FOUNDATION NEWS

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PRESIDENT'S MESSAGE

Tim Walker, CGCS, President of Tri-State Turf Research Foundation

INSIDE THIS ISSUE

New Research Never Gets Old

If we've learned anything from the COVID-19 pandemic, it's the value of research. In Covid's case, research has yielded the vaccines and treatment methods designed to prevent and manage a potentially deadly virus. Similarly, turfgrass research has yielded solutions and preventive measures critical in combating the many turf-threatening pests and problems we encounter.

Since 1992, the Tri-State Turf Research Foundation has funded numerous research projects pertinent to turf issues plaguing tri-state area courses. Starting with Rutgers' Dr. Bruce Clarke's summer patch research, the foundation has contributed nearly $1 million over the past 30 years to area universities in search of controls for such turf pathogens and insects as anthracnose, dollar spot, earthworms, and the annual bluegrass weevil. They've taken the guesswork out of selecting appropriate putting green root zone mixes and microbial and organic-based nutritional products, prepping greens for tournament play, and much more.

Like ills that affect the human population, there will always be a turf pest or agronomic practice that requires research. Fortunately, we have a pool of talented researchers to delve into these issues as they arise. They come from such institutions as Rutgers, Penn State, Cornell, University of Rhode Island, UMass, and the University of Connecticut. But each and every study conducted by these researchers on our behalf has been made possible with contributions from the Tri-State Turf Research Foundation's six affiliated associations (listed on the back-page masthead), along with donations from area clubs and corporate contributors.

A CALL TO ACTION

While support from our affiliated organizations and corporate contributors has stayed strong, over the past five years, our club contributions have fallen from 125 to only 74 in 2021! I want to thank all who have contributed to the foundation's research efforts and encourage those who have not to seriously consider joining the foundation's list of supporters.

At our annual meeting, the Tri-State Board of Directors did vote to increase our request for donations. It has been five years since our last increase, and with inflation and the cost of living on the rise, we thought it prudent to bump up our donation request. Club and corporate contributions will increase from $250 to $300, while association contributions will go from $3,000 to $3,500. A truly small price to pay for the valuable research you'll receive in return.

Thinking outside the box, we will also be asking clubs to donate foursomes, much like the Rounds for Research, as an alternative to a financial donation. Be on the lookout for these requests later in the season. I want to thank Rich Duggan for spearheading this effort, which generated $6,766 from seven donations last year.

If you are new to the area, don't know what the Tri-State is or stands for, or simply forgot to pass the donation form on to your accounting department, I ask that

(continued on page 15)

TRI STATE
TURF RESEARCH FOUNDATION

Rutgers Researchers Close in on Controls for Summer Decline of Annual Bluegrass

In their final year of funding from the Tri-State Turf Research Foundation, Rutgers researchers Dr. Bingru Huang and Dr. James Murphy delved deeper into the effects of foliar applications of PGRs, biostimulants, and fungicides in promoting annual bluegrass *(Poa annua)* tolerance to heat stress. This has been of particular interest to superintendents whose courses are predominantly *Poa* or who maintain *Poa*/bentgrass greens.

During 2021, the researchers conducted year two of a field study in the university research farm, as well as a golf course study to investigate the effects of plant-health products on summer performance of *Poa* on putting green conditions.

What follows is a look at the outcome of their trials.

2021 FIELD TRIAL: METHODOLOGY

PLOT MAINTENANCE

The experiment was conducted on Rutgers University research plots managed under putting green conditions.

» The field sites were established with mixed biotypes of *Poa annua* originally collected from Rutgers University Golf Course and Plainfield Country Club.

» The *Poa* turf was maintained at a cutting height of 0.125 inches with adequate irrigation and fertilization, as well as curative and preventive programs for disease control that included:

- Controls for Brown Ring Patch, Dollar Spot, Anthracnose, and Summer Patch (Prostar, Secure, Medallion + Banner Maxx, Prostar, Torque, Affirm + Emerald, Maxtima + Heritage TL, Maxtima + Prostar)
- Fertilizer (2.2 lbs per 1000 ft^2 from mid-April to September)

Plant-Health Product Applications

Three types of plant-health products were examined for their effects on *Poa* heat tolerance. The following chemical treatments were applied by foliar spray to field plots:

1: Untreated control: plants were sprayed with water (2 gal / 1000 ft^2)

2: Biostimulants: amino acids A (60 mM / 1000ft^2), amino acids B (.44 uM / 1000 ft^2), amino acids A + B (amino acid C); seaweed-based A (12 fl oz / 1000 ft^2), seaweed-based B (15 fl oz / 1000 ft^2)

3: Plant growth regulators: Primo Maxx (trinexapac-ethyl) (0.1 fl oz / 1000 ft^2), Proxy (ethephon) (2 fl oz / 1000 ft^2), Primo Maxx + Proxy

4: Fungicides: Signature XTRA StressGard (4.0 fl oz / 1000 ft^2) (Sig), Daconil Action (3.5 fl oz / 1000 ft^2) (DacAc), Appear II (6 fl oz / 1000 ft^2) (AppII), Daconil Action + Appear II (DAppII), Daconil Action + Appear II + Primo (DAIIP)

» All treatments were applied to 3' x 4' field plots (5 replicates each) every 14 days between June 3 and August 31.

» The following measurements were taken weekly based on weather conditions:

- Turf quality (TQ) was visually rated.
- Regular photos were taken to measure the percent green canopy cover and Dark Green Color Index (DGCI) using imaging analysis programs.
- Canopy temperature was measured by taking thermal pictures and using FLIR image analysis software to calculate the change in canopy temperature.

» Treatment effects on different parameters were determined by analysis of variance procedure according to the general linear model (GLM) procedure of the SAS program.

» Significant effect of each individual treatment was compared to the untreated control at p = 0.05.

RESULTS

The following is the culmination of the researchers' findings after year two of their field trials:

Fungicide and PGR Effects

» *Poa* plots with application of Daconil Action, Appear II, Daconil Action + Appear II, and Daconil Action + Appear II + Primo had significantly higher turf quality *(Figure 1A)*, and also maintained greener canopy cover.

» Of these fungicides, Daconil Action, Daconil Action + Appear II, and Daconil Action + Appear II + Primo also had significantly higher DGCI (Dark Green Color Index) throughout August.

» Application of Primo alone had little to no significant effect on any of the parameters examined in this experiment.

» *Poa* treated with Proxy alone and the combination of Proxy and Primo had significantly lower turf quality *(Figure 1B)*, and relatively lower DGCI levels.

Biostimulant Effects

Treating *Poa* with biostimulants had mixed results:

» Seaweed Extract A plots had relatively higher TQ (turf quality) throughout the study and had significant increases toward the end of the summer *(Figure 1C).*

» However, TQ for all three amino acid treatments had inconsistent effects throughout the study, fluctuating between having relatively higher TQ to lower TQ compared to the control *(Figure 1C).*

Rutgers Researchers Close in on Controls for Summer Decline of Annual Bluegrass

» Additionally, Seaweed Extract B and Amino Acid C both maintained greener canopy cover, while both Seaweed Extract treatments and Amino Acid B maintained significantly higher DGCI toward the end of summer.

