John Deere
J.R. Simplot Company
Koch Agronomic Services
Legacy Farms
LidoChem
Mid-Georgia Nurseries
MNI Direct
Moghu
National Turfgrass Evaluation Program (NTEP)
New Concept Turf
NG Turf
Nonami Plantation
NuFarm Turf & Specialty
Patten Seed
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Pennington Seed
Petro Canada
Pike Creek Turf
Plant the Future Inc.
Precision Turf, LLC
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Urban Ag. Council
USDA–ARS
USDA–NIFA
USDA–SCBG
U.S. Golf Association
Valent U.S.A.
Valley Irrigation
Wright Turf

Thank you! If we have inadvertently omitted a contributor, we apologize.

Research Facilities Enhancement

David Jespersen, Associate Professor, Crop and Soil Sciences
UGA-Griffin

Clint Waltz, Professor, Crop and Soil Sciences
UGA-Tifton

Alfredo Martinez-Espinoza, Professor, Plant Pathology
UGA-Griffin

Gerald Henry, Professor, Crop and Soil Sciences
UGA-Athens

RESEARCH GREEN

A 9,600 sq ft bermudagrass green was built in 2020. This facility is built to United States Golf Association specifications with a sand-based root zone, planted with ‘TifEagle’ bermudagrass, and hosts eight independent irrigation zones to cater to research needs ranging from abiotic stresses to disease factors. The project was funded by Bayer Environmental Science. Additional services and support were provided by Green Tee Golf Inc. and Pike Creek Turf.

SPORTS FIELD

A 22,000 sq ft sports field, built as a ‘Tifway’ bermudagrass soccer field, serves both as a research and extension site. It also serves the local community that meets several times a week for pickup games. Support was provided by Sports Turf Company and NG Turf.

LINEAR GRADIENT IRRIGATION SYSTEM

Drought stress and reducing irrigation requirements are major challenges facing turfgrass areas. To expose plants to varying levels of water stress, a linear gradient irrigation system was constructed. This system allows plants to be exposed to a continuous range of conditions, from wet or nonstress water conditions all the way to drought level. This is achieved with grading and an irrigation layout that allows for differences in water replaced via irrigation (Figure 1). The data generated from this field will be used to ground-truth remote sensing tools and aid in the development of artificial-intelligence-driven decision support systems. Ultimately this information will be used as the basis for precision irrigation management tools that allow for the application of water to specific areas when needed. Funding for this project comes from a USDA Specialty Crops Research Initiative project focusing on precision irrigation management. Additionally, industry support has been provided by Toro, Irrigation Consultant Services, Jerry Pate Turf and Irrigation, as well as Gold Mine Golf Inc.

These projects highlight the importance of industry partnerships and collaborative work to improve research outcomes that ultimately benefit all sectors of the turf industry.

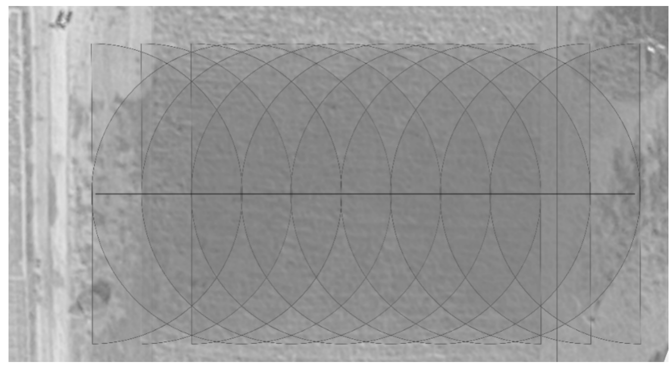


Figure 1. Layout of irrigation heads along the mainline of the linear gradient irrigation system.

ACKNOWLEDGMENTS

A huge thank you to supporters, including: Bayer Environmental Science, Green Tee Golf Inc., Pike Creek Turf, Sports Turf Company, NG Turf, Toro, Irrigation Consultant Services, Jerry Pate Turf and Irrigation, and Gold Mine Golf Inc. A portion of this work is supported by the Specialty Crop Research Initiative Grant 2021-51181-35855 from the USDA National Institute of Food and Agriculture.

Water Requirements for Turfgrasses with Improved Drought Performance

David Jespersen, Associate Professor, Crop and Soil Sciences
UGA-Griffin

Ravneet Kaur, Master's Student, Crop and Soil Sciences
UGA-Griffin

ABSTRACT

The ability to maintain turfgrass performance with reduced irrigation inputs or under drought conditions is a highly valuable trait. Newly developed germplasm has been shown to have improved drought performance in multi-location field trials. The goal of this study is to quantify the minimum water requirements of newly developed cultivars and compare them to commercially available standards. Replicated plots of bermudagrass (*Cynodon* spp.), seashore paspalum (*Paspalum vaginatum*), St. Augustinegrass (*Stenotaphrum secundatum*), and zoysiagrass (*Zoysia* spp.), were planted under a rainout shelter and irrigated on a plot-by-plot basis to determine water inputs over the growing season. Information from this study will help quantify the levels of improved drought performance and help guide future irrigation recommendations for improved cultivars.

INTRODUCTION

Turfgrasses provide numerous benefits to landscapes. Despite these benefits, the turfgrass industry faces many challenges, most importantly limited water resources and the desire to develop sustainable irrigation practices. A collaborative effort among turfgrass breeding programs at public universities across the southern U.S. (including the University of Georgia, North Carolina State University, University of Florida, Oklahoma State University, and Texas A&M) has been working to develop new turfgrasses with improved drought performance to meet landscape needs. As part of a USDA Special Crop Research Initiative project ("Improving drought tolerance and sustainability of turfgrasses used in southern landscapes through the integration of breeding, genetics, physiology, economics, and outreach"), a number of breeding lines have been identified as having improved drought performance. These lines are being tested to determine the minimum water requirements needed to maintain acceptable quality. This study will help quantify the level of improvement in the newly developed lines compared to commonly used commercial cultivars and the potential of water savings that these lines afford. Additionally, information from this study will help inform irrigation practices for improved cultivars to reduce water use.

MATERIALS AND METHODS

In the summer of 2020 plots were established under a rainout shelter structure at the UGA Griffin campus to allow control of the moisture reaching plots. Plant materials included three cultivars (many of which are experimental lines) developed as part of a collaborative, multi-institution breeding effort and one widely used commercial check cultivar per species (Table 1). Three replicate blocks were planted in the field.

After establishment, irrigation was turned off in July 2021. Three times per week all plots were assessed for visual quality and signs of wilt, digital image analysis to assess percent green cover, and canopy temperature via infrared thermometry to assess transpiration. Individual plots that were rated as having greater than

Table 1. Plant materials tested for drought performance.

Species	Cultivar name			
Bermudagrass	'Tifway' [C]	'TifTuf'	'Tahoma31'	'TifB16117'
Seashore paspalum	'Seastar' [C]	'UGP73'	'UGP113'	'UGP198'
St. Augustinegrass	'Floratam' [C]	'Citrablue'	'DALSA1404'	'DASLA1618
Zoysiagrass	'Empire' [C]	'DALZ1606'	'DALZ1613'	'FAES1319'

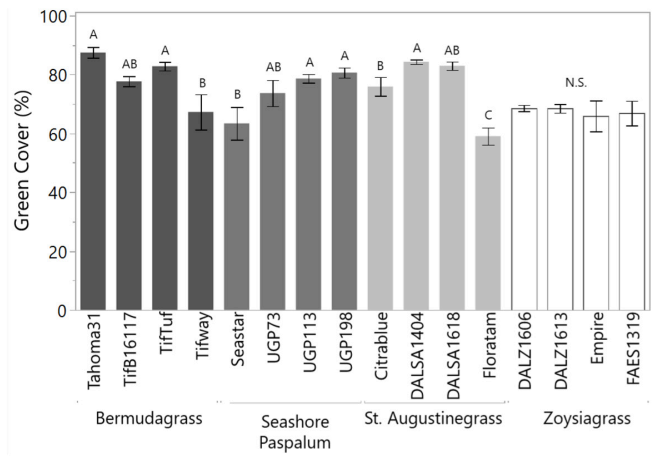
[C] Commercial standard

50% wilt and showing obvious signs of drought were given 1 in. of water. This continued through September 2021, cumulative water rates were determined, and irrigation was resumed to allow plots to recover. The 2022 trial began in June and will run through September 2022.

RESULTS

Over the course of the trial in 2021, differences were seen in several measurements. All three bermudagrass lines, including the recently released 'TifTuf' and 'Tahoma 31', as well as the experimental line from UGA 'TifB16117', all maintained significantly greater visual quality than 'Tifway' (Figure 1). 'TifTuf' and 'Tahoma 31' also maintained greater percent green cover compared to 'Tifway', as seen in the September 2021 measurements. In seashore paspalum, again, all three experimental lines had greater visual quality ratings than the commercial check, with both 'UGP198' and 'UGP113' having greater percent green cover than 'Seastar'. Similarly, both experimental St. Augustinegrass lines developed at Texas A&M ('DALSA1404' and 'DALSA1618') as well as 'Citrablue' (developed at the University of Florida), had greater visual quality ratings and percent green cover compared to the commercial check 'Floratam'. Among St. Augustinegrass lines 'DALSA1404' was the top performer. No differences in visual quality or green cover were noted among the zoysiagrasses tested. Although there was a trend for lower canopy temperatures in experimental lines of seashore paspalum and St. Augustinegrass compared to the check cultivars, only in bermudagrass were there significant differences between the experimental lines and the check cultivar 'Tifway'. Across data collection in 2021, canopy temperatures in experimental lines were on average 2–3 °C cooler. These trends also were seen for the total amount of applied irrigation, where commercial cultivars were always in the group that required the most irrigation, but these differences were the most pronounced among bermudagrass cultivars. Data collection is ongoing and continuing through 2023.

Figure 1. Green cover data, September 2021. Bars are standard error, letters represent LSD groupings.



CONCLUSIONS

While research is ongoing, to date the collected data supports that the previously identified lines have superior drought performance. Due to the limited time of the 2021 trial to allow plots to finish establishing, some plots did not require any supplemental irrigation during the trial period. In addition to requiring less irrigation, many lines maintained overall greater quality and had reduced canopy temperatures. These differences in canopy temperature indicate that the improved lines were better able to extract water from the soil or otherwise regulate transpirational water loss from their leaves. Data collection will continue through 2022 and 2023. Other trials looking at these lines at other locations, as well as under controlled-environment studies, will allow for a greater understanding of both of the improvements in drought performance achieved through collaborative breeding efforts as well as provide insight into the mechanisms of improved drought performance. The adoption of improved cultivars with reduced water requirements has the potential to greatly reduce irrigation demands and meet the needs of future sustainable turfgrass areas.

ACKNOWLEDGMENTS

Funding for this project was provided by Specialty Crop Research Initiative Grant 2019-51181-30472 from the USDA National Institute for Food and Agriculture.

Evaluation of Mowing Frequency for Lawn Health and Performance

Clint Waltz, Professor, Crop and Soil Sciences
UGA-Griffin

ABSTRACT

Mowing is a regular practice of removing turfgrass leaf tissue to maintain an aesthetically attractive lawn. Conventional mowing practices for lawn maintenance involves mowing every 7 to 10 days. With the advent of robotic mowers, it is now possible to effectively mow more regularly and remove less leaf tissue at each mowing, potentially reducing turfgrass stress and improve turfgrass quality. A multiyear trial was initiated in summer 2019 and continues through 2022 to investigate if more frequent mowing affects warm-season turfgrass. There were two mowing treatments, conventional mowing (CM) and robotic mowing (RM), used throughout the growing season. At the July 2021 sampling date, shoot counts were greater for the robotically mowed turf. Similarly, RM plots had greater root dry weight, total length, and volume at the July 2021 sampling. This trial indicates that more regular mowing at a recommended mowing height, which can be performed by a robotic mower, does not harm warm-season turfgrass shoots and may increase root characteristics.

INTRODUCTION

Mowing is a regular practice of removing turfgrass leaf tissue to maintain an aesthetically attractive lawn. However, mowing is a stress that can compromise the health and growth of the turfgrass. Conventional mowing (CM) practices for lawn maintenance involves mowing every 7 to 10 days. Accepted recommendations for mowing are to remove no more than one-third of the leaf in a single mowing. On a CM program this can allow the grass to grow then be cut back, imposing minimal stress on the plant. With the advent of robotic mowers it is now possible to mow more regularly, removing less than one-third of the leaf and potentially imposing less stress to the plant than CM. Additionally, quality of cut can affect the appearance and quality of the turfgrass. Conventional rotary-type mowers use a relatively thicker blade than the blade on an automower. The substantially thinner and sharper blade of the automower could reduce mowing stress, resulting in improved turfgrass appearance and performance compared to CM. With less stress the plant may be able to grow more shoots and roots, allowing the turfgrass to withstand or recover from other stresses (e.g., drought, disease, insects, malnutrition, etc.) while maintaining an attractive appearance.

The objective of this study was to determine if more frequent mowing and removal of less than one-third of the leaf improves turfgrass quality and growth characteristics (e.g., shoot and root density, rooting depth, etc.).

MATERIALS AND METHODS

This multiyear study was initiated in August 2019 on a mature stand of 'TifSport' bermudagrass at UGA Griffin. Prior to the start of the trial, the plot area was permitted to grow to 1.25 in., repeat applications of postemergence herbicides were applied to control grassy and broadleaf weeds, and a 16-4-8 fertilizer was applied using a soluble nitrogen source at a rate of 1.0 lb N per 1000 sq ft. Irrigation was applied to a target of 1 in. of irrigation per week to supplement, or in the absence of, rainfall. Fungicides were applied on a preventive basis specifically for dollar spot (*Sclerotinia homoeocarpa*) and spring dead spot (*Ophiosphaerella* spp.).

There were two mowing treatments, CM and robotic mowing (RM). CM plots were mowed one time each week during the growing season at approximately 1.25 in. with a rotary-type walk-behind mower. The RM plots were programed to be mowed three times weekly (i.e., Monday, Wednesday, and Friday) for 9 hours per day using a Husqvarna Automower set at approximately 1.25 in. Manufacturer-recommended new blades were installed on both mowers about every 6 weeks. A "mulching" blade was used for the CM. For both mowing treatments, clippings were returned.