Mixed Effects

Treatments had mixed effects on canopy temperature throughout the summer months.

» Daconil Action + Appear II, and Daconil Action + Appear II + Primo maintained cooler canopies toward the end of the summer.

» Seaweed Extract A and Seaweed Extract B maintained cooler temperatures in the beginning and again at the end of the study compared to untreated control.

2021 GOLF COURSE TRIAL: METHODOLOGY

GREEN MAINTENANCE

This study was conducted at Tamarack Golf Course, a 36-hole facility located in East Brunswick, NJ, with putting greens made up of a mixture of *Poa* and bentgrass. Trials were conducted on putting greens on the West Course's holes #4 and #17.

» *Poa* was not uniformly distributed on the *Poa*/Bent putting greens. Therefore, greens were examined and patches with relatively more uniform *Poa* were selected for treatments.

» *Poa* patches on the putting greens were not arranged adjacent to each other unlike uniform research field plots. A total of 6 replicate patches were selected for each treatment, three at hole #4 and three at hole #17.

» Putting greens were mowed at 0.150", well-irrigated and fertilized, and under disease control.

Product Applications

The following treatments were applied by foliar spray to field plots:

1: Untreated control: plants were sprayed with water (2 gal / 1000 ft²)

2: Seaweed-based Extract C (12 fl oz / 1000 ft²), Seaweed-based Extract D (12 fl oz / 1000 ft²) + wetting agent + a granular seablend (4.2 lbs / 1000 ft² applied in May and end of August)

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1A

1B

1C

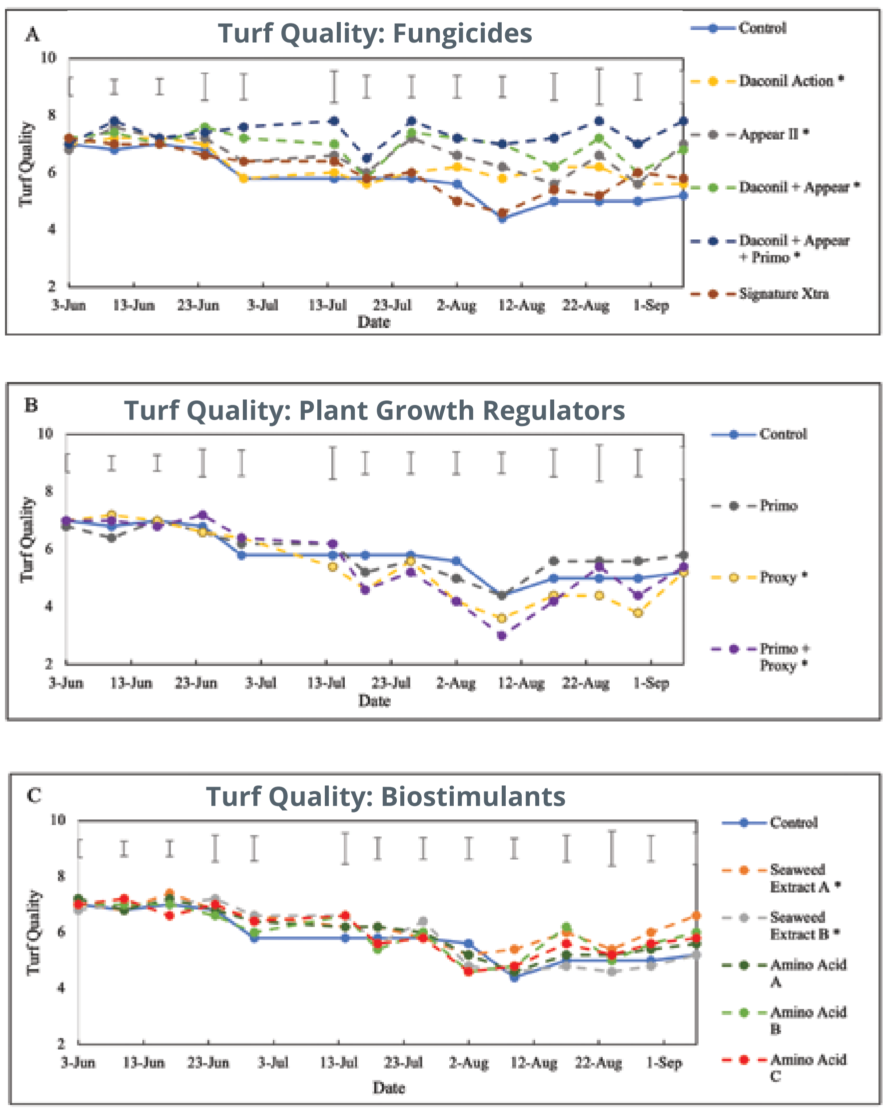


FIGURE 1 (A,B,C)

Turf quality of *Poa* putting green as affected by different treatments.
**Indicates treatments significantly different from the control at p = 0.05.*

Rutgers Researchers Close in on Controls for Summer Decline of Annual Bluegrass

3: Daconil Action (3.5 fl oz) + Appear II (6.0 fl oz) + Primo (0.125 fl oz)

4: Daconil Action (3.5 fl oz) + A23728A (6.0 fl oz) + Primo (0.125 fl oz)

5: Amino Acid C (same concentration as field trial)

6: Amino Acid D (25 uM / 1000 ft^2)

7: Amino Acid C + Amino Acid D (Amino Acid E)

» Each treatment was applied once every 2 weeks from June 7 to August 26.

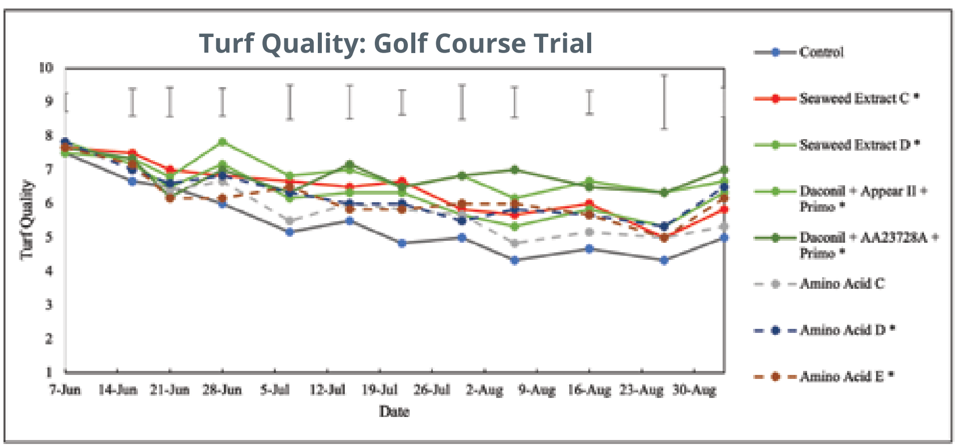
» The following measurements were taken weekly based on weather conditions from June 7 to September 6.