Plots (12 x 60 ft) were in a randomized complete block design with three replications. Throughout the study, plots were visually evaluated for turfgrass quality and color, and core samples were taken for shoot count and root measurements. For root dry weight, soil was washed from 2-in. cores, dried in a forced air oven at 80 °C for 48 hr, and weighed. Total root length and volume analysis was performed using a flatbed scanner and RhizoVision Explorer software. All data underwent an analysis of variance with means separated by least significant difference (alpha = 0.10).

The intent was for this study to be conducted during the 2020 and 2021 growing seasons. Because of the COVID-19 pandemic and UGA policies during 2020, the study was not maintained as planned (e.g., scheduled CM, data collection, etc.). Proper mowing treatments and data collection resumed in 2021 and have continued into 2022.

RESULTS

Shortly after the initiation of mowing treatments (i.e., first 3 to 4 weeks) in 2019, the visual quality of RM plots was below that of the CM plots, but as the grass adjusted to RM the visual differences between the two mowing techniques disappeared and were comparable. The mowing height between the two techniques is not exact with the RM plots being slightly lower than the CM. The greatest visual difference between the two mowing practices was the development of fire ant mounds. Because of the lack of even distribution of ants this was a noticeable observation, with ant mounds visible only in CM plots. This observation is consistent with fire ant behavior. Fire ants do not like regularly disturbed areas and the routine of the robotic mower is more regular than the once-per-week mowing of the conventional mower. For worker safety, the entire plot area was treated with an insecticide to control fire ants in 2020, 2021, and 2022.

At the July 2021 sampling date, shoot counts were greater for the RM plots (Table 1). It was interesting that in 2019, within a few weeks of initiating the study, all root parameters that were measured were greater for the RM plots. Similarly, RM plots had greater root dry weight, total length, and volume at the July 2021 sampling. By October 1, 2021, there was no difference in shoot counts or root measurements between the two mowing practices. These results are similar to a nonreplicated trial conducted in July 2019 on zoysiagrass.

Unfortunately, getting the trial started in 2019 resulted in a shortened season, and 2020 essentially was a lost data-collection year, so the cumulative long-term results from more frequent mowing (e.g., three times per week) are not yet known. Research will continue to investigate the benefits of robotic mowing on the turfgrass plant.

Table 1. Shoot and root measurements of 'TifSport' bermudagrass from conventional mowing (CM) and robotic mowing (RM).

	Sampling Date		
	08-21-19	07-21-21	10-01-21
Shoot Count*			
CM	23.4 a**	19.7 b	29.6 a
RM	26.2 a	37.6 a	34.4 a
Root Dry Weight***	grams		
CM	1.65 b	1.15 b	1.51 a
RM	2.21 a	1.57 a	1.57 a
Total Root Length	mm		
CM	29,336 b	17,067 b	24,741 a
RM	34,951 a	24,151 a	24,948 a
Root Volume	mm^3		
CM	22,008 b	12,193 b	31,687 a
RM	27,536 a	17,103 a	29,115 a

* Shoots per 3.15 sq in.

** Means within a grouping with the same letter are not statistically different.

*** All root measurements are per 12.6 cubic in.

CONCLUSIONS

This trial indicates that more regular mowing (e.g., three times per week) at a recommended mowing height, which can be performed by a robotic mower, does not harm warm-season turfgrass shoots and may increase root characteristics. The timing of improved root length and volume — midsummer — may be ideal to help warm-season species maintain commercial acceptability during stress periods (e.g., heat and drought).

ACKNOWLEDGMENTS

We would like to thank Husqvarna for the support and assistance in installation of this research. Student workers that contributed to this study were Hunter Daniel, Ethan Barr, and Mitch Crawford.

Sustainably Managing Turfgrass Diseases with Nanobubble Technology and Biofungicides

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Mussie Habteselassie, Professor, Crop and Soil Sciences
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ABSTRACT

The University of Georgia Turfgrass Team is currently focusing on developing more environmentally friendly disease management strategies. Two projects currently are underway, investigating the effects of nanobubble technology and biofungicide treatments in controlling major turfgrass diseases such as dollar spot and Rhizoctonia large patch. Preliminary results showed the favorable effect of oxygenated nanobubbles in reducing *Rhizoctonia solani* development and the potential importance of incorporating biofungicide treatments to reduce fungicide applications in the field.

INTRODUCTION

Turfgrass is a valuable commodity used in home lawns, golf courses, sports fields, and recreational lands. It was shown to improve groundwater recharge, soil erosion, soil carbon sequestration, noise, and pollution. Turfgrass is a multibillion dollar industry in the United States that contributes more than 822,848 jobs and has a total economic impact of $57.94 billion annually. Several diseases damage and depreciate turf quality. Dollar spot and Rhizoctonia are among the most important diseases of seashore paspalum and zoysiagrass worldwide. Typically, turfgrass disease management relies heavily on fungicide applications. A research priority is the discovery of sustainable disease management options with efficient and applicable solutions in golf course practices.

Nanobubble technology has also been increasing rapidly in agriculture and crop production. Oxygenated and ozonated nanobubbles were shown to have high oxidizing potential and antimicrobial activity, to be effective in controlling some seed-borne pathogenic fungi, and are currently used as a disinfectant in water treatment (Atkinson et al., 2019). Furthermore, several biological agents and plant extracts are promising for the control of fungal diseases in diverse crops (Kiewnick et al., 2001). However, the effectiveness of nanobubble technologies and the application/formulation of biological agents in controlling turfgrass diseases currently are unknown.

Federal and state research grants through USDA–NIFA, USDA Specialty Crop Block Grant, Georgia Golf Course Superintendents Association, and Georgia Golf Environmental Foundation have provided an opportunity for the UGA Turfgrass Team to investigate several innovative technologies in turfgrass disease management, in collaboration with companies including Super Sod, NanoOxygen Systems, Nano Air Bubble Aeration Systems, and Marrone Bio Innovations.

The UGA Turfgrass Team has several current research projects investigating in vitro, greenhouse, and field trials on 1) the effects of oxygenated and ozonated nanobubble treatments on turfgrass pathogen development with emphasis on dollar spot; and 2) the potential use of biofungicides to reduce Rhizoctonia large patch.

MATERIALS AND METHODS

We investigated whether oxygenated and ozonated nanobubbles could play an important role in controlling dollar spot and Rhizoctonia large patch in vitro on PDA media. Infusion of oxygenated nanobubbles into irrigation water also is being tested in greenhouse and field trials at the UGA Griffin campus for controlling dollar spot and Rhizoctonia large patch diseases in seashore paspalum and zoysiagrass, respectively. Trials were performed in vitro, in the greenhouse, and in the field, applying nanobubble treatments every other day.

Furthermore, we assessed the potential use of several biofungicides to reduce *R. solani* in vitro. The biofungicides targeted included Rhapsody (*B. subtilis* QST713), Ennoble (*Muscodor albus* QST 20799), Stargus (*Bacillus amyloliquefaciens* F727), and a plant extract, Regalia (*Reynoutria sachalinensis*). During in-greenhouse and field trials at the UGA Griffin campus, we evaluated their efficiency in controlling Rhizoctonia large patch in zoysiagrass, and compared them to several fungicides registered for turfgrass, including Heritage 50WG (azoxystrobin).

Natural infections are used for the field trials; a *Clarireedia monteithiana* isolate and a *R. solani* isolate, sampled from the UGA Griffin campus on seashore paspalum and zoysiagrass, respectively, were used for in vitro and greenhouse trials.

For all these trials, data collected included repetitive measurements of the mycelial growth in vitro, severity of the diseases, turf quality, and NDVI values using handheld and drone images during the growing season. Three to five replicates were used within each treatment and the experiments were conducted more than two times when possible.

RESULTS

Oxygenated and ozonated nanobubble trials

In preliminary in vitro trials, the application of water enriched with oxygen nanobubbles did not significantly reduce mycelial growth of *Clarireedia* (experiment 1 and 2) and *Rhizoctonia solani* (experiment 1) on artificial media. However, for experiment 2, oxygen nanobubbles suppressed mycelial growth of *Rhizoctonia solani* by 9% in vitro (Figure 1).

Biofungicide trials

Preliminary in vitro results showed that the fungicides Banner Maxx (propiconazole; at 1X), Rhapsody (at 1X and 10X), and Regalia (at 10X) reduced *R. solani* mycelial growth by 17 to 83% on average compared to the control. However, Stargus did not significantly affect the pathogen mycelial growth compared to the control (Figure 2). Field experiments were initiated in Spring 2022.

Figure 1. Effect of the oxygenated nanobubble treatments on *Clarireedia monteithiana* (a) and *Rhyzoctonia solani* (b) mycelial growth in vitro (experiment 2, day 3 results).

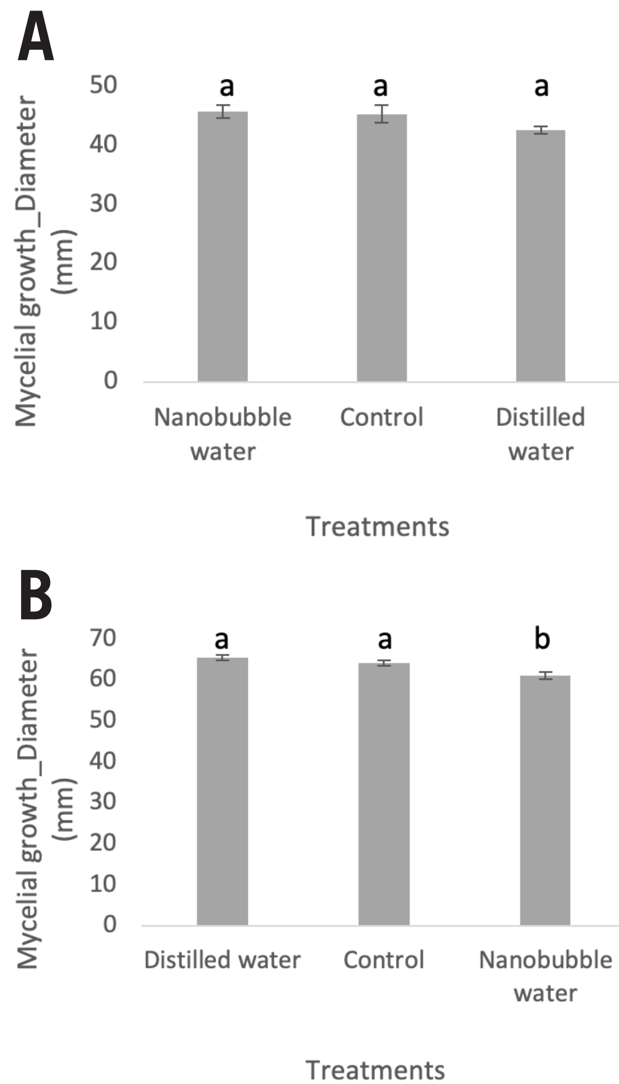
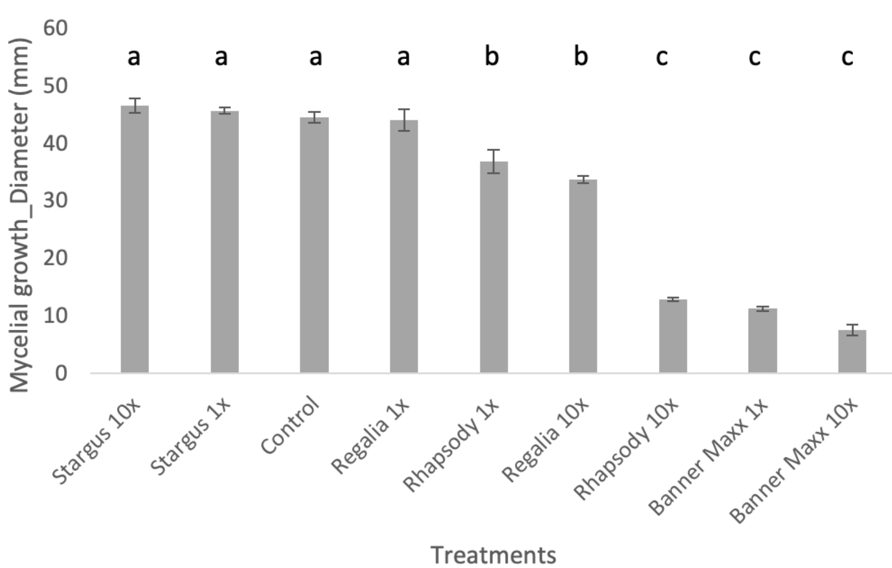


Figure 2. Effect of the biofungicides and fungicides on *Rhizoctonia solani* mycelial growth in vitro on PDA media (experiment 1 results).



Sustainably Managing Turfgrass Diseases with Nanobubble Technology and Biofungicides, *continued*

CONCLUSIONS

The collaborative efforts of our UGA Turfgrass Team, supported by federal and state funding, provided encouraging preliminary results on nanobubble technology that need to be confirmed with additional greenhouse and field trials. The continued efforts with these nanobubble and biofungicide projects will help to develop more sustainable turfgrass disease management strategies.

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ACKNOWLEDGMENTS

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Turf Disease Management: Fungicide Round-up

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In the last 4 years, we have implemented a series of research trials to determine fungicide efficacy, rates, and their application timing as pre- and post-epidemic control on various turfgrass diseases. All these fungicide trials were conducted in our turfgrass research areas at the UGA Griffin campus.

The fungicides were tested in zoysiagrass cv. 'El Toro'; bermudagrass cv. 'Princess', cv 'TifEagle'; Seashore paspalum cv. 'SeaIsle', cv. 'SeaStar', and several paspalum experimental lines; tall fescue cv. 'The Rebels', cv 'Kentucky 31'; and bentgrass cv. A1/A4, 'Pencross 2.0'. Fungicides evaluated in our research areas included mefentrifluconazole (Maxtima); mefentrifluconazole + pyraclostrobin (Navicon); boscalid + chlorothalonil (Encartis); prothioconazole (Densicor); tebuconazole (Mirage Stressgard); flupyram + trifloxystrobin (Exteris Streesgard); *Bacillus amyloliquefasciens* strain D747 (Double Nickel); *Bacillus mycoides* isolate J (Lifegard®); isofetamid (Kabuto); isofetamid + tebuconazole (Tekken); benzovindiflupyr + difenconazole (Ascernity); pydiflumetofen + azoxystrobin + propiconazole (Posterity Forte, Posterity XT). Numerous numbered products (fungicides in development) also have been tested in our research plots.