- Turf quality (TQ) was visually rated.
- Normalized Difference Vegetation Index (NDVI), Stress Index (SI), and Leaf Area Index (LAI) was evaluated using a multispectral radiometer (CropScan).

» Data analysis was conducted following the same procedure used for the field trial.

FIGURE 2

Turf quality of mixed *Poa*/Bent putting green on the golf course as affected by different treatments.
**Indicates treatments significantly different from the control at p = 0.05.*



RESULTS

The following is the outcome of the researchers' golf course trial:

» Several treatments showed significant increases in TQ (turf quality): Seaweed-based Extract C, Seaweed-based Extract D, Daconil Action + Appear II + Primo, Daconil Action + A23728A + Primo, Amino Acid D, and Amino Acid E *(Figure 2)*.

» All treatments had relatively higher NDVI, LAI, and lower stress levels throughout the summer. On August 16, Seaweed-based Extract C, Daconil Action + Appear II + Primo, and Daconil Action + A23728A + Primo showed significant increases in NDVI and LAI, and significantly lower stress levels.

» Of the amino acid treatments, Amino Acid D had significantly higher NDVI on August 16, and both Amino Acid C and Amino Acid D plots had significantly higher LAI and lower stress levels at the end of the summer.

PLANS FOR 2022

The researchers plan to repeat the experiment in the research farm and on golf course putting greens in 2022. The future replication of the experiment with more affective anthracnose control over all plots may serve to confirm if improved performance is due specifically to improved heat tolerance.

SIDEBAR

Quick Take on Trial Results

» Results from 2021 are consistent with those of 2020, where Daconil Action, Appear II, Daconil Action + Appear II, and Daconil Action + Appear II + Primo effectively enhanced *Poa* performance during summer, but unlike 2020, Signature XTRA was not as effective.

» The combined treatment of Daconil Action + Appear II or Daconil Action + Appear II + Primo was more effective in improving *Poa* summer performance than each individual treatment alone.

» Seaweed Extract A had positive effects on *Poa* health and quality in the field trial at the university research farm.

» Of the plant growth regulators, Primo, when used alone, had no significant effect on *Poa* summer performance, while Proxy alone and the combination of Proxy and Primo had adverse effects during summer months.

» In the golf course trial, Seaweed-based Extract C, Daconil Action + Appear II + Primo, and Daconil Action + A23728A + Primo had the greatest effect on enhancing *Poa*/Bent mixed greens throughout the summer.

» Amino acid treatments enhanced turf performance in the summer in both trials.

For further information, you can reach Dr. Huang at huang@sebs.rutgers.edu or Dr. Murhpy at Jamurphy@NJAES.rutgers.edu.

Rutgers Researchers Put ABW to the Test as Viable Biological Control

Dr. Albrecht Koppenhöfer and His Team Investigate ABW's Potential as a Biological Weed Management Agent

Annual bluegrass is one of the most problematic weeds of creeping bentgrass fairways. Infested fairways often exhibit poor playing quality during hot and dry summer conditions. Unfortunately, ridding creeping bentgrass fairways of this undesirable turf is often challenging at best. Herbicides are not widely used for annual bluegrass control because they can cause creeping bentgrass injury or are too expensive, and annual bluegrass control is inconsistent and often too rapid, creating large voids in the turfgrass canopy.

Superintendents commonly use plant growth regulators (PGRs), such as flurprimidol or paclobutrazol, to suppress annual bluegrass. Extensive research on putting greens and limited fairway research has shown that annual bluegrass control from PGR programs is inconsistent likely due to different annual bluegrass biotypes and lack of complementary cultural practices. However, research on biological or natural agents for annual bluegrass control has been very limited.

Interestingly, research and field observations have demonstrated that the annual bluegrass weevil (ABW) has a strong preference for annual bluegrass. The ABW can cause damage to creeping bentgrass, but creeping bentgrass can tolerate three to four times higher larval densities and is much more likely to recover from damage than annual bluegrass.

Although creeping bentgrass fairways predominate in areas where the ABW occurs, synthetic insecticides are usually applied repeatedly throughout the season to prevent ABW damage because these fairways usually have a significant population of annual bluegrass. No research had been conducted on the use of ABW for annual bluegrass management until recently.

Between 2017 and 2019, Drs. Matt Elmore and Albrecht Koppenhöfer and their teams from Rutgers discovered that annual bluegrass can be effectively reduced in creeping bentgrass-annual bluegrass fairways with a combination of the PGR paclobutrazol and a threshold control approach of ABW. It was the first attempt at using a turfgrass pest for the management of a turfgrass weed, and there is more to be learned.

In hope of determining the viability of threshold-based ABW management for annual bluegrass control in creeping bentgrass fairways, the Tri-State Turf Research Foundation has agreed to fund Dr. Albrecht Koppenhöfer and his Rutgers team in their work to transform a major insect pest of golf course fairways into a biological weed management agent.

OBJECTIVE

Investigate efficacy of threshold-based ABW management for annual bluegrass control in mixed creeping bentgrass-annual bluegrass fairways at different CBG-ABG ratios.

METHODOLOGY

Two field experiments were laid out in late summer 2020 at Rutgers Hort Farm No. 2 in a field simulating fairway conditions with a history of ABW infestation.

» During 2020, different areas of the field were treated with a paclobutrazol program to achieve annual bluegrass covers of approximately 50%, 25%, 10%, and 0%, the balance being creeping bentgrass.

» During late April to early May 2021, overwintered ABW adults were vacuumed from other ABW-infested fields and spread throughout the experimental areas to ensure a uniform ABW infestation among plots.

» Post-emergence herbicides and fungicides were applied as necessary to control weeds without injuring the annual bluegrass and creeping bentgrass. As the experiment is still ongoing (at least through spring 2022), the data have not been analyzed yet and are presented in summarized form.

EXPERIMENT 1

Reduction of annual bluegrass with the ABW using different insecticide programs at different annual bluegrass proportions

This experiment tested the effect that three ABW management programs (preventive, threshold, no control) at four different annual bluegrass percentages (50%, 25%, 10%, 0%) had on the reduction of ABG and turfgrass quality.

» There are four replications that consist of four whole plots (each 6.1 × 4.6 m) with one each of the four ABG percentages.