On this stop, we will discuss and answer questions regarding the latest fungicides available to turfgrass professionals. Results obtained in these investigations provide turfgrass managers with new disease management tools, improved disease control, and better turf quality. For a complete and up-to-date list of turfgrass fungicides, visit https://turf.caes.uga.edu/publications/pest-control-recomendations.html

Updates on Fall Armyworm and Rhodesgrass Mealybug Research in Turfgrass

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FALL ARMYWORM AND BENEFICIAL ARTHROPODS

Fall armyworm is a serious pest of turfgrass. The moths lay several hundreds of eggs (in eggmasses) on any surface they can find near turfgrass, such as fences, house walls, porches, storage sheds, barns, trees, and shrubs. The eggmasses are an off-white color, and may be a woolly or fussy mass. Eggs hatch within 48 hr in summer. The tiny caterpillars land on the turfgrass when the eggs hatch and immediately feed on turfgrass leaf blades. The small caterpillars are difficult to see as they are mostly hidden in the turfgrass canopy. As the size of the caterpillar increases, they become noticeable. When you have an infestation, you will see hundreds of them munching on the turfgrass leaf blades. A fully grown caterpillar can reach approximately 1½ in. long.

We witnessed a fall armyworm outbreak in 2021. The infestations in turfgrass started in mid-June, intensified by late July, and lasted until October. Although the exact reasons for the outbreak are unclear, we suspect early dispersal events, wet weather, and warmer temperatures contributed to the problem. The problem was observed in golf courses, sod farms, and residential lawns. Those affected used pyrethroids for management, but pyrethroid treatments did not provide effective control in some locations. Researchers in neighboring states also suffered similar severe pressure from fall armyworm.

There are two strains of fall armyworm, rice- and corn-strain, that occur on crops. The strains are determined using molecular tools rather than morphological characters. Studies have shown that most fall armyworms found on turfgrass have been rice-strain. Previously, corn-strain fall armyworms rarely were reported on turfgrass. Researchers working with turfgrass pests in the southeastern U.S. suspect that the fall armyworm outbreak in 2021 on turfgrass could have been corn-strain, which is suspected to be less susceptible to pyrethroid treatments. Many sod growers and golf course superintendents reported reduced fall armyworm control when using pyrethroid products.

Monitoring is the critical step for managing fall armyworms. Scout the edges around any structures, trees, or shrubs in lawns at least three times a week (especially in August and September) for caterpillar infestations. Once they start feeding, they grow in size. It is easier to manage caterpillars when they are small. Once an infestation is detected, treat it with insecticide. We have seen severe fall armyworm infestations on newly laid sod in residential and public lawns. Although moths can lay eggs on the sod (turfgrass) pallets during transit or before planting the sod, newly laid sod is particularly vulnerable to fall armyworm attacks. Bermudagrass and tall fescue are particularly susceptible to fall armyworm caterpillar feeding. Zoysiagrass is relatively resistant to fall armyworm infestation. Pay close attention to newly laid lawns and act immediately when an infestation is detected. Once an infestation occurs, the turfgrass may turn from green to brown. The affected lawn usually recovers within 3 weeks. Maintain the turfgrass with recommended irrigation and fertilizer, which is essential for establishing the newly laid sod.

For management, try using *Bt* insecticide products, which are available to homeowners. They are effective when caterpillars are smaller but are not effective on larger caterpillars. Products containing a pyrethroid insecticide, such as bifenthrin, cyfluthrin, deltamethrin, etc. (usually ends with "-thrin"), should provide adequate control. Newer insecticides, such as chlorantraniliprole and pinosad, also are effective on fall armyworm larvae. Remember, read the insecticide label before use because the label is the law. **It is not clear if the insecticides targeting fall armyworm larvae affect nontargets, such as beneficial arthropods like ground beetles, rove beetles, etc**. This research is underway at the Griffin campus.

RHODESGRASS MEALYBUG

Rhodesgrass mealybug, *Antonina graminis* (Hemiptera: Pseudococcidae), is an invasive pest native to Asia and was first found in the United States in Texas in 1942. Rhodesgrass mealybug can infest more than 100 grass species (Poaceae), including all warm-season grasses commonly used for pastures and turf in the southern U.S.

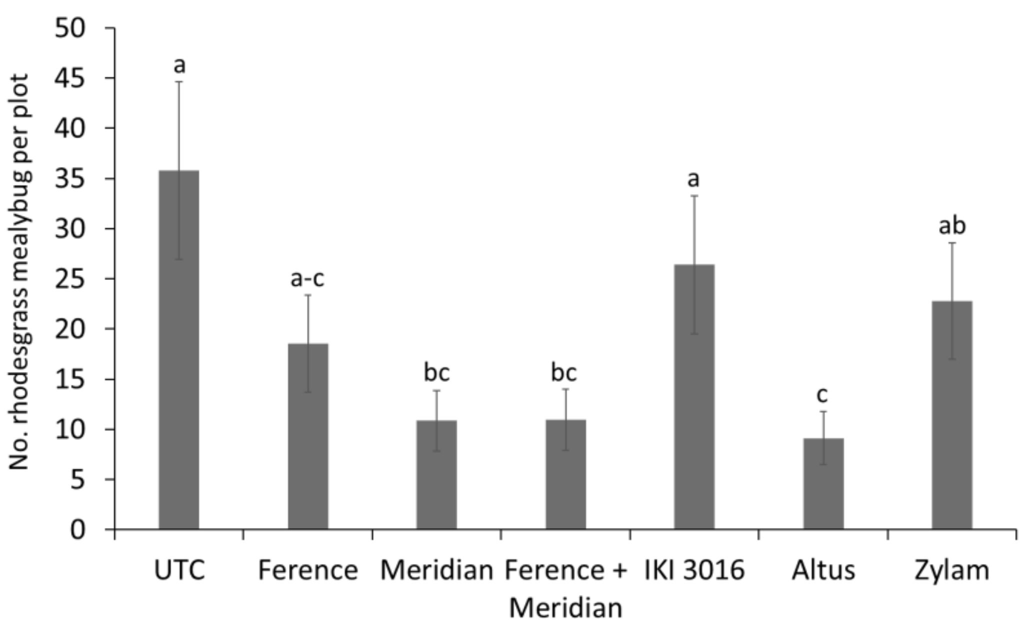
Rhodesgrass mealybug populations in the southern U.S. successfully had been suppressed by the parasitoid *Neodusmetia sangwani* (Hymenoptera: Encyrtidae). A native parasitoid (*Acerophagus* sp.) and an adventive parasitoid (*Pseudectroma* sp.; both Hymenoptera: Encyrtidae) may also have contributed to population suppression.

Rhodesgrass mealybug infestation causes yellowing, stunting, and thinning of bermudagrass greens on golf courses. The unreliability of biological control, extremely low tolerances for damage on golf turf, and high susceptibility of bermudagrass to rhodesgrass mealybug necessitate the identification of effective insecticides for management programs on golf greens. Prior to our research, **no study has evaluated the efficacy of insecticides against rhodesgrass mealybug since the 1950s**. We conducted a series of field experiments in Georgia to evaluate the efficacy of selected insecticides.

All insecticide treatments applied to golf course greens in Georgia, except for Zylam (dinotefuran), **significantly reduced the densities of live rhodesgrass mealybugs at 1 month after application** (Figures 1 and 2). While Altus (flupyradifurone), Ference (cyantraniliprole), and Meridian (thiamethoxam), and their combination reduced mealybug densities at 1 month after application, no treatment significantly suppressed mealybug densities when compared to the water-treated control at 2 and 2.5 months after application.

Figure 1. Turfgrass quality after application of insecticide.

Figure 2. Mean number of rhodesgrass mealybug per plot at 30 days post-application of insecticides on infested green.



Role of Pollinators in Centipedegrass

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ABSTRACT

Turfgrasses are generally considered devoid of pollinators, as they are wind-pollinated. Centipedegrass is a popular turfgrass type planted in the southeastern U.S., and it produces a large number of inflorescences from August to October each year. In a recent study, sweat bees (small bees) and bumble and honey bees (large bees) were captured while actively foraging on the centipedegrass inflorescences. More sweat bees were collected in the pan and flight-intercept traps than large bees. We also captured hoverflies in the samples. The adult hoverflies consumed pollen during flower visits. This research is a first step toward developing bee-friendly lawns. **It is not clear if the foraging pollinators collect pollen from the centipedegrass inflorescences.**

Table 1. The total number of pollinators collected using various methods.

Family	Genus	Number of Pollinators
Sample method: Sweep		
Halictidae	Lasioglossum	28
Apidae	Bombus	17
Apidae	Apis	9
Apidae	Melissodes	1
Halictidae	Augochlorella	1
Syrphidae	-	37
Sample method: Pan		
Halictidae	Lasioglossum	32
Apidae	Bombus	1
Apidae	Melissodes	1
Halictidae	Augochlorella	4
Syrphidae	-	3
Sample method: Malaise		
Halictidae	Lasioglossum	7
Apidae	Melissodes	1

Ninety-three pollinators were collected from centipedegrass inflorescences in the 30 min sweep samples (Figure 1). Most of them were sweat bee (*Lasioglossum* spp.) followed by bumble bee (*Bombus* spp.) and honey bee (*Apis* spp.; Table 1). Other bees, such as *Melissodes* spp. and *Augochlorella* spp., as well as syrphid flies also were collected.

Implications of the results will be discussed at this stop.

Figure 1. Various bees foraging on centipedegrass.

Evaluation of Fall Herbicide Programs for Annual Bluegrass Control in Bermudagrass

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ABSTRACT

Field experiments were conducted in 2021–2022 at the UGA Griffin campus to evaluate herbicide programs consisting of various rates, timings, and modes of action for annual bluegrass control in bermudagrass. The treatments were evaluated at early-postemergence timings and consisted of herbicide programs with pre- and post-emergence activity on annual bluegrass.

INTRODUCTION

Annual bluegrass (*Poa annua*) continues to be the most problematic weed in turfgrass. Turf managers are allocating more resources to controlling annual bluegrass due to herbicide resistance and failures of management programs. Annual bluegrass can survive through early summer in turf in many areas of Georgia. The survival and adaptation of these biotypes of annual bluegrass are contributing to the challenges with control in turf management. Our current research focuses on the ecology of annual bluegrass and management programs that influence the spread and establishment of populations. Although this work contributes to our understanding of annual bluegrass, there is a need to develop herbicide recommendations that utilize various modes of action for resistance management strategies.

MATERIALS AND METHODS

The experiment was conducted at the UGA Griffin campus on a ‘Tifway’ bermudagrass fairway. Herbicide programs were applied in November and December 2021 and are listed in Table 1. Bermudagrass injury, greenup, and annual bluegrass control were visually evaluated through May 2022. The design was a randomized complete block with five replications of 5 x 10 ft plots.

Table 1. Herbicide programs evaluated for annual bluegrass control.

Program	Herbicide	Rate/acre	Application date
1	Nontreated	-	-
2	Barricade + Monument + simazine	0.75 lb ai + 0.5 oz + 1 qt	11/12/21
3	Barricade + Monument + simazine	0.75 lb ai + 0.5 oz + 1 qt	11/12/21
	simazine	1 qt	12/14/21
4	Specticle Flo + Tribute Total + simazine	3 oz + 1 oz + 1 qt	11/12/21
5	Specticle Flo + Tribute Total + simazine	3 oz + 1 oz + 1 qt	11/12/21
	simazine	1 qt	12/14/21
6	Kerb	3.5 pt	11/12/21
7	Kerb	1.75 pt	11/12/21
		1.75 pt	12/14/21
8	Sureguard	12 oz	11/12/21
9	Roundup Pro + Specticle Flo	6 oz + 3 oz	11/12/21
10	Roundup Pro + Specticle Flo	6 oz + 3 oz	12/14/21

Evaluation of Fall Herbicide Programs for Annual Bluegrass Control in Bermudagrass, *continued*

RESULTS

There were no meaningful differences in bermudagrass injury detected among treatments in late November or December. The turf was dormant for most of the trial and differences in greenup were not detected. There were no differences in annual bluegrass control between Barricade + Monument + simazine and Specticle + Tribute Total + simazine programs applied in November. Both of these programs gave 100% control of annual bluegrass and there was no benefit to making a sequential application of simazine in December. Kerb applied once in November at 3.5 pint/acre and Sureguard at 12 oz/acre in December gave similar control to the three-way combination treatments from March through May. There also was no difference in annual bluegrass control from splitting Kerb applications at 1.75 pint/acre compared to a single application of 3.5 pint/acre. The program of Roundup at 6 oz/acre + Specticle Flo at 3 oz/acre applied in November gave 98% control of annual bluegrass in spring, but delaying this treatment until December gave unacceptable control (< 70%).

CONCLUSIONS

Timing herbicide programs with various modes of action in November gave excellent control of annual bluegrass. There was no benefit to applying sequential treatments of simazine in December for programs with a November application of Barricade + Monument + simazine or Tribute Total + Specticle Flo + simazine. These programs gave equivalent control to Kerb and Roundup + Specticle applied in November and Sureguard applied in December. To achieve acceptable control when treatments are delayed until December, users may need to apply Roundup at rates greater than 6 oz/acre with Specticle Flo.

Development of Recommendations for an Herbicide-Resistant Turfgrass System

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ABSTRACT

Weed control is a major issue for turfgrass managers. Although major row crops successfully have utilized herbicide-resistant systems to enhance weed control, the turfgrass industry has lagged decades behind. University of Georgia turf scientists have developed a non-genetically modified herbicide-resistant system for seashore paspalum with resistance to several ACCase-inhibiting herbicides that can be effective in controlling weedy grasses. Since herbicide-resistant breeding lines have been developed and are nearing commercial release, field research was initiated to aid in the development of weed control recommendations that maximize the usefulness of this new weed control system.

INTRODUCTION

Regardless of species, weed control is a major management issue. Although major row crops have successfully utilized herbicide-resistant systems to enhance weed control for decades, the turfgrass industry has lagged behind. The first herbicide-resistant turfgrass cultivars recently were introduced by the Scotts Company with the commercialization of glyphosate-tolerant St. Augustinegrass and Kentucky Bluegrass cultivars under the ProVista™ brand. Although these cultivars are registered for use in the United States, genetically modified (GM) turfgrasses such as these remain problematic because of regulation and registration costs, and many international governments prohibit their importation and use.