» The whole plots are divided into three subplots (1.5 × 1.5 m) that received one of three ABW management programs in spring 2021:

- The *preventive program* is to completely prevent ABW damage by controlling both early instar larvae (cyantraniliprole at 175 g ai/ha applied on May 18, 2021) and late-instar larvae (indoxacarb at 252 g ai/ha applied on May 25, 2021) of the ABW spring generation.
- The *threshold program* allows first generation ABW larvae to cause limited annual bluegrass damage. The plots were monitored closely to determine when ABW damage resulted in marginally acceptable (~ 5 on a 1 to 9 scale, 9 being ideal) turfgrass quality, at which time (June 2, 2021) cyantraniliprole (293 g ai/ha) was applied to all threshold plots to halt further damage.
- In the third ABW program, *no insecticides for ABW control were applied*.

(continued on page 6)

Rutgers Researchers Put ABW to the Test as Viable Biological Control

ABW Densities and Stages

ABW development was observed in May and June 2021 by taking turf/soil plugs (5.3 cm diameter, 3.8 cm depth) and extracting the ABW in a saturated salt solution to determine the number and stages present.

» Before the final evaluation, plugs were taken only from the borders between the plots to minimize effects on the annual bluegrass/creeping bentgrass ratio in the plots.

» Three plugs were taken from each block (total of 12).

» For the final evaluation, eight plugs were taken from within each subplot.

» ABW densities per 0.1 m^2 (in parentheses is average larval stage with pupa and teneral adult included as 6^{th} and 7^{th} instars) were 33.2 (3.0) on May 18, 105.8 (3.4) on May 25, and 51.4 (4.7) on June 2.

» For the final evaluation (June 10), densities in the untreated plots were 15.8, 15.8, 41.6, and 31.5 at 0%, 10%, 25%, and 50% annual bluegrass, respectively (average larval stage 5.5-5.6).

» Averaged across all ABG percentages, ABW densities were reduced by 46% in the threshold treatment and by 95% in the preventive treatment.

Annual Bluegrass Cover: Visual Estimate

Annual bluegrass percentage cover in the plots was regularly estimated by two evaluators (values averaged) from peak annual bluegrass seedhead production in the spring through the duration of the growing season.

» Annual bluegrass cover in early May was around 10%, 28%, 50%, and 60% for the 0%, 10%, 25%, and 50% annual bluegrass cover treatments, respectively.

» Annual bluegrass cover declined in all annual bluegrass treatments throughout the season, though more dramatically at the higher annual bluegrass percentages and during the time when ABW spring generation larvae were feeding (from May to June).

» At the end of the growing season, annual bluegrass cover was around 5%, 8%, 15%, and 25% in the 0%, 10%, 25%, and 50% annual bluegrass cover treatments, respectively.

» There was no clear effect of the ABW program on annual bluegrass decline at any of the annual bluegrass cover treatments with similar rates of decline in all programs.

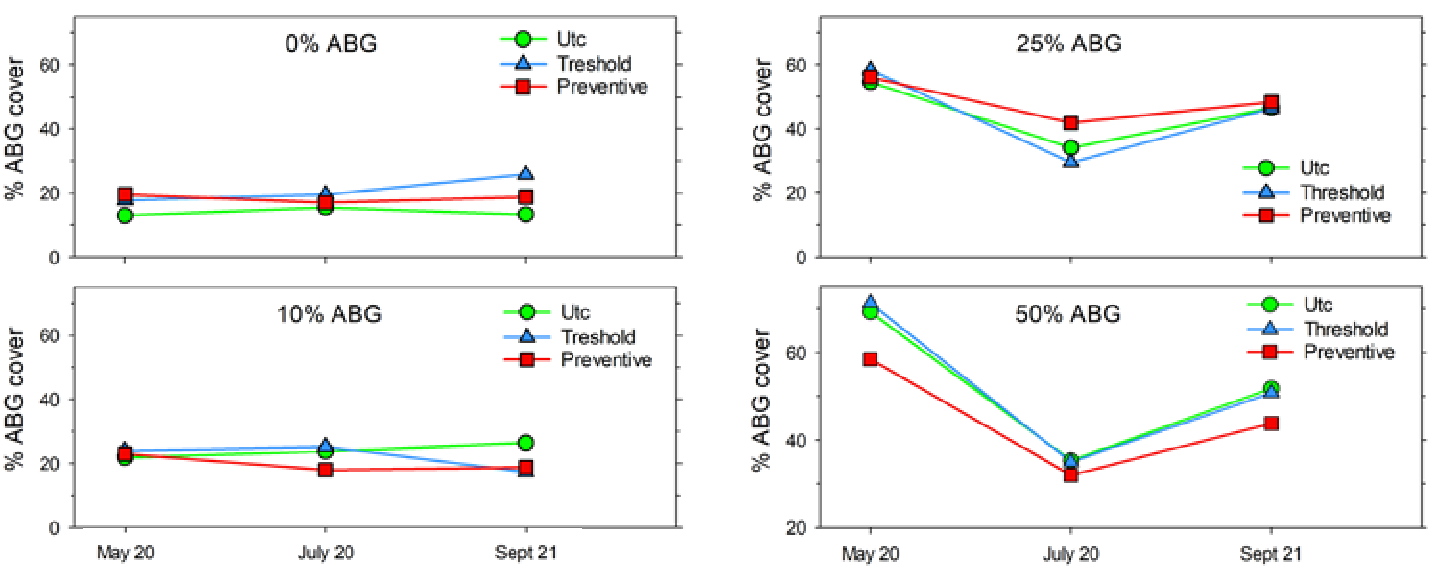
Annual Bluegrass Cover: Grid Counts *(Figure 1)*

To quantitatively assess creeping bentgrass and annual bluegrass cover, grid counts were conducted on a subplot basis using a 0.9 × 0.9 m grid with 200 intersection points at peak ABG seedhead production in early spring, in mid-summer, and in early fall. The presence of ABG, CBG, or dead turf was noted for each intersection point.

» Annual bluegrass cover in early May was around 17%, 23%, 56%, and 66% for the 0%, 10%, 25%, and 50% ABG cover treatments, respectively.

FIGURE 1

Effects of different initial ABG cover (0, 10, 25, 50%) and different ABW management programs an ABG cover on percent ABG cover determined by grid counts during the 2021 growing season (Experiment 1).



Rutgers Researchers Put ABW to the Test as Viable Biological Control

» In the 0% and 10% annual bluegrass cover treatments, ABG cover did not significantly change during the season.

» In the 25% and especially the 50% annual bluegrass cover treatments, cover declined significantly from May to July but had recovered partially by October.

» At the end of the season, annual bluegrass cover was around 20%, 25%, 49%, and 47% in the 0%, 10%, 25%, and 50% ABG cover treatments, respectively.

» In the 0% and 10% annual bluegrass cover treatments, the ABW program had no effect on ABG cover.

» In the 25% and 50% annual bluegrass cover treatments, there was a stronger relative decline in the untreated control plots and the threshold plots than in the preventively treated plots between May and June, but also a stronger recovery by September.

Turf Quality

Turfgrass quality (1-9 scale, 9 being ideal) was regularly estimated by two evaluators (values averaged) on a subplot basis from peak annual bluegrass seedhead production in the spring through to the end of the growing season.

» In the 0% and 10% annual bluegrass cover treatments, turf quality was not significantly affected by the ABW program and stayed between 6.5 and 8.2 throughout the season with only a slight dip between May and June.

» In the 25% annual bluegrass cover treatment, turf quality declined from around 7 to 6 from early May to late May in all ABW programs, but then recovered more quickly in the preventive treatment than in the threshold treatment, and recovered most slowly in the untreated plots.

» After that point, the ABW programs did not differ from each other. At the 50% annual bluegrass cover, ABG declined in all ABW programs but more so in the threshold and untreated plots than in the preventive plots. Recovery was also the fastest in the preventive plots and the slowest in the untreated plots. Thereafter, quality was similar in all ABW programs.

EXPERIMENT 2

Reduction of annual bluegrass with the ABW using a threshold insecticide program at different annual bluegrass proportions

This experiment examines in more detail the effect that the threshold ABW management program at four different annual bluegrass percentages (50%, 25%, 10%, 0%) had on the reduction of ABG and turfgrass quality by making application decisions for each ABG percentage separately.

» Each of five replications contains one plot (1.5 × 1.5 m) of each annual bluegrass percentage in a randomized complete block design.

» If plots within an annual bluegrass percentage treatment reach the quality threshold, all plots of that ABG percentage treatment are treated with cyantraniliprole (293 g ai/ha).

» This occurred on May 28, 2021 for the 50% ABG plots and on June 2, 2021 for the 25% ABG plots.

» The 10% and 0% ABG plots did not reach the threshold and were not treated.

The sampling methods used are the same as for Experiment 1.

ABW Densities and Stages

» ABW densities per 0.1 m² (in parentheses average larval stage with pupa and teneral adult included as 6th and 7th instars) were

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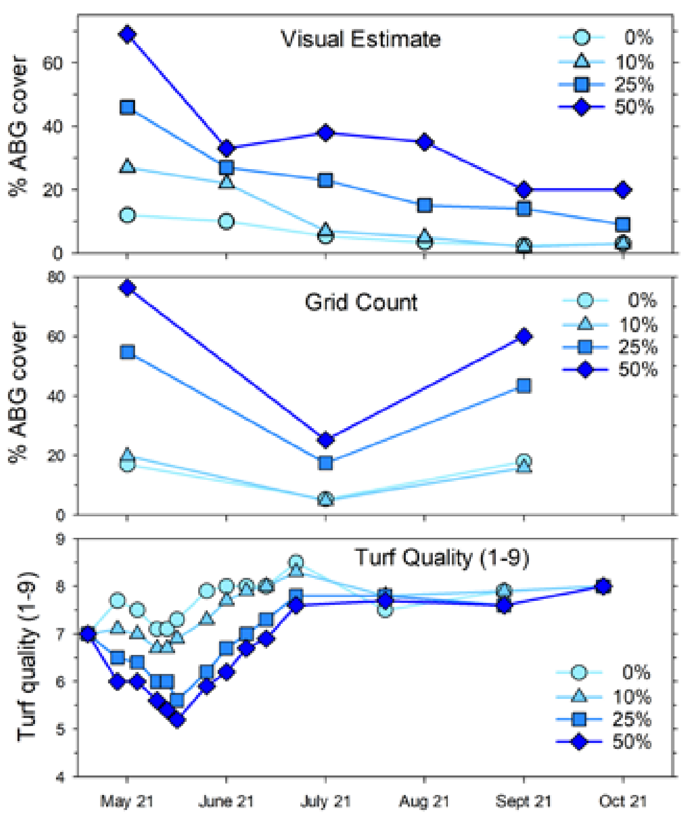

FIGURE 2

Effects of different initial ABG cover (0, 10, 25, 50%) on percent ABG cover determined by visual estimates, on percent ABG cover determined by grid counts, and on turf quality (1-9 scale, 9 being ideal) during the 2021 growing season (Experiment 2). All plots of a given ABG cover treatment were treated with an ABW larvicide when turf quality dropped to a quality threshold of around 5. Only the 25% and 50% plots were treated, both around late May/early June.

Special Thanks to Our 2021 Contributors

We'd like to thank our contributors for their generous show of support to the Tri-State Turf Research Foundation. Your contributions go a long way toward helping the foundation continue its mission "to provide turfgrass research for better golf and a safer environment." We hope those of you on the list will continue to support the foundation's work. We also hope you will encourage more of your fellow turfgrass professionals to add their names to the growing list of contributors.

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Rutgers Researchers Put ABW to the Test as Viable Biological Control

135.4 (3.0) on May 18, 89.5 (3.4) on May 25, 127.7 (4.2) on May 28, and 60.4 (4.4) on June 2.

» For the final evaluation (June 10), densities were 7.2 (6.2) at 0% ABG (untreated), 27.0 (5.9) at 10% ABG (untreated), 26.1 (6.2) at 25% ABG (treated), and 33.3 (6.1) at 50% ABG (treated).

Annual Bluegrass Cover: Visual Estimate *(Figure 2)*

» Annual bluegrass cover in early May was around 12%, 27%, 47%, and 69% for the 0%, 10%, 25%, and 50% annual bluegrass cover treatments, respectively.

» Annual bluegrass cover declined in all ABG treatments, but the quickest was between May and June or May and July when spring generation ABW larvae were active.

» In the treatments that reached damage threshold and were treated, there was a temporary recovery (50%) or slower decline (25%), whereas in the untreated samples, the annual bluegrass decline continued into July.

» In October, annual bluegrass cover was around 3%, 3%, 10%, and 21% in the 0%, 10%, 25%, and 50% ABG cover treatments, respectively.

Annual Bluegrass Cover: Grid Counts *(Figure 2)*

» Annual bluegrass cover in early May was around 18%, 20%, 54%, and 77% for the 0%, 10%, 25%, and 50% ABG cover treatments, respectively.

» Cover declined to 4%, 5%, 18%, and 27% in the 0%, 10%, 25%, and 50% ABG cover treatments between May and July but recovered to 14%, 16%, 42%, and 60%, respectively, by September.

Turf Quality *(Figure 2)*

» Turf quality was around 7 in all treatments in early May. It declined rapidly at the 25% and especially 50% annual bluegrass cover treatments by early June when ABW larvae were active but then recovered steadily thereafter to be around 7.5 to 8 from July onward.

» In the 0% and 10% annual bluegrass cover treatments, ABG did not decline significantly in spring and increased to around 8 by July and stayed around 7.5 to 8 for the rest of the season.

CONCLUSIONS

» Annual bluegrass cover declined throughout the season, especially in plots with higher ABG cover at the beginning of the year. The decline was the strongest between May and June or July when spring generation ABW larvae were active.

» The greater the decline in annual bluegrass from May to July, the greater the loss in turf quality.

» In all treatments, however, turf quality loss was only temporary. Quality was never below 5 and was never below 6 for more than about two weeks.