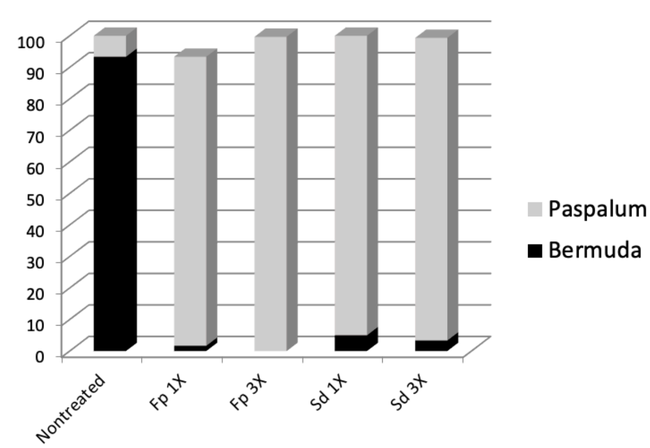
University of Georgia turf scientists utilized the tissue culture of seashore paspalum to select for a mutation conferring high levels of resistance to several widely used grass herbicides (Heckart et al., 2010; Raymer et al., 2016; Tate et al., 2021). This non-GM herbicide-resistant system (sethoxydim resistant or SR) for seashore paspalum promises to become an effective tool for control and/or management of weedy grasses. Earlier greenhouse studies and field research demonstrated that the SR seashore paspalum genotypes were tolerant to 3x the recommended rates of both fenoxaprop and sethoxydim, and repeated applications of fenoxaprop at 1x and 3x and sethoxydim at 3x rates provided adequate control of common bermudagrass (Figure 1) and other grassy weeds.

The breeding program has utilized this novel trait to develop improved vegetative cultivars of seashore paspalum and is working closely with Pure Seed of Canby, OR, to develop newly seeded SR seashore paspalums. As we approach the release of both seeded and vegetatively propagated SR cultivars, additional research is needed to develop the best weed control strategy to maximize the effectiveness of this new herbicide-resistant system.

MATERIALS AND METHODS

During the summer of 2021, a research area heavily infested with common bermudagrass was sprayed with 4 quarts of glyphosate, tilled, and sprigged with

Figure 1. Control of common bermudagrass in SR seashore paspalum (SR31.15.15).



Note. Observations made 15 months after planting into a field infested with common bermudagrass. Herbicide treatments were fenoxaprop (Fp) and sethoxydim (Sd) at 1x and 3x the recommended rates. Treatments were applied monthly during the growing season. Values are percentage of each species present.

Development of Recommendations for an Herbicide-Resistant Turfgrass System, *continued*

SR vegetatively propagated seashore paspalum (UGA SR31.15.15). In the spring of 2022, this area contained a mixture of both seashore paspalum and common bermudagrass. Herbicide treatments were applied on a prescribed basis beginning in mid-May. Treatments included Segment II (sethoxydim), Fusilade II (fluazifop-P-butyl), and Acclaim Extra (fenoxaprop-p-ethyl) alone and in various combinations (Table 1).

RESULTS

At the time of this writing, herbicide treatment applications were just beginning, and therefore, results were not available. Results to date of this ongoing research will be discussed, and plots showing treatment effects will be on display at the field day.

CONCLUSIONS

The development of new cultivars with resistance to grass-specific herbicides promises to greatly enhance weed control options in seashore paspalum.

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ACKNOWLEDGMENTS

We gratefully acknowledge the technical support provided by Lewayne White, Austin Foster, and Pure Seed.

Table 1. Herbicide treatments applied to a mixed stand of SR seashore paspalum and common bermudagrass.

Program	Herbicide	Rate/acre	Application date
1	Nontreated	-	-
2	Segment II	1.5 pt	May 15 + May 30
	Fusilade + NIS	2 oz	June 15 + biweekly through Oct. 1
3	Segment II	1.5 pt	May 15 + May 30
	Fusilade + NIS	4 oz	June 15 + biweekly through Oct. 1
4	Segment II	1.5 pt	May 15 + May 30
	Acclaim Extra	10 oz	June 15 + biweekly through Oct. 1
5	Segment II	1.5 pt	May 15 + May 30
	Acclaim Extra	20 oz	June 15 + monthly through Oct. 1
6	Fusilade + NIS	2 oz	May 15 + biweekly through Oct. 1
7	Fusilade + NIS	4 oz	May 15 + biweekly through Oct. 1
8	Acclaim Extra	10 oz	May 15 + biweekly through Oct. 1
9	Acclaim Extra	20 oz	May 15 + monthly through Oct. 1
10	Prograss + Cutless MC	42 oz + 25 oz	May 15 + monthly through Oct. 1

Computer Vision-Based Weed Mapping

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ABSTRACT

Weeds are a persistent problem on sod farms, and herbicides to control different weed species are one of the largest chemical inputs. Recent advances in precision agriculture and computer vision have enabled green-on-green weed detection, which requires further development to be implemented in sod production. Studies were conducted with the goal of training models to identify and geo-locate the weeds in sod production fields. A high-level application programming interface implementation of the PyTorch deep learning library was used to train multiple convolutional neural networks (CNNs) to identify and map weeds in sod fields using drone and rover cameras. The performance of the CNNs based on drone imagery with resolutions from 0.57 to 1.28 cm per pixel were overall similar to, and in some classes (broadleaf and spurge) better than, human eyes as indicated by the metric recall. This CNN demonstrated precision above 90% and missed identifying less than 10% of the targets during turf establishment when the weeds are mature. However, to achieve sufficient resolution to identify grasses and new establishing weeds, it was ideal to take images closer to the target. This led us to test rover-based solutions with the image resolution of 1 mm per pixel. The CNN trained on these high-resolution images demonstrated high precision and recall in identifying weed types such as broadleaf, grass weeds, and sedge. Precision weed treatment using CNNs will require changes in mowing practice to allow weeds to emerge and be treated. A combination of CNNs may be used depending on the treatment and mowing condition.

INTRODUCTION

Weeds are a persistent problem on sod farms. Herbicides are one the largest chemical inputs, and weed control often requires multiple applications throughout the growing season. A variety of annual and perennial broadleaf and grassy weeds usually are present in Georgia sod farms, including annual bluegrass, goosegrass, crabgrass, dallisgrass, sedges, spurge, chickweed, and pigweed (Colvin et al., 2013). Site-specific weed management, such as applying herbicides only where the weeds are located, instead of whole-field broadcast applications, would significantly reduce herbicide use, thereby improving economic and environmental sustainability in sod production. One of the key components for site-specific weed management is the generation of a weed map. Cameras on both aerial and ground platforms can collect images with different levels of resolution. Recent technical advances in unmanned aircraft systems (UAS) have allowed for fast image acquisition and weed mapping using UAS in other crops. However, little research has been done on how to best implement UAS-based weed mapping for sod production. Deep learning neural networks may be a good approach to address these challenges, and there is a growing set of literature developing weed image recognition models (Mahmudul Hasan et al., 2021). These often depend on high-resolution images of the weed leaf with or without background vegetation (Olsen et al., 2019). Yu et al. (2019a, b, c) reported several deep CNN models that are exceptionally accurate (F1 score > 0.92, accuracy = 0.99) at detecting several broadleaf weeds in dormant and nondormant bermudagrass and perennial ryegrass using images taken at ground level (0.05 cm per pixel). These previous examples exploited either very high-resolution images or distinct cropping system features to aid in identifying weeds.

Currently we lack enough information to quantify the potential savings of using site-specific weed management in sod production; this information likely is needed before end users such as farmers and certification agencies adopt this new technology. The objectives of this study were 1) to investigate weed-type composition and distribution through both ground and UAS-based weed surveys on sod farms, and 2) to train CNNs for weed mapping in sod fields using both drone-based and rover-based images.

Computer Vision-Based Weed Mapping, *continued*

MATERIALS AND METHODS

Drone-based images collection, labeling, and ground survey

For full details, please refer to Zhang et al. (2021). Turfgrass weed surveys were carried out on sod production fields, on six different occasions during the growing season in 2019 and 2020. Ground weed surveys were conducted shortly after UAS flights for ground-truth labeling of the images for deep learning.

Drone flights were conducted using a DJI Phantom 4 Pro V2 equipped with a 20 megapixel RGB camera. The flights were conducted at 75% side and front overlap using DroneDeploy, and the flight altitudes ranged from 20 to 40 m, resulting in ground sampling distances of 0.57 to 1.28 cm per pixel. Raw images were processed through Pix4DMapper, and orthomosaics were generated using a standard workflow template, "Ag RGB." The orthomosaic of each flight was further cropped into smaller images representing a 1.5 x 1.5 m cell size. The cropped images were labeled according to the ground survey results. Labels were divided into five classes, including broadleaf, grassy weeds, spotted spurge, sedge, and no weeds.

Rover-based images collection and labeling

A GoPro Hero 9 camera was used for image collection. It was mounted on a boom that was attached to a utility vehicle. The camera was located at a height of 6 ft and captured images in a 12 ft swath at 1 mm resolution. The images were further cropped to 15 smaller square images with 1024 × 1024 resolution.

Training and metrics

For details on the training workflow in Fastai, please refer to Figure 2 in Zhang et al. (2021). All the CNNs were trained based on a similar workflow. Two metrics were calculated to assess the model performance, including precision and recall:

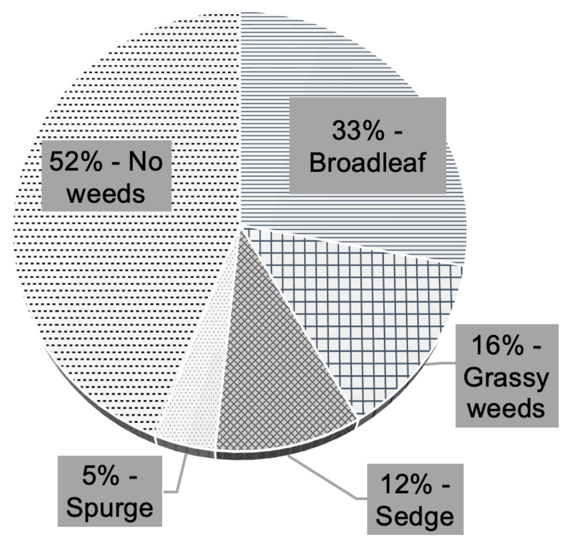
Precision = True positives/(True positives+False positives)
Recall = True positives/(True positives+False negatives)

RESULTS

Percentage of area with no weeds and potential herbicide savings

On average, about 52% of the 1.5 x 1.5 m surveyed areas had no weeds present (Figure 1). Areas of broadleaf, grassy weeds, or sedge accounted for 33%, 16%, and 12% of the total surveyed area, respectively. Spotted spurge was found only in survey 6 and accounted for 5% of the total surveyed area.

Figure 1. Average of percentage of area with different weed types was presented in six surveys. All surveys were conducted on Georgia sod farms in 2019 and 2020.

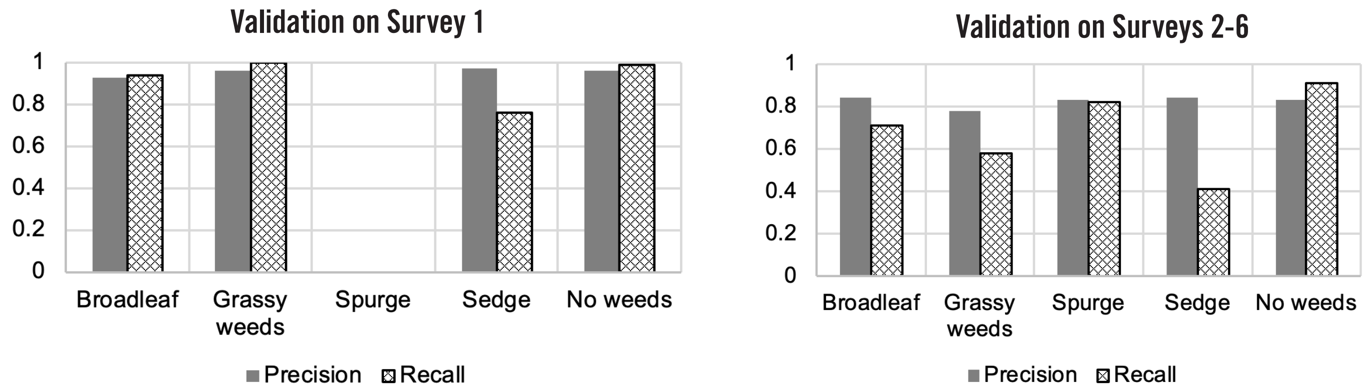


Performance of drone-imagery-based CNN

The CNN performed better in detecting validation images from survey 1 than from surveys 2–6 (Figure 2). Precision for detecting broadleaf, grassy weeds, sedge, and no weeds in survey 1 were 0.93, 0.96, 0.97, and 0.96, respectively. Recall ranges for these four classes were 0.94, 1.00, 0.76, and 0.99, respectively. The metrics for validation images from surveys 2–6 were 10–40% lower in precision and 1–46% lower in recall than the metrics calculated from survey 1. It was noted that the CNN detected classes such as grassy weeds and sedge in survey 1 at a much higher recall than in the other five surveys, likely because of the larger, more mature weed size.

The model performance indicated by recall was compared against human performance (Figure 3). The model was able to detect more weed targets than human eyes if the threshold value was set at 0.3. The lowest human recall was for detecting sedge at 0.54, indicating approximately half of the sedge targets were not visually identifiable by human eyes.

Figure 2. Validation results on survey 1 (left) and surveys 2 to 6 (right) of multiple class neural networks trained on images collected during the growing season using architecture resnet-34 for detection of weed types in sod production fields. The presence of mature weeds (bigger in size) and establishing the status of turf (more soil exposure) in survey 1 allowed better model performance on the validation images than in other surveys.



Performance of rover-imagery-based CNNs

Two main CNNs were trained based on the images collected by rover camera and labeled afterward by human eyes. In the case of dormancy (Figure 4, left), the CNN detected winter weeds such as *Poa annua* at a precision of 0.96 and ryegrass at a precision of 0.91. About 4% of *Poa annua* targets and 14% of ryegrass targets were missed. During the transition and growing season (Figure 4, right), the CNN detected broadleaf, grassy weeds, and sedge at a precision of 0.97, 0.91, and 0.92, respectively. About 5% of broadleaf targets, 10% of grassy weeds targets, 12% of sedge targets were missed. The performance of both CNNs was satisfactory, and more testing and improvement of the CNNs will be conducted in the future.