» There was no clear and significant effect of an ABW management program. This may have been the result of a combination of two factors: relatively low ABW population densities and well-above-average precipitation rates throughout much of the growing season that limited ABW damage to the annual bluegrass and allowed ABG to recover better from it.

FUTURE PLANS

Dr. Koppenhöfer and his team plan to continue their experiments at least into June 2022. If the ABW densities are higher than in 2021 and/or precipitation lower than the previous year, the researchers will continue with the experiments throughout the 2022 season and likely into spring 2023 and beyond, if the data supports another year of observations. ■

For further information, you can reach Dr. Koppenhöfer at a.koppenhofer@rutgers.edu.

Clemson Research Insight for Managing Bacterial Etiolation of Cool-Season Fine Turf

Etiolation, the abnormal elongation of turfgrass stems and/or leaves of turfgrasses, is a phenomenon that has plagued turfgrass stands for decades. While etiolation can occur at all heights of cut, golf course putting greens, surrounds, tees, and fairways are most commonly affected.

Over the past several years, etiolation has emerged as a recurring issue for superintendents in the tri-state area. Hoping to discover an effective method for managing or eliminating this troublesome turfgrass phenomenon, the Tri-State Turf Research Foundation granted Clemson University's Dr. Joseph Roberts funding in 2020 for a one-year study to examine the causes and options for managing etiolation on cool-season fine turf.

With the Covid-19 pandemic affecting the U.S. and the researchers' ability to gather appropriate samples and data, the project has been extended into 2022. What follows are the preliminary results of their 2020 and 2021 research.

WHAT IS KNOWN

» There are currently three known bacterial pathogens of turfgrass with variable infection levels with individual species of turfgrass.

- *Xanthomonas translucens* is a known pathogen of annual bluegrass, creeping bentgrass, and perennial ryegrass.
- *Acidovorax avenae* bacteria is a known pathogen of creeping bentgrass and has also been shown to infect annual bluegrass.
- *Pantoea ananatis* bacteria have also been shown to infect creeping bentgrass and perennial ryegrass.

» Previous research on bacterial diseases has shown that cultural management options can vary according to bacterial species causing infection; therefore, accurate diagnosis is critical to successful control.

THE OBJECTIVES

During the course of their trials in 2020 and 2021, the researchers sought to:

1: Isolate and identify bacteria associated with etiolation symptoms observed in the tri-state region.

Macro image of etiolated creeping bentgrass fairway turfgrass in College Park, MD.

Clemson Research Insight for Managing Bacterial Etiolation of Cool-Season Fine Turf

2: Examine the impact of chemical control methods for etiolation on cool-season fine turf caused by *Pantoea ananatis*.

PRELIMINARY RESULTS

OBJECTIVE 1: IDENTIFY BACTERIA ASSOCIATED WITH ETIOLATION

Throughout 2020 and 2021, the Clemson Turfgrass Pathology Laboratory at Pee Dee Research and Education Center in Florence, SC, accepted samples for diagnosis of bacterial etiolation. Sample submissions were received during the early fall months of each year when bacterial etiolation typically develops in cool-season turfgrasses.

» To date, the lab has identified 18 bacteria from 7 locations in Connecticut (1), Maryland (1), New Jersey (3), and New York (2).

» Bacteria isolated include known plant pathogenic bacteria (i.e., *A. avenae*, *P. ananatis*, and *X. translucens*), but the scant number of sample submissions to date limits the researchers' ability to determine which bacteria are most frequently associated with bacterial etiolation occurring in the tri-state region *(Figure 1)*. Many of the samples submitted have been from golf course fairway turf *(Figure 2)*.

» Similar to previous research, *A. avenae* was found in creeping bentgrass exhibiting etiolation while *X. translucens* was isolated from *Poa annua* samples. *Pantoea* spp. and *Pseudomonas* spp. were also found in some samples, indicating the need to examine these bacteria in more detail.

With the pandemic impacting the U.S. and limiting sample submissions, the Clemson turf lab has extended sample submissions through 2022. The researchers are hoping that an additional year of collection will allow for a better representation of locations in the tri-state region and a more accurate depiction of bacteria associated with etiolation occurring in the region.

Please see the sidebar on page 12 for instructions on how to submit samples.

OBJECTIVE 2: IMPACT OF CHEMICAL CONTROLS ON COOL-SEASON FINE TURF ETIOLATION

While antibiotics are not a viable option for control of etiolation, previous research has shown that plant growth regulators (PGRs) can have a significant impact on symptom development and that PGR response is contingent on the bacterial species present. Experiments with *A. avenae* on creeping bentgrass have shown that frequent (i.e., 0.125 fl oz 1000 ft^2 every 7 days) or high rate (i.e., 0.250 fl oz 1000 ft^2 every 14 days) applications of Primo Maxx (trinexapac-ethyl) resulted in *increased* etiolation compared to the untreated control. A greenhouse trial was completed in 2021 to evaluate various applications on etiolation and/or decline caused by *Pantoea ananatis*, another bacteria observed with the etiolation phenomenon.

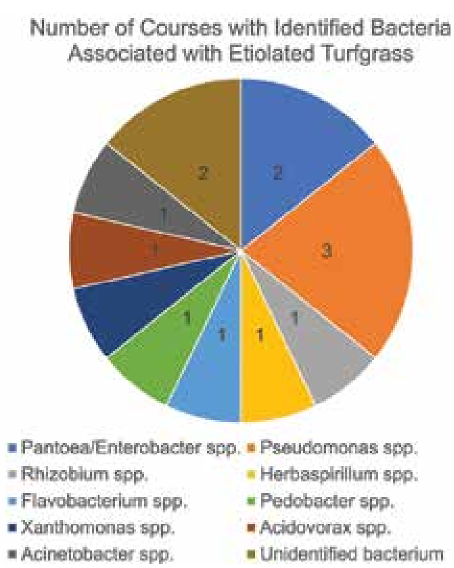
(continued on page 12)

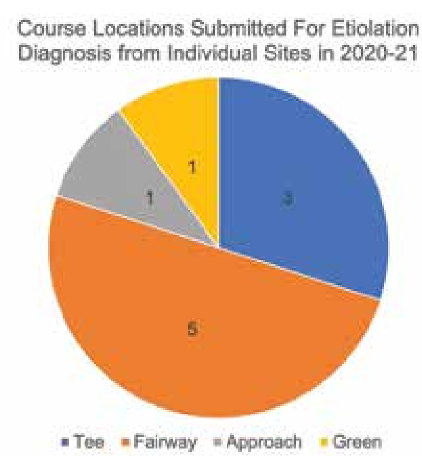
FIGURE 1 (LEFT)

Frequency of plant pathogenic bacteria associated with etiolated turfgrass samples submitted for diagnosis in 2020 and 2021.

FIGURE 2 (RIGHT)

Identified golf course areas exhibiting etiolation with sample submissions in 2020 and 2021.