Figure 3. The comparison of recall (threshold values = 0.3) in validation results of drone-based CNN and recall from human performance (averaged from three evaluators).

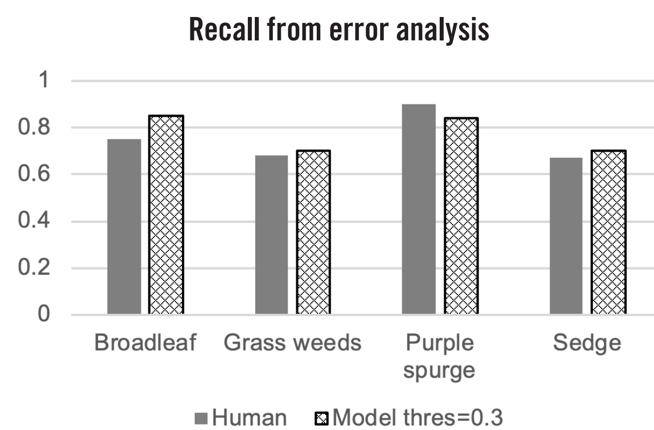
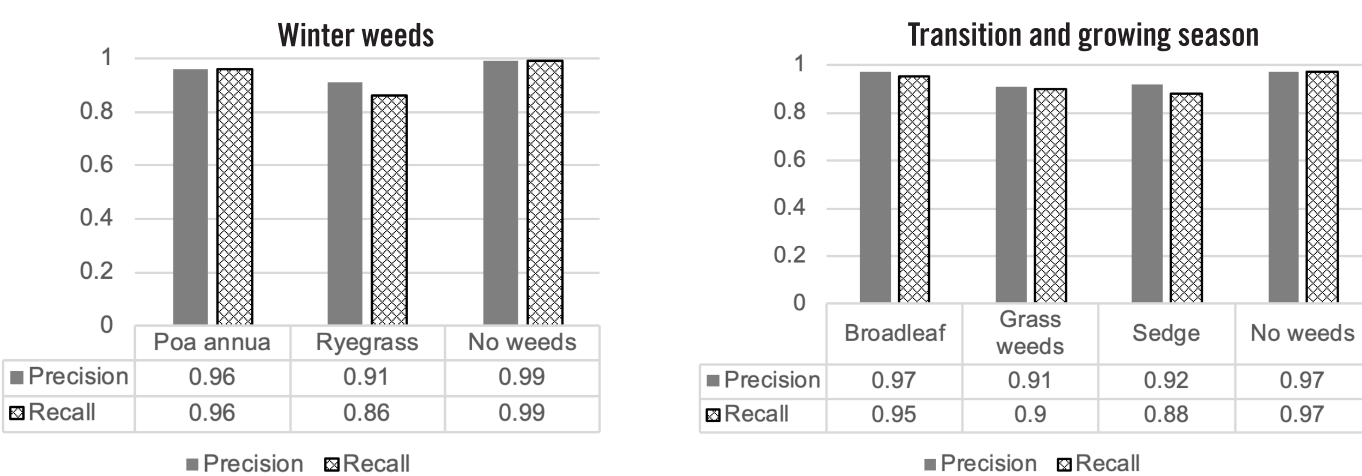


Figure 4. Validation results of multiple class neural networks trained on images collected during turf dormancy (left) and transition and growing season (right) using architecture resnet-34 to detect weed types in turfgrass.



	Poa annua	Ryegrass	No weeds
Precision	0.96	0.91	0.99
Recall	0.96	0.86	0.99

	Broadleaf	Grassy weeds	Sedge	No weeds
Precision	0.97	0.91	0.92	0.97
Recall	0.95	0.9	0.88	0.97

Computer Vision-Based Weed Mapping, *continued*

CONCLUSIONS

Three CNNs were trained using images collected from different platforms (drone and ground levels), all of which can be useful in different use cases. A drone-level CNN can quickly scout a sod field with mature weeds, and weed pressure can be estimated to help growers make treatment decisions. Ground-level scouting takes longer but provides more details on the weed types, and subsampling a field may be a compromise between time and the resolution of the output. In the future, more ground-level images will be collected using different cameras, and more testing will be conducted to improve the performance of the model.

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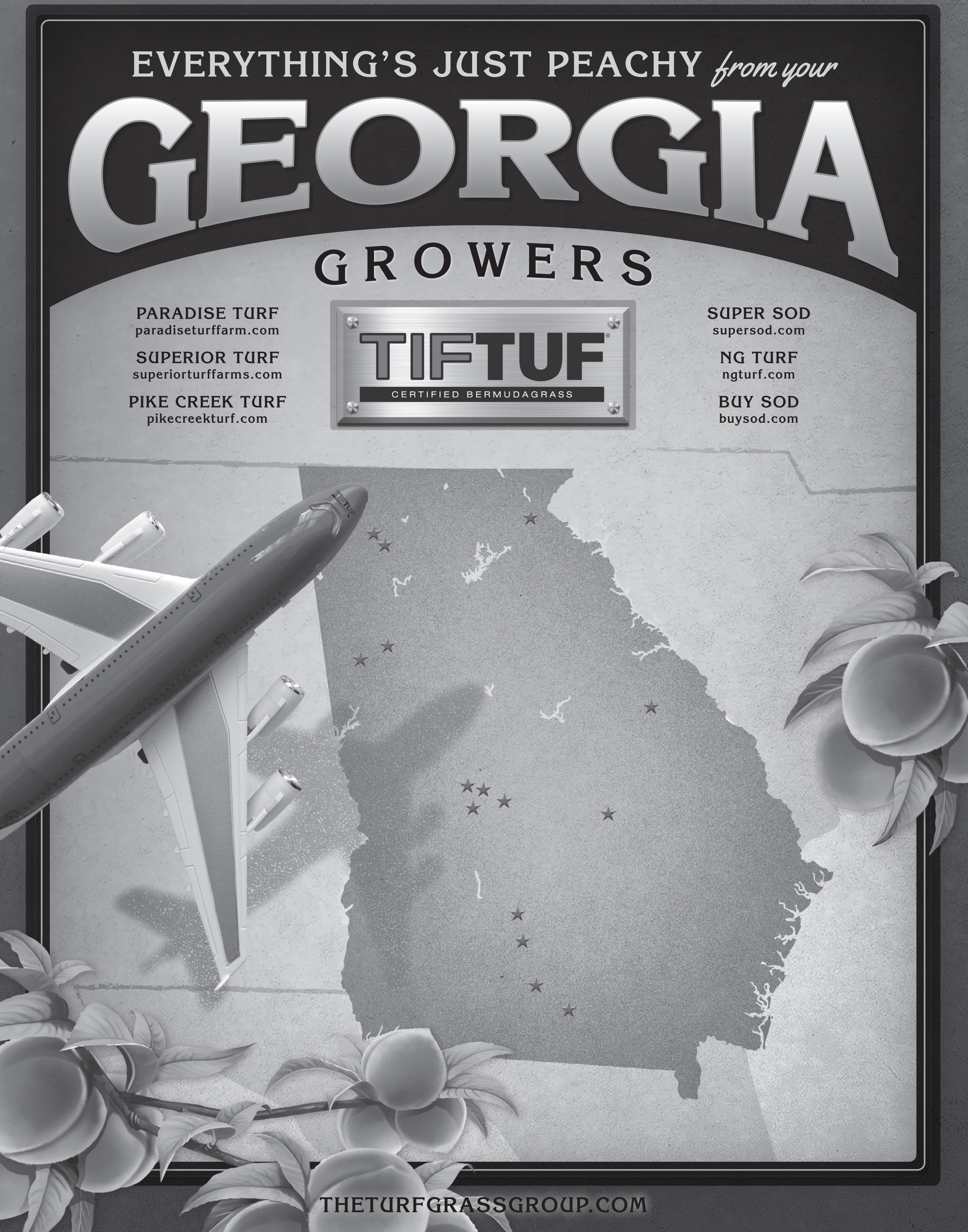
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Sustainably Managing Dollar Spot with UV-C Light Technology

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ABSTRACT

The University of Georgia Turfgrass Team, in collaboration with private companies and with support from federal and state funding, is developing several approaches to sustainably manage turfgrass diseases. Greenhouse and field trials are now underway to test the use of UV-C light technology in controlling dollar spot. Preliminary results were promising and revealed a reduction in pathogen development as well as enhancement of turf quality after the application of UV-C light treatment. A remote sensing approach also was investigated to accurately phenotype the disease in the field.

INTRODUCTION

Dollar spot is one of the most economically significant diseases of turfgrass worldwide. More than $80 million is spent annually on turfgrass fungicides in the United States, and resistance to thiophanate-methyl and DMI fungicides has been reported in the dollar spot pathogen. Because of the economic costs, environmental issues associated with fungicide applications, and the emergence of resistant strains, the UGA Turfgrass Team is investigating alternative approaches to manage the disease.

Physical treatment alternatives have received increasing attention in recent years and currently are under investigation. Ultraviolet light (UV-C) in particular, was shown to reduce powdery mildew infestation on apple and strawberry leaves (Van Hemelrijck et al., 2010), and impact postharvest decay without damaging the crop or production. However, the efficiency of UV-C light treatment in managing turfgrass diseases still is unknown.

A state research grant through the USDA Specialty Crop Block Grant Program has provided an opportunity for the UGA Turfgrass Team to investigate the efficiency of UV-C light in controlling dollar spot development, with in vitro, greenhouse, and field trials.

MATERIALS AND METHODS

In these in vitro, greenhouse, and field trials to assess the efficiency of UV-C light in controlling dollar spot, a range of 1 to 30 min of daily UV-C treatment was assessed in vitro and in planta to evaluate its effect on the pathogen and the plant. The field trial was performed from May to September at the UGA Griffin campus with a daily UV-C treatment at night using a robot.

Natural infections were used for the field trials, while a *Clarireedia monteithiana* isolate sampled from the UGA Griffin campus on seashore paspalum was used for in vitro and greenhouse trials. Three to five replicates were used within each treatment and, when possible, the experiments were conducted more than two times. Data collected during the growing season included repetitive measurements of the mycelial growth in vitro, severity of the diseases, turf quality, and normalized difference vegetation index (NDVI) values derived from handheld and drone images.

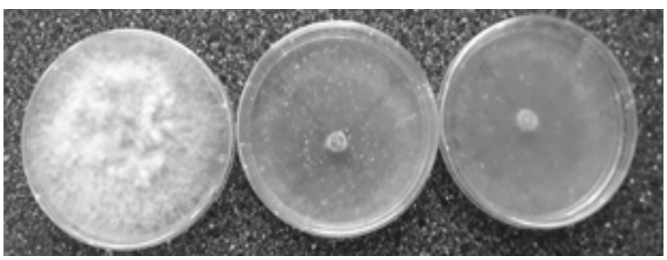
The team used a drone equipped with a remote sensor to collect multispectral images that support the calculation of indices indicative of plant health and vigor. These images highlight the contrast between photosynthetic and nonphotosynthetic plant material. Flights for image collection were planned for systematic sampling of the area and images were processed to create seamless mosaics. Centimeter-level positional accuracy guarantees repeated sampling of the same area over time and the same spatial overlay of results. Positioning is supported by multiple control points with known coordinates placed in the field. These drone-related methods, including flights for data acquisition using multispectral images, will be demonstrated and discussed during this afternoon session.

RESULTS

The in vitro trials showed that the UV-C light treatment did not kill the pathogen even after 1 month of daily application. However, significant decreases in dollar spot mycelial growth by 10.3% and 12.2% were observed with 1 and 5 min, respectively, of daily treatment compared to the untreated control at optimal pathogen growth conditions (Figure 1). Dark and low-temperature conditions did not increase the sensitivity of the *Clarireedia* to the UV-C light treatment in vitro. In the 2021 field season, the daily UV-C light treatment reduced the number of dollar spot infection centers by 67% and the overall dollar spot incidence by 63% when compared to nontreated controls. The disease suppression persisted for more than 7 weeks after the UV-C light treatment had ended. In addition, results in planta showed that lower UV-C doses (1 min and 6 sec) improved turfgrass performance (resulting in greater density, reduced clipping yields, and increased chlorophyll content) compared to control plants. This enhancement of the turf quality because of the UV-C light treatment also was confirmed in the field.

CONCLUSIONS

Figure 1. Effect of UV-C light treatment (none, 5, and 10 min) on dollar spot mycelial growth in vitro.



The collaborative efforts on testing the UV-C light technology provided us with promising results. Continued efforts with this UV-C project will help to confirm the efficiency of UV-C light in controlling dollar spot across several field seasons.

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Past, Present, and Future of Golf Course Putting Greens Grasses from Tifton

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UGA-Tifton

Amanda Webb, Technician and Graduate Student, Crop and Soil Sciences
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FIRST A LITTLE HISTORY

Golf courses in the southern United States changed forever when it became possible to plant bermudagrass on the greens. The grass species used for golf greens during the early 1900s were ill-suited for the southern U.S. climate. When these cool-season species were planted, golf course superintendents spent a large amount of time and effort to keep them from dying from disease and drought during the hot, humid summers. Greenkeepers for southern courses needed better options than either to struggle with these species or revert back to using sand greens. Several golf courses began planting seeded bermudagrass greens, but this came with its own set of problems. Most of the seed came from common-type bermuda and struggled to survive under rigorous mowing. These greens were highly inconsistent in appearance, texture, and play. They also tended to thin under low mowing, and became very weedy over time. However, greenkeepers began to find patches of small, dense turf that were thriving under intense mowing on the greens. They often selected and increased these grasses for other greens on their golf courses.

In 1946, the USGA Green Section approached USDA's Glen Burton to improve bermudagrass greens. With funding provided by the USGA and generous aid of golf course superintendents who donated plugs of these turf-type bermudagrasses, Burton eventually developed and released 'Tifgreen 328'. Tifgreen is an interspecific hybrid between a common bermudagrass selection from North Carolina and an African *Cynodon transvaalensis*. Tifgreen became an immensely popular greens grass in the south because of its ability to withstand so many of the issues facing greenkeepers. Tifgreen was uniform, low-growing, and survived under the intense management found on golf greens during the harsh summers, providing a dense mat that also suppressed weeds.