Clemson Research Insight for Managing Bacterial Etiolation of Cool-Season Fine Turf

PRELIMINARY RESULTS

» In the initial experiment, preventive treatment effects were observed on perennial ryegrass inoculated with *Pantoea ananatis*. Applications were made every 14 days prior to and post-inoculation. Etiolation developed with a week of inoculation, and treatment effects were observed within 2 weeks post-inoculation.

» All PGRs and fertilizers tested significantly impacted bacterial etiolation compared to the untreated control on the second rating date. Banner Maxx (1 and 2 fl oz 1000 ft^{-2} every 14 days), Aneuw (0.09 and 0.18 oz 1000 ft^{-2} every 14 days), Primo Maxx (0.125 fl oz 1000 ft^{-2} and 0.25 fl oz 1000 ft^{-2}), Extreme Green (4 oz 1000 ft^{-2}), and EcoMag (4 fl oz 1000 ft^{-2}) reduced etiolation compared to the untreated control *(Figure 3)*.

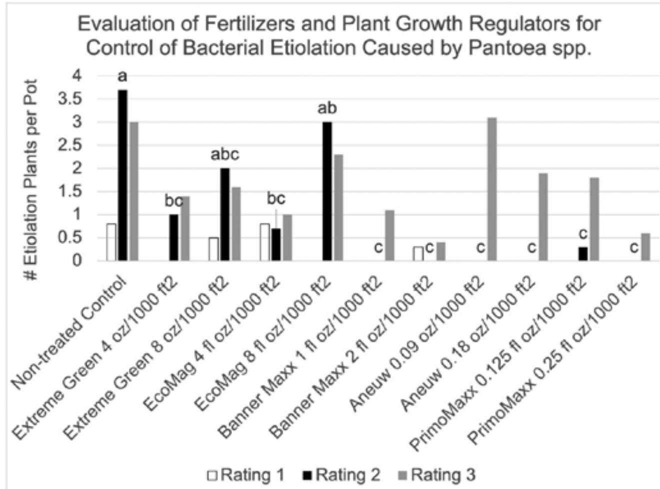
» Future field research is needed to understand how treatments can be implemented to reduce etiolation in the field.

FUTURE PLANS

The researchers are hopeful that results obtained this year can be used to develop more long-term management projects to reduce etiolation in the future. Continued characterization of bacteria associated with etiolation will aid in research to improve management recommendations for prevention.

FIGURE 3

Results from growth chamber experiment evaluating multiple fertilizer and plant growth regulator products in reducing etiolation of perennial ryegrass caused by *Pantoea ananatis* in 2021.



For further information, you can reach Dr. Roberts at jar7@clemson.edu.

SIDEBAR

Disease Diagnostic Sample Collection

Dr. Joseph Roberts at Clemson University in conjunction with the team of researchers at Rutgers is looking at all options to manage etiolation, including but not limited to nutrient deficiencies, growth regulators, chemical applications, and cultural control methods. ***However, we need your help.*** It is vitally important for Dr. Roberts to receive samples from across the tri-state region with ETS on different grass varieties and on different surfaces.

If you could please send a few samples to Clemson following the instructions below it would be greatly appreciated.

INSTRUCTIONS

Please take a sample from the symptomatic turfgrass along the leading edge of the area that is impacted. If the affected turf area includes patches of symptomatic turf, the sample can be collected so that ⅔ to ¾ of the sample is affected and the remaining turfgrass is healthy. The sample should be wrapped around the base with aluminum foil and shipped overnight to the following address:

Dr. Joseph Roberts
Clemson Pee Dee REC
2200 Pocket Road
Florence, SC 29501

When sending a sample, please send an email to Dr. Roberts at jar7@clemson.edu with shipping information. Due to recent restrictions with Covid-19, shipping delays are possible and having tracking information will ensure that samples are not lost in the mail. In the email, it is also beneficial to include turfgrass species, cultivar, date of when symptoms were first observed, and recent cultural and chemical applications.

New Rutgers Study Investigates *Poa* Sustainability on Putting Green Turf

Recognizing that it is very difficult to completely eradicate annual bluegrass *(Poa annua)* from stands of other turfgrass species, many golf course superintendents have resigned themselves to accepting—and cultivating—annual bluegrass on their putting greens. Though *Poa* can provide an attractive, high-quality putting surface, its inherent shallow root systems make the plant prone to heat and drought stress that lead to severe problems with summer decline. When intermingled on greens with creeping bentgrass, which has significantly longer root systems *(see photos below)* the *Poa* declines more rapidly, resulting in yellow or dead patches and ultimately reducing the playing surface's uniformity.

The shallow root system of *Poa annua* calls for intensive water management because the turf is not taking up water from deep within the soil profile. Enhancing root elongation and proliferation deeper into the soil is critically important for maintaining high-quality *Poa* putting greens during summer stress periods.

WHAT STUDIES TO DATE HAVE SHOWN

Phytohormones play a key role in regulating root growth, as Dr. Haung and other researchers have found in previous studies.

Some hormones, such as *strigolactone (SL)* and *cytokinins*, promote root growth while other hormones, such as *ethylene*, inhibit root growth in turfgrass.

» Ethylene production in turfgrass plants is typically elevated under environmental stress conditions, which can lead to plant death. Therefore, ethylene inhibitors of chemical or microbial products that suppress ethylene accumulation under stressful environments are beneficial to alleviate ethylene-related damage to roots.

- *Aminoethoxyvinylglycine (AVG)* is a chemical inhibitor of ethylene synthesis and well known for its role in alleviating stress-induced ethylene accumulation.
- Some *plant-growth promoting rhizobacteria (PGPR)* act as ethylene suppressors by eliminating the precursor of ethylene, 1-aminocyclopropane-1-carboxylate (ACC) using the bacterial ACC-deaminase enzymes. When plants are colonized by PGPR with ACC-deaminase activity, (this includes those bacteria species isolated from grass roots collected in New Jersey Pine Barrens with sandy, acidic, nutrient-poor soils), they can eliminate ACC in the plant, restricting ethylene production.

» The bacterial consortium of *Burkholderia phenazinium* ('WSF14' and 'WSF23') has been found to be effective in maintaining better creeping bentgrass during drought stress and promoting plants' recovery from drought damage (Bingru Huang' lab, unpublished data).

After screening several hormones and PGPR *Burkholderia phenazinium* for their effect on root growth of *Poa* in controlled-environment growth chambers, the researchers found that s*trigolactone (SL)*

(continued on page 14)

FIGURE 1
A comparison of *Poa* and creeping bentgrass root systems

New Rutgers Study Investigates *Poa* Sustainability on Putting Green Turf

and the two ethylene inhibitors (AVG and PGPR with ACC-deaminase activity) were most effective in stimulating root elongation into deeper soil depth for *Poa* under heat stress conditions *(see photo below)* and under drought stress.

The positive effects of those hormones and PGPR on *Poa* root growth on putting greens have not been tested under natural field or golf course conditions. If confirmed to be effective, these hormones and PGPR could be used as biostimulants incorporated in management practices to grow *Poa* as desirable turf.

Hoping to enable turfgrass managers to avoid summer decline of their *Poa annua* greens cover, the Tri-State Turf Research Foundation has granted Rutger's Dr. Bingru Huang funding in 2022 for a two-year study to develop effective management strategies to improve *Poa* root growth and maintain high-quality annual bluegrass throughout the summer months and in areas with limited irrigation.

OBJECTIVE

The objective of this study is to:

» determine biostimulant effects of *phytohormones* and *plant-growth promoting rhizobacteria* on rooting characteristics in *Poa* managed under putting green conditions in field plots

» identify the effective biostimulant component to improve *Poa* root growth and turf performance during summer stress

Incorporating natural PGPR in turfgrass management is a promising sustainable approach to enhance plant health and stress tolerance by improving root growth.

EXPERIMENTAL PLAN

The experiment will be conducted in field plots at Rutgers turfgrass research farm (Hort Farm II) in 2022 and 2023.

» The field site has been established with mixed biotypes of *Poa annua* originally collected from Rutgers University Golf Course and Plainfield Country Club.

» The field plots are being managed as putting greens, which are regularly maintained at a cutting height of 0.125 inches with adequate irrigation and fertilization, as well as curative and preventive programs for disease control.

» Field plots are also aerified and topdressed with sand as needed.

» Dr. Huang and her research team have already determined the optimal rates of different treatments for promoting root growth of *Poa* in controlled-environment growth chambers in projects noted earlier.

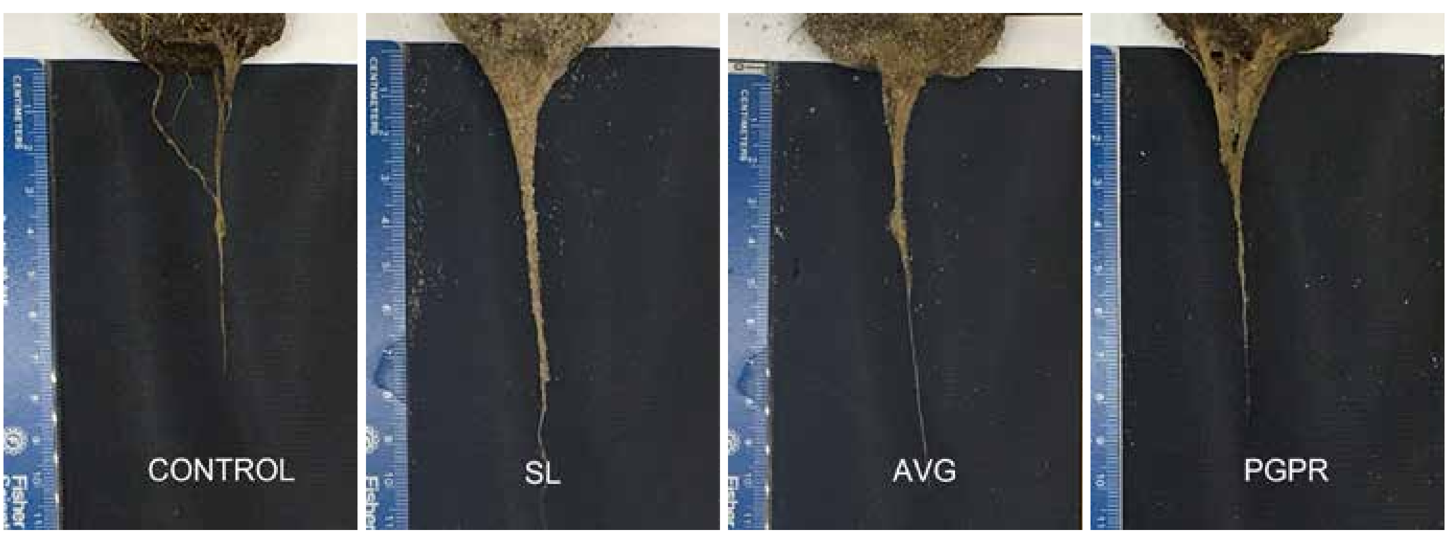
» Those rates will be further tested in the field trial to confirm their effectiveness for promoting root growth of *Poa* under putting green conditions.

EXPERIMENTAL TREATMENTS

1: Untreated control: Turf plots will be foliar sprayed with water at 2 gallons / 1000 ft^2.

FIGURE 2

Promotive effects on root growth by different hormones and plant-growth-promoting bacteria.



New Rutgers Study Investigates *Poa* Sustainability on Putting Green Turf

2: Foliar spray with hormone, SL: Turf plots will be foliar sprayed with 10 μM SL solution in 2 gallons / 1000 ft^2 of water.

3: Foliar spray with ethylene inhibitor, AVG: Turf plots will be foliar sprayed with at 25 μM AVG solution in 2 gallons / 1000 ft^2 of water.

4: Soil drenching with ethylene-inhibiting PGPR: The consortium consisting of two bacterial strains of Burkholderia phenazinium ('WSF14' and 'WSF23') from our bacterial collection in New Jersey Pine Barrens will be used to inoculate *Poa* plants by soil drenching.

» Bacteria will be revived from frozen stock vials.

» Single colonies will be picked, inoculated, and then incubated at room temperature.

» Bacterial suspension will be centrifuged, then resuspended in deionized and distilled water.

» Bacterial inoculant suspensions at the density of 1 x 105-107 cfu/mL and mixed in humic acid (0.01%) will be watered into field plots as soil drenching in sufficient volume to moisten the upper 2-inch root zone.

» The treatments will be applied starting from the beginning of May and every 14 days until September.

» Each treatment will be replicated in four plots (3' x 5' each).

EVAUATION OF *POA* ROOT GROWTH AND TURF PERFORMANCE

Root growth and turf performance will be evaluated biweekly from May to September to determine the dynamic changes in rooting and summer stress tolerance for *Poa* under putting green conditions as affected by the bacterial and *phytohormone* treatments.

ROOT GROWTH EVALUATION

» Soil cores (1 inch in diameter) going 10 inches deep will be taken from each treatment plot.

» Roots from three different soil depths: 0-2 inches, 2-4 inches, and 4-6 inches, and 6-10 inches will be collected by washing free of soil.

» Root length (or rooting depth), number, and surface area collected from each soil depth will be measured using an image scanner and imaging analysis program (WinRhizo).

» Root biomass will be determined after roots are dried in an oven to examine total quantity of roots in each soil depth.

TURF QUALITY EVALUATION

» Turf quality will be visually rated according to turf color, density, and uniformity on the scale of 1 to 9, with 9 indicating turf that is dense, green, and completely healthy and 1 indicating turf that is brown in color and desiccated.

» Canopy temperature is a good indicator of plant