Tifgreen did come with its own set of unique problems. Soon after its release in 1956, a few dwarf off-types were found at two of the original testing locations, one on the greens of Sea Island Country Club and another at the Country Club in Florence, SC. Samples of these off-types were returned to Burton, who determined that they were somaclonal variations of Tifgreen. Somaclonal variants are distinctively separate plants produced by genetic anomalies that occur during normal cell division. Tifgreen's inherent tendency to produce these somaclonal variations has provided the turf industry with new grasses with beneficial traits that traditional plant breeding has not been able to accomplish. Today, all of the most popular bermudagrass greens cultivars used on golf courses originated from Tifgreen: 'Tifdwarf', 'Champion', 'MiniVerde', and 'TifEagle', among them.

The downfall of this unique ability to produce somaclonal variations is the trait itself. It has been difficult for the turf industry to maintain the genetic purity of these varieties. For this reason alone, the importance of turfgrass certification cannot be overstated. Certified turfgrass is routinely inspected for off-types, including those that are produced by the process of somaclonal variation. The turfgrass certification process identifies problems and helps to ensure variety purity for end users.

WHERE WE FOUND IT

The University of Georgia's Tifton turfgrass breeding program scouted the 50-year-old Tifgreen putting greens at Taylors Creek Golf Course in Fort Stewart, GA, during 2012 before the greens were replaced with 'TifEagle'. Samples of visually differing and thriving variations were collected by Brian Schwartz, a UGA plant breeder, Earl Elsner, retired director of Georgia Seed Development, Patrick O'Brien, now-retired USGA Green Section Southeast Regional director, and Jared Nemitz, CGCS, director of golf course and grounds at the Ford Field and River Club. One of the 169 selections, found on the 13th green, was brought back to Tifton for further observation because it was dense, dark green, and growing well under heavy shade. Later named 12-TG-101, this selection continues to perform better in Tifton-based trials than the others.

Off-site trials of 12-TG-101, along with the cultivar 'TifEagle', were planted at 15 different locations between 2015 and 2019. These experiments were conducted on practice greens and test areas on courses from Virginia to southern Florida. Each off-site planting location was managed and maintained under the established practices of that golf course, including mowing height and schedule, fertilizer and growth regulator programs, fungicide applications, and thatch-management practices. Seasonal observations were taken at each trial and included Stimpmeter measurements in addition to visual color and uniformity ratings.

WHY WE LIKE IT

One of the first observations made of 12-TG-101 is that it is closer in appearance to 'TifEagle' than Tifgreen. Its leaf structure and node lengths are similar to that of an ultradwarf. The color of 12-TG-101 resembles that of 'Tifdwarf', which is darker green than 'TifEagle', making it aesthetically pleasing. In research conducted since 2015, Stimpmeter comparisons between 'TifEagle' and 12-TG-101 have shown little to no difference. Under the intense management applied by golf courses, 12-TG-101 performed as well or better than 'TifEagle', typically appearing more uniform in look and texture.

Like many other ultradwarf bermudagrasses, 12-TG-101 needs mechanical thatch removal because of the nature of its growth habit. Verticutting, hollow- and solid-tine aeration, and sand topdressing are necessary care for ultradwarfs, sometimes leaving weeks of recovery time for the grasses. 12-TG-101 has demonstrated an outstanding rapid recovery time. It has the ability to grow back faster from mechanical injury and other stresses, like drought and disease injury, than other ultradwarf putting greens grasses.

WHAT DO WE WANT TO KNOW IN THE FUTURE?

Studies on establishment and fertilizer usage are being conducted by the UGA Tifton turf breeding program on 12-TG-101 to help superintendents better understand this grass. Trials are underway on sprig rates, cutting-in methods after sprigging, and water usage following sprigging. Results will help define the best grow-in practices for 12-TG-101. These sprigging trials will be followed with studies on fertilization, growth regulator needs, and topdressing and verticutting intervals. The information compiled over the next few years will allow us to summarize a general management plan for this new variety. Shade and drought trials are other possible research areas. It stands to reason that 12-TG-101 may have some shade tolerance because of the environment of the 13th green at Taylors Creek. Further research should also be conducted to confirm what we have observed to date in our golf course trials.

WHEN WILL IT BE AVAILABLE?

12-TG-101 was officially released from the University of Georgia in 2021. In July 2021, Georgia Seed Development oversaw the establishment of a 1-acre foundation field at Pike Creek Turf in Adel, GA. The goal is to begin the establishment of sod-producer fields during 2022, with a limited supply being available for sale to consumers in late 2023 or early 2024.

For more information, please contact Brian Schwartz at tifturf@uga.edu.

Release Timeline of Tifgreen 328 Derived Cultivars

1956 Tifgreen is a triploid hybrid cross developed and released by the USDA-ARS and the University of Georgia.

1964 Tifdwarf a dark green off-type found in Tifgreen was released by the USDA-ARS and the University of Georgia.

1968 Pee Dee 102 was released from the South Carolina AES as a selection chosen from an early planting of Tifgreen.

1987 Champion Dwarf was an ultradwarf selection isolated from Tifdwarf greens in Walker County, Texas.

1992 MiniVerde was a selection made from Tifdwarf in greenhouses owned by H&H Seed Company in Yuma, AZ.

1995 Floradwarf was released by the Florida AES as a selection out of Tifgreen made from a golf course in Hawaii.

1997 TifEagle was originally reported to be from an irradiated sprig of Tifway II. Genetic testing has since found it related to Tifgreen.

1997 MS-Supreme is a selection made from Tifgreen by Mississippi State University from a putting green at Gulf Shores Golf Club.

2019 Mach 1 is a selection made by Rodney Lingle from Tifdwarf greens in Memphis, TN.

2021 12-TG-101 is a selection out of Tifgreen from the shady 13th green at Taylors Creek Golf Course in Fort Stewart, GA.

Problem Weed Control and New Turfgrass Herbicides

Patrick McCullough, Professor, Crop and Soil Sciences
UGA-Griffin

ABSTRACT

This afternoon session will briefly review demonstration plots and include a group discussion of weed control issues in Georgia. We will discuss strategies for problem weed control, new herbicides, and resistance management. Demonstration plots will include various new herbicides such as Celsius Xtra, Recognition, and Sulfencor. We will discuss these and other new herbicides in development with improved selectivity in turfgrasses for problem weed control and resistance management. Other topics include updates on the status of oxadiazon and the alternatives available for controlling goosegrass and other problem weeds.

We will have a group discussion about current challenges with weeds in management programs, including a review of the establishment and growth of problem weeds, such as doveweed and kyllinga, and the importance of planning control programs around the initial emergence of these species in turfgrass. Participants also may ask questions about any other topics, including annual bluegrass control, herbicide rotation programs, and best management practices for problem weeds.

Water Efficiency Improvements in Warm-Season Turfgrasses

Clint Waltz, Professor, Crop and Soil Sciences
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ABSTRACT

In collaboration with the United States Golf Association and Turfgrass Producers International, the National Turfgrass Evaluation Program funded a study to evaluate the water use efficiency of warm-season grasses. In 2018, 17 warm-season grasses (Table 1) were planted at 10 locations across the country. UGA Griffin was one of these sites. Grasses were established in 2018 and given 2019 to perennialize before imposing moisture stress on the plots. Data collection was to begin in 2020, but because of the COVID-19 pandemic and UGA policies during 2020, there was insufficient staffing to conduct the experiment according to the research protocol. In 2021, the rain exclusion structure was erected and the first year of the study was initiated on June 4, 2021. During a 120-day dry-down, individual plots only were irrigated if their visual quality fell below commercially acceptable standards. Using a light box, digital images also were collected to support the visual assessments. Visual evaluations and subsequent irrigation occurred twice weekly throughout the trial. When irrigated, centers of plots were watered using a box (Figure 1) to contain 0.5 in. of water. A single irrigation event did not exceed 0.5 in. At the end of 120 days, the total amount of water for each plot was summed and averaged for each cultivar. At the end of year 1, all plots were irrigated and permitted to recover through the fall and through the spring of 2022. On May 15, 2022, the study was repeated for a second year and is ongoing. Visit www.NTEP.org to see the data from UGA Griffin and other locations.

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Table 1. Cultivars tested for warm-season water use in the 2018 National Turfgrass Evaluation Program trial.

Entry/Cultivar	Species	Establishment Method*
Tiway	Bermudagrass	Vegetative
Dog Tuff	Bermudagrass	Vegetative
ASC 118	Bermudagrass	Seed
ASC 119	Bermudagrass	Seed
OKC 1221	Bermudagrass	Vegetative
Premier Pro	Bermudagrass	Vegetative
Tahoma 31	Bermudagrass	Vegetative
TifTuf	Bermudagrass	Vegetative
JSC 2009-6-s	Bermudagrass	Seed
Monaco	Bermudagrass	Seed
Meyer	Zoysiagrass	Vegetative
Stellar	Zoysiagrass	Vegetative
FAES 1306	Zoysiagrass	Vegetative
FAES 1307	Zoysiagrass	Vegetative
FB 1628	Bermudagrass	Vegetative
Prestige	Buffalograss	Vegetative
Cody	Buffalograss	Seed

* Vegetative plots were plugged on 12-in. centers. The seeding rate was 1.0 lb seed per 1,000 sq ft for bermudagrass and buffalograss.

Figure 1. Water box used to contain 0.5 in. of water within the center of a plot.

Turfgrass Response to Shaded Conditions

Paul Raymer, Professor, Crop and Soil Sciences
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David Jespersen, Associate Professor, Crop and Soil Sciences
UGA-Griffin

ABSTRACT

Shade and reduced light levels are common environmental conditions that turfgrasses must cope with in landscapes. It is estimated that up to 25% of turf areas experience some form of shade stress (Fry & Huang, 2004). Light is the driver of the photosynthetic process and is essential for plant growth and development. Under shaded conditions turfgrasses exhibit a number of notable changes. This includes changes in leaf morphology (e.g., leaf and cuticle layer thickness, changes in chlorophyll content) and growth (e.g., reduced lateral growth, and enhanced vertical elongation; Dudeck & Peacock, 1992). Changes in light quantity (i.e., the amount of light reaching the canopy) and quality (i.e., the balance of specific wavelengths) can create a situation where the plant is not generating enough sugars through photosynthesis and has a negative carbon balance. The ultimate long-term consequence of shaded conditions is poor turfgrass coverage and thinning canopies. However, among turfgrass species there is a range of shade tolerances. Among warm-season turfgrass species, generally St. Augustinegrass and zoysiagrass are considered more tolerant, and bermudagrass the least tolerant, with bermudagrass requiring almost twice as much light to maintain an acceptable canopy (Zhang et al., 2017). In addition to differences among species, there are shade-response differences among cultivars within a given turfgrass species. This stop will discuss turfgrass responses to reduced light levels and ongoing research at the University of Georgia to improve turfgrass performance under shaded conditions. This will include an overview of considerations for growing turfgrasses under shade, how levels of shade and associated turfgrass responses are quantified, and a discussion on the evaluation of germplasm to identify future cultivars with enhanced performance.

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Diagnosing Turfgrass Disease

Rapid Dollar Spot Detection and Fungicide Resistance

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UGA-Griffin

Effective and efficient disease control always begins with an accurate diagnosis of the problem. At this stop, we will review practical and critical steps for an accurate turf disease diagnosis. Microscopy and visual observation will be part of the session. Advanced but practical molecular techniques for disease detection will be discussed, as well as environmental and cultural factors that promote each disease. We also will cover turfgrass pathogen biology and different methods of disease control.

Clarireedia spp. (formerly *Sclerotinia homoeocarpa*) disease: Dollar spot

DIAGNOSTIC TIPS

In the field:

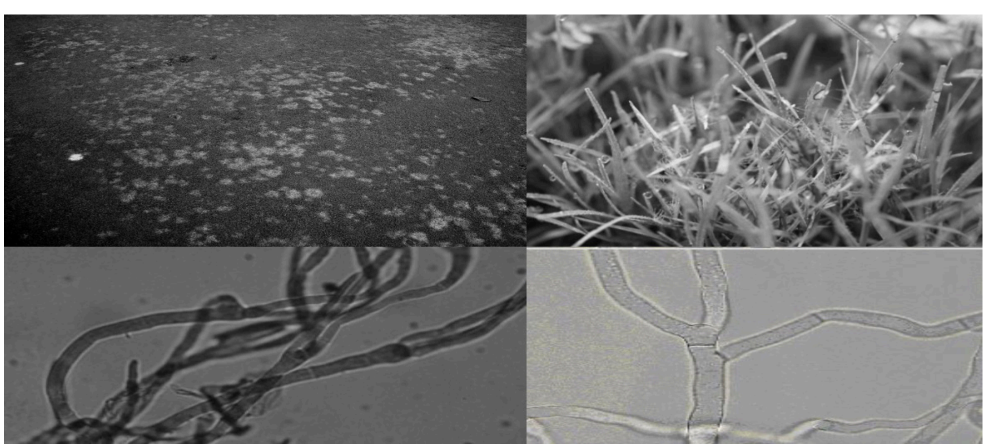
Symptoms of dollar spot include sunken, circular patches that measure up to several inches on turfgrass. The patches turn from brown to straw color and may eventually coalesce, forming irregularly shaped areas. Infected leaves may display small lesions that turn from yellow-green to straw color with a reddish-brown border. The lesions can extend the full width of the leaf. Multiple lesions may occur on a single leaf blade. Mycelia may be present. Affected grasses exhibit white to straw-colored lesions that progress downward from the leaf tip or laterally across leaf blades. A brown border usually surrounds each lesion. Older lesions on higher mowed grass frequently appear hourglass-shaped, being narrower in the middle than at the top or bottom. Individual leaf blades may contain many small lesions or one large lesion or the entire leaf blade can become blighted. Infected leaves turn white to straw-colored as lesions expand and coalesce. Blighted leaves are formed in aggregates that appear as circular, sunken patches, measuring from < 1 to > 10 cm (< 0.5 to > 4 in.) in diameter. On golf putting greens and other closely mown areas, the patches appear as white to straw-colored spots. Grayish-white, cottony mycelium often forms on infected grass blades in the early morning hours when dew is present.

Under a microscope, look for:

- Septated hyphae
- Hyphae may vary in diameter and usually are larger in diameter than Rhizoctonia
- Hyaline, white, crystalline mycelium
- Cytoplasm in hyphal cells might be grainy, coarse

Procedure:

- Incubate in a moist chamber overnight to promote mycelium production
- Start with dissecting scope and scan crowns of turf
- Using scalpel and tweezers remove infected tissue containing mycelium
- Place on glass slide containing a drop of stain
- Examine at low magnification on compound microscope (4×, 10× objective)



RAPID MOLECULAR DETECTION AND FUNGICIDE RESISTANCE TESTS FOR DOLLAR SPOT

Rapid, accurate, and efficient detection of turfgrass pathogens is vital to implement effective management strategies as soon as possible. As the amount of time needed to make a diagnosis increases, time available to develop and implement an effective management protocol decreases. Different pathogens call for varying management techniques, and in the turfgrass industry time is limited. Detection of *Clarireedia* spp. has relied on identification based on signs, symptomology, and morphology. Loop-mediated isothermal amplification (LAMP) PCR is an assay recognized for its high specificity and rapid detection time. Amplification occurs at a constant temperature and takes 15 min to 1 hr to complete. LAMP also could be conducted in the field, allowing for real-time diagnosis and point-of-care testing. We have developed a LAMP PCR detection method for pathogens that cause dollar spot, *C. monteithiana* and *C. jacksonii*. This assay will be described at this stop. Additionally, fungicide resistance in dollar spot (to DMI and benzimidazole) has been detected and documented within the state of Georgia, but its scale and spread is unknown. Therefore, 57 isolates of *Clarireedia* spp. collected from golf courses, landscapes or research sites from 2019 to 2021 in different counties in Georgia were tested in vitro for their sensitivity to thiophanate-methyl and propiconazole fungicides. Fifty-four isolates (95%) were sensitive, and three isolates (5%) were found resistant to thiophanate-methyl. In the case of propiconazole, 16 isolates (28%) were sensitive while 41 isolates (72%) were found to be resistant. This is the first time a comprehensive documentation of fungicide resistance in Georgia has been carried out. This information is crucial to develop fungicide management strategies.

ACKNOWLEDGMENTS

This work was supported by Georgia Agriculture Specialty Crop Block Grant AWD00011205.

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Graduate Student Research

Turfgrass Team Master's and Doctoral Students, Crop and Soil Sciences, Plant Pathology, and Entomology
UGA-Griffin

Graduate students are a key component of the UGA Turfgrass Team, and they participate in some of the most cutting-edge research at the university. Student research that will be highlighted during this session ranges from answering applied questions — such as how to improve turfgrass performance — to fundamental research that seeks to understand the molecular underpinning of basic biology. These students, pursuing master's and doctoral degrees in various departments, will go on to careers ranging from industry to academia. The skills they learn at UGA will serve them beyond their time at UGA as they become future leaders in our communities. Students will give a brief presentation about their work (10 min) and answer any audience questions.

SCHEDULED PRESENTATIONS INCLUDE:

Rehan Arshad *– master's student, Entomology.* Source of *Systena frontalis* adults attacking the panicle hydrangea in the ornamental nursery.

John Bagwell *– master's student, Plant Pathology.* Identification of disease resistance genes in soft red winter wheat.

Brody Deaton *– master's student, Plant Breeding Genetics and Genomics.* Obtaining pre-emerge herbicide resistance in tall fescue.

Qianqian Fan *– doctoral student, Crop and Soil Sciences.* Heat tolerance in creeping bentgrass.

Bikash Ghimire *– postdoctoral associate, Plant Pathology.* Evaluating fungicides and biofungicides for controlling large patch and dollar spot in turfgrasses.

Mahesh Ghimire *– master's student, Entomology.* Effects of turfgrass cover on occurrence and abundance of beneficial arthropods in sod farms.

Daniel Ibiyemi *– doctoral student, Entomology.* Bees collect pollen from centipedegrass inflorescence.

Ravneet Kaur *– master's student, Crop and Soil Sciences.* Drought performance of zoysiagrass cultivars.

Mathew Molini *– master's student, Crop and Soil Sciences.* Oxygenated nanobubble technology and its application in a turfgrass system.

Saptarshi Mondal *– doctoral student, Crop and Soil Sciences*. Genetics of salt tolerance in zoysiagrasses.

Willis Turner Spratling *– doctoral student, Plant Pathology.* Effectiveness of gaseous nanobubble water in controlling dollar spot in seashore paspalum.

Turfgrass IPM Impact Evaluation – survey

Zia Williamson *– master's student, Entomology.* Exploring risk factors for insect borer attack in Georgia's urban landscapes.

Morgan Willis *– master's student, Plant Pathology.* Temperature and pathogen plant host preference of *Clarieedia* species.

Robert Wolverton *– doctoral student, Entomology.* Efficacy and timing of insecticide on rhodesgrass mealybug (Hemiptera: Pseudococcidae).

Extension in Urban Ag

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Rolando Orellana, Urban Water Management Agent, UGA Extension

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UGA Extension and Center for Urban Agriculture

Richie Braman, Systems Administrator and Developer,
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Beth Horne, Event Coordinator, Center for Urban Agriculture
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Kimberly Allen, Administrative Associate
UGA-Griffin

Agriculture touches everything around us including food, fiber, the environment, recreation areas, workplaces, and home life, whether you live in rural, suburban, or urban areas. Agriculture in urban settings presents unique challenges and opportunities in research, public service, and outreach. The mission of the Center for Urban Agriculture is to combine the resources and expertise of Georgia producers and agribusinesses, public and commercial consumer groups, and the University of Georgia to define and address the challenges inherent in urban agriculture. We work to increase the economic growth of urban agribusiness, promote environmental stewardship, and enhance the development and delivery of science-based urban agricultural information.

GETTING THE BEST OF PESTS

The University of Georgia's Center for Urban Agriculture (UGA Griffin campus), in cooperation with the Urban Ag Council and the Turfgrass Research and Education Center at UGA-Griffin, has developed an online program that allows green industry professionals to receive world-class training from the convenience of their home or office.

Getting the Best of Pests (GTBOP) is a live webinar series offering online CEU category credits that save companies time, travel, and expenses.

Green webinars are offered on the third Thursday of every odd-numbered month (January, March, May, July, September, and November). Live webinars air online from 3–5 p.m. utilizing Zoom.

Registered participants stay informed on timely topics while earning approved pesticide recertification credits. Archived recordings also are available for recertification credits when viewed at a participating local county Cooperative Extension office. A list of archives is available at https://archive.gtbop.com.

For more information or to receive announcements about upcoming sessions, contact Beth Horne at 770-228-7214 or bhorne@uga.edu.

IRRIGATION & WATER MANAGEMENT

Best practices for irrigation and water management are vital to the state's economy, natural resource stewardship, and the quality of life for all citizens. A new irrigation demonstration and training site on the UGA Griffin campus will showcase the latest irrigation products and technologies while serving as a training ground for best practices in irrigation and water management.

The project is a collaboration with Hunter Industries, Rain Bird, Toro/Irritrol, Moreno Landscape LLC, North Georgia Turf, Rainmaker Irrigation Inc., Unique Environmental, SiteOne Landscape Supply, Ed Castro Landscape, Georgia Urban Ag Council, Georgia Green Industry Association, Georgia Arborist Association, and the Georgia Certified Landscape and Plant Professional programs.

The demonstration site will consist of four plots which are 30 by 30 ft each. Three of the plots will be designated for irrigation manufacturing companies to showcase the latest equipment and technologies, and the fourth plot will be used for research by faculty and graduate students on the UGA Griffin campus.

INDUSTRY CERTIFICATION

The Center for Urban Agriculture's flagship certification programs are Georgia Certified Landscape Professional and Georgia Certified Plant Professional. These programs offer industry practitioners the opportunity to demonstrate their knowledge and proficiency, and that they exemplify the highest standards of excellence in their profession. The programs provide a comprehensive resource of the latest information from UGA Cooperative Extension and promote best practices in urban agriculture. These programs build a better Georgia by strengthening business resiliency and promoting best practices in environmental stewardship.

The Georgia Certified Landscape and Plant Professional programs were developed as a collaborative work of the University of Georgia, industry practitioners, and professional associations. The programs are guided by an industry-based task force and administered through the Center for Urban Agriculture and UGA Extension.

SCHOOL AND COMMUNITY GARDENS

Schools across the state of Georgia are returning to normal after 2 years of the pandemic, and their school gardens are exploding. More and more schools are adding gardens to their campuses and using them in multiple disciplines such as math, history, literature, horticulture, and nutrition. Extension is a leader in this area, providing educators with horticulture expertise, and assistance with garden management and tying the garden to the curriculum. Additionally, schools are using their gardens as a pathway to science, technology, engineering, and math (STEM) certification. The Great Georgia Pollinator Census is an example of a no-cost STEM program with resources offered to all educators. We are excited that the Golden Radish awards will return this fall.

In some cases, community gardens thrived during the pandemic as a way for people to get outside and garden safely distanced from others. However, this took the “community” out of community gardens. Most community gardens now are in full production with community workdays, gardeners sharing information, and even group garden classes. Extension is proud to be part of Georgia’s community garden network. We provide resources on plant selection, soil testing capabilities, information on seed saving, and horticultural support.

KEY POINTS: Georgia's Turfgrass Industry and UGA's Turfgrass Program

INDUSTRY

- Estimates suggest that at 1.8 million acres, turfgrass is one of the largest agricultural commodities in the state.
- This includes home lawns, sports fields, golf courses, sod farms, and other managed landscapes areas.
- Georgia turfgrass and related industries contribute a total of $14.8 billion annually to the economy.
- The federal, state, and local tax impact is more than $1.4 billion dollars annually.
- This industry accounts for 111,000 full- and part-time jobs.
- The majority of these jobs involve landscape maintenance of buildings and households.
- Annually, Georgia's golf-related activities generate approximately $5 billion of direct and indirect economic impact and account for more than 45,000 jobs.
- The landscape and golf industries have a history of investing in professional development and using research-based information.
- Through drought periods, the golf and landscape segments have demonstrated exceptional environmental stewardship with their best-management-practices approach to water use efficiency and conservation.
- These industries strive to be a part of the solution to Georgia's environmental issues.

UGA TURFGRASS PROGRAM

- UGA is the research, development, and education arm of Georgia's turfgrass industry.
- For more than 65 years, UGA has provided scientifically based information to the turfgrass industry.
- UGA's renowned scientists and specialists develop practices, pest-management strategies, and grasses that are best adapted to Georgia.
- Turfgrass breeding for warm-season species dates back to the 1950s and continues today with productive programs focused on sustainable bermudagrass, centipedegrass, seashore paspalum (pronounced pass-pal-um), and zoysiagrass cultivars.
- UGA's scientists continue to stretch scientific boundaries with novel approaches and strategies to solve the most challenging management and environmental issues that face this industry.
- UGA scientists continue to be involved with water conservation and have demonstrated effective methods of achieving sustainability of natural resources (i.e., water) while maintaining industry viability.
- UGA emphasizes Extension programming and professional development for Georgia's turfgrass practitioners. A well-educated workforce is critical to the economic success of the turfgrass industry.
- The continued support of strong academic programs along with industry partnerships provide opportunities to increase economic development, further scientific exploration, and enhance the environment.

2019 Georgia Agricultural Commodity Rankings

Rank	Commodity	Farm Gate	% of GA Total
1	Broilers	$4,032,731,000	31.02%
2	Cotton	$983,630,257	7.57%
3	Timber	$679,546,899	5.23%
4	Beef	$666,136,366	5.12%
5	Peanuts	$663,042,432	5.10%
6	Greenhouse	$476,533,296	3.67%
7	Corn	$321,373,871	2.47%
8	Hay	$306,246,800	2.36%
9	Dairy	$305,971,569	2.35%
10	Pecans	$263,359,174	2.03%
11	Horses	$246,202,650	1.89%
12	Eggs	$230,723,940	1.77%
13	Blueberries	$220,444,595	1.70%
14	Misc. Vegetables	$206,195,361	1.59%
15	Field Nursery	$182,489,887	1.40%
16	Watermelon	$180,278,529	1.39%
17	Container Nursery	$177,969,627	1.37%
18	Sweet Corn	$145,026,886	1.12%
19	Onions	$133,179,945	1.02%
20	Bell Peppers	$127,851,345	0.98%
21	Turfgrass	$125,936,720	0.97%
22	Ag-based Tourism	$125,675,476	0.97%
23	Pine Straw	$100,165,580	0.77%
24	Pork	$98,899,630	0.76%
25	Hunting Lease - Deer	$88,468,286	0.68%
26	Silage	$81,463,741	0.63%
27	Cucumbers	$75,519,198	0.58%
28	Straw	$71,991,458	0.55%
29	Peaches	$71,776,414	0.55%
30	Greens (collards, Chard, kale, lettuce, mustard, spinach, turnip greens)	$67,462,333	0.52%
31	Breeder Pullet Unit	$52,493,085	0.40%
32	Cabbage	$51,946,265	0.40%
33	Honeybees	$43,732,546	0.34%
34	Tomato	$37,624,476	0.29%
35	Squash (Yellow and Winter)	$37,603,158	0.29%
36	Soybeans	$37,501,377	0.29%
37	Tobacco	$36,486,446	0.28%
38	Wheat	$29,912,201	0.23%
39	Eggplant	$28,324,105	0.22%
40	Catfish	$26,663,480	0.21%
41	Zucchini	$26,014,038	0.20%
42	Snap Beans	$25,790,094	0.20%
43	Grapes	$24,698,747	0.19%
44	Quail	$22,420,954	0.17%
45	Other Peppers (banana and hot)	$17,134,592	0.13%
46	Sorghum	$16,144,661	0.12%
47	Goats	$16,078,279	0.12%
48	Hunting Leases - Turkey	$13,135,760	0.10%
49	Cantaloupe	$12,915,395	0.10%
50	Apples	$11,225,675	0.09%
51	Strawberries	$10,570,169	0.08%
52	Rye	$7,140,723	0.05%
53	Oats	$6,766,487	0.05%
54	Blackberries	$6,629,830	0.05%
55	Christmas Trees	$5,589,310	0.04%
56	Southern Peas	$5,390,740	0.04%
57	Sheep	$4,610,715	0.04%
58	Hunting Leases - Duck	$1,900,555	0.01%
59	Okra	$953,145	0.01%
60	Barley	$52,386	0.00%
	Crop Insurance	$163,817,298	1.26%
	Government Payments	$572,798,956	4.41%
	All Other Miscellaneous	$191,576,574	1.47%
	2019 Total Farm Gate Value	**$13,001,935,486**	

Comparison of Turfgrass Farm Gate Value by Year

Commodity	2014	2015	2016	2017	2018	2019
Ag-based Tourism	156,092,226	109,660,245	115,032,225	115,458,449	125,119,491	125,675,476
Apples	12,597,616	13,113,114	14,329,175	9,961,740	8,089,100	11,225,675
Barley	804,608	211,184	162,072	336,280	206,742	52,386
Beef Cattle Finished Outside Co	62,328,600	59,881,450	45,638,700	51,104,865	51,213,470	57,502,556
Beef Cows	739,898,421	724,443,210	455,588,213	453,680,067	482,163,793	491,015,718
Beef Stockers	200,963,023	139,034,577	91,627,449	91,858,254	99,802,715	117,618,093
Blackberries	5,461,119	7,031,331	6,846,790	4,469,712	4,342,483	6,629,830
Blueberries	335,250,992	255,714,085	283,874,343	226,635,695	300,358,592	220,444,595
Breeder Pullet Unit	142,877,184	148,207,859	160,179,699	168,803,844	272,881,260	52,493,085
Broilers	4,543,256,669	4,428,452,093	4,370,498,425	4,422,695,768	4,460,396,286	4,032,731,000
Catfish	26,637,425	30,032,500	30,020,280	27,509,530	28,173,880	26,663,480
Christmas Trees	9,917,140	9,619,150	10,016,563	8,380,980	8,622,357	5,589,310
Corn	264,768,473	252,970,802	277,231,197	244,094,642	288,229,368	321,373,871
Cotton	964,678,523	713,144,293	967,690,060	901,546,722	792,718,852	983,630,257
Crop Insurance	137,795,578	97,752,470	138,924,940	172,245,029	290,082,679	163,817,298
Dairy	438,112,611	407,721,765	397,501,015	323,884,589	308,349,680	305,971,569
Eggs	822,870,998	937,050,097	772,609,464	850,689,401	948,205,221	230,723,940
Goats	21,241,483	20,111,780	19,472,309	19,369,663	18,460,353	16,078,279
Government Payments	304,726,327	463,893,851	613,098,990	467,802,224	471,803,832	572,798,956
Grapes	12,472,830	8,937,419	20,414,060	18,675,180	19,730,336	24,698,747
Greenhouse for OrnHort	265,397,311	428,051,228	452,850,333	443,966,174	487,692,208	476,533,296
Hay	152,922,872	218,837,630	198,745,440	241,030,654	232,130,985	306,246,800
Hogs, Farrow to Finish	36,747,461	22,038,650	27,988,970	26,397,119	23,139,890	21,441,019
Hogs, Feeder Pigs	197,529,000	99,336,735	68,214,735	65,705,955	45,173,040	66,229,950
Hogs, Finishing Only	34,764,526	19,850,893	22,239,524	23,951,247	13,396,178	11,228,661
Honeybees	28,561,487	51,370,149	37,413,405	39,916,707	41,161,438	43,732,546
Horses	333,328,738	280,366,400	255,770,300	261,129,300	247,745,600	246,202,650
Hunting Lease - Deer	77,167,524	82,870,744	82,582,497	80,655,781	87,928,735	88,468,286
Hunting Leases - Duck	1,612,395	1,631,425	1,358,425	1,610,750	1,661,605	1,900,555
Hunting Leases - Turkey	8,112,969	8,638,706	10,914,481	10,895,021	11,580,925	13,135,760
Miscellaneous (All Other)	218,060,061	131,403,370	132,133,215	137,505,745	184,187,423	191,576,574
Nursery - Container	146,818,855	151,384,024	164,052,969	160,817,885	144,726,279	177,969,627
Nursery - Field	77,986,787	90,363,200	102,648,114	115,420,347	125,696,305	182,489,887
Oats	11,026,891	9,941,454	6,594,259	6,323,155	9,183,231	6,766,487
Peaches	53,511,847	48,978,318	48,030,446	30,011,587	48,322,284	71,776,414
Peanuts	563,933,740	684,626,931	624,380,318	825,040,700	624,572,608	663,042,432
Pecans	313,313,250	361,301,753	355,854,324	401,146,059	218,477,486	263,359,174
Pine Straw	79,532,675	62,386,540	66,796,065	74,401,250	80,619,320	100,165,580
Quail	39,755,596	33,653,445	32,761,690	20,680,503	20,665,109	22,420,954
Rye	11,893,369	7,713,823	4,535,082	7,819,263	7,914,788	7,140,723
Sheep	4,573,688	4,270,203	3,512,801	3,955,734	4,316,968	4,610,715
Silage	67,883,244	61,508,780	103,190,931	109,095,047	60,624,172	81,463,741
Sorghum	8,435,847	11,848,657	7,039,659	10,295,545	16,308,707	16,144,661
Soybeans	125,066,896	128,485,343	112,201,927	77,088,542	66,855,752	37,501,377
Straw	23,454,825	19,862,250	11,939,323	18,339,779	19,493,833	71,991,458
Strawberries	15,823,867	7,798,784	9,749,656	9,438,120	9,893,856	10,570,169
Timber	601,805,142	681,237,748	681,114,224	669,471,994	632,205,059	679,546,899
Tobacco	79,348,361	56,183,988	51,190,155	52,287,901	44,221,582	36,486,446
Turfgrass	104,304,869	109,710,020	111,689,673	116,679,820	118,321,229	125,936,720
Vegetables - Bell Peppers	121,547,501	120,429,097	112,983,837	115,294,892	125,983,101	127,851,345
Vegetables - Cabbage	74,219,966	49,686,198	49,609,871	53,689,775	41,888,607	51,946,265
Vegetables - Cantaloupe	19,794,025	19,225,505	24,210,064	19,601,989	13,450,217	12,915,395
Vegetables - Cucumbers	60,916,220	66,854,930	69,510,597	78,313,805	83,651,291	75,519,198
Vegetables - Eggplant	30,233,977	25,145,285	25,912,664	29,453,435	23,541,796	28,324,105
Vegetables - Greens	54,295,497	43,770,455	44,944,340	48,510,903	36,505,804	67,462,333
Vegetables - Okra	2,996,996	2,730,651	1,970,551	1,401,596	1,018,008	953,145
Vegetables - Onions	138,255,865	148,976,285	156,881,260	140,672,645	149,550,320	133,179,945
Vegetables - Other Peppers	9,198,937	10,276,223	10,369,941	12,736,472	14,553,662	17,134,592
Vegetables - Other Veg	115,054,523	199,164,464	214,662,946	221,077,479	209,450,320	206,195,361
Vegetables - Snap Beans	27,353,793	21,810,764	24,873,608	23,621,698	24,011,849	25,790,094
Vegetables - Southern Peas	5,170,111	11,160,701	7,616,104	5,326,353	5,216,301	5,390,740
Vegetables - Squash	27,918,277	30,668,879	32,144,356	31,712,494	40,837,931	37,603,158
Vegetables - Sweet Corn	117,373,539	140,132,554	156,210,920	158,867,276	156,679,146	145,026,886
Vegetables - Tomato	53,892,514	56,118,792	61,306,670	49,239,946	50,921,844	37,624,476
Vegetables - Watermelon	134,206,241	124,526,870	124,491,830	134,853,988	123,888,134	180,278,529
Vegetables - Zucchini	25,447,880	20,514,880	26,531,229	23,179,186	25,058,564	26,014,038
Wheat	86,714,104	45,166,519	26,013,694	26,688,478	21,710,328	29,912,201
Totals	**13,990,015,902**	**13,838,993,517**	**13,748,493,392**	**13,794,522,725**	**13,755,084,305**	**13,001,935,486**

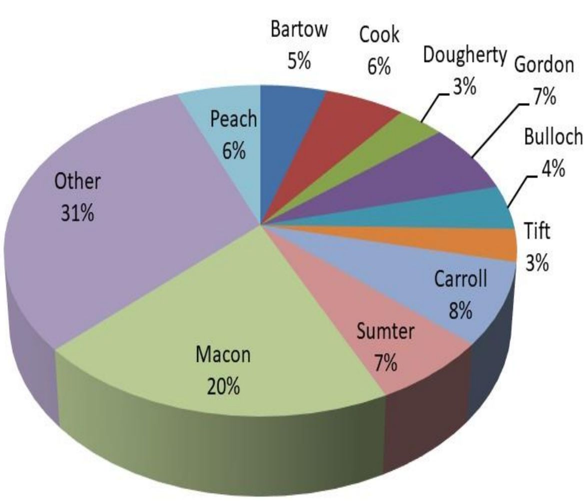
Turfgrass Farm Gate Value 2019

Rank	County	Acres	$/Acre	Farm gate
36	Appling	50	$6,500.00	$227,500
-	Atkinson			$0
-	Bacon			$0
42	Baker	15	$3,000.00	$31,500
-	Baldwin			$0
37	Banks	45	$6,500.00	$204,750
-	Barrow			$0
7	Bartow	1,353	$6,500.00	$6,156,150
-	Ben Hill			$0
19	Berrien	250	$6,050.00	$1,058,750
-	Bibb			$0
-	Bleckley			$0
-	Brantley			$0
-	Brooks			$0
45	Bryan	2	$7,000.00	$9,800
8	Bulloch	1,200	$6,500.00	$5,460,000
31	Burke	80	$6,500.00	$364,000
-	Butts			$0
-	Calhoun			$0
-	Camden			$0
-	Candler			$0
2	Carroll	2,200	$6,500.00	$10,010,000
17	Catoosa	280	$6,500.00	$1,274,000
-	Charlton			$0
-	Chatham			$0
-	Chattahoochee			$0
-	Chattooga			$0
-	Cherokee			$0
-	Clarke			$0
-	Clay			$0
36	Clayton	50	$6,500.00	$227,500
-	Clinch			$0
44	Cobb	5	$6,500.00	$22,750
-	Coffee			$0
40	Colquitt	30	$6,500.00	$136,500
43	Columbia	6	$6,050.00	$25,410
6	Cook	1,611	$6,500.00	$7,330,050
-	Coweta			$0
-	Crawford			$0
-	Crisp			$0
-	Dade			$0
-	Dawson			$0
-	Decatur			$0
-	Dekalb			$0
-	Dodge			$0
11	Dooly	610	$6,500.00	$2,775,500
9	Dougherty	950	$6,500.00	$4,322,500
-	Douglas			$0
14	Early	400	$6,500.00	$1,820,000
-	Echols			$0
15	Effingham	350	$6,500.00	$1,592,500
-	Elbert			$0
25	Emanuel	150	$6,500.00	$682,500
-	Evans			$0
-	Fannin			$0
-	Fayette			$0
35	Floyd	55	$6,500.00	$250,250
-	Forsyth			$0
39	Franklin	40	$6,500.00	$182,000
44	Fulton	5	$6,500.00	$22,750
-	Gilmer			$0
-	Glascock			$0

Rank	County	Acres	$/Acre	Farm gate
-	Glynn			$0
3	Gordon	1,910	$6,500.00	$8,690,500
34	Grady	60	$6,500.00	$273,000
-	Greene			$0
-	Gwinnett			$0
21	Habersham	200	$6,500.00	$910,000
-	Hall			$0
20	Hancock	210	$6,500.00	$955,500
-	Haralson			$0
41	Harris	25	$6,500.00	$113,750
32	Hart	74	$6,700.00	$347,060
23	Heard	175	$6,500.00	$796,250
22	Henry	185	$6,500.00	$841,750
16	Houston	300	$6,500.00	$1,365,000
12	Irwin	550	$6,050.00	$2,329,250
18	Jackson	250	$6,500.00	$1,137,500
-	Jasper			$0
-	Jeff Davis			$0
27	Jefferson	120	$6,500.00	$546,000
-	Jenkins			$0
-	Johnson			$0
-	Jones			$0
-	Lamar			$0
28	Lanier	100	$6,500.00	$455,000
13	Laurens	500	$6,500.00	$2,275,000
21	Lee	200	$6,500.00	$910,000
-	Liberty			$0
-	Lincoln			$0
-	Long			$0
25	Lowndes	150	$6,500.00	$682,500
-	Lumpkin			$0
1	Macon	5,500	$6,500.00	$25,025,000
-	Madison			$0
-	Marion			$0
33	McDuffie	70	$6,500.00	$318,500
-	McIntosh			$0
34	Meriwether	60	$6,500.00	$273,000
-	Miller			$0
21	Mitchell	200	$6,500.00	$910,000
-	Monroe			$0
-	Montgomery			$0
21	Morgan	200	$6,500.00	$910,000
-	Murray			$0
-	Muscogee			$0
-	Newton			$0
-	Oconee			$0
-	Oglethorpe			$0
-	Paulding			$0
5	Peach	1,700	$6,500.00	$7,735,000
-	Pickens			$0
-	Pierce			$0
-	Pike			$0
-	Polk			$0
21	Pulaski	200	$6,500.00	$910,000
-	Putnam			$0
-	Quitman			$0
-	Rabun			$0
-	Randolph			$0
28	Richmond	100	$6,500.00	$455,000
-	Rockdale			$0
-	Schley			$0
26	Screven	125	$6,500.00	$568,750

Rank	County	Acres	$/Acre	Farm gate
21	Seminole	200	$6,500.00	$910,000
-	Spalding			$0
-	Stephens			$0
-	Stewart			$0
4	Sumter	1,800	$6,500.00	$8,190,000
-	Talbot			$0
-	Taliaferro			$0
-	Tattnall			$0
38	Taylor	50	$5,500.00	$192,500
18	Telfair	250	$6,500.00	$1,137,500
-	Terrell			$0
27	Thomas	120	$6,500.00	$546,000
10	Tift	880	$6,500.00	$4,004,000
-	Toombs			$0
-	Towns			$0
16	Treutlen	300	$6,500.00	$1,365,000
24	Troup	300	$3,500.00	$735,000
29	Turner	95	$6,500.00	$432,250
-	Twiggs			$0
-	Union			$0
-	Upson			$0
30	Walker	90	$6,500.00	$409,500
25	Walton	150	$6,500.00	$682,500
-	Ware			$0
27	Warren	120	$6,500.00	$546,000
21	Washington	200	$6,500.00	$910,000
-	Wayne			$0
-	Webster			$0
-	Wheeler			$0
-	White			$0
-	Whitfield			$0
17	Wilcox	280	$6,500.00	$1,274,000
-	Wilkes			$0
-	Wilkinson			$0
25	Worth	150	$6,500.00	$682,500
	Totals & Avg.	**27,886**	**$6,451.61**	**$125,936,720**

Top Ten Counties for Turfgrass



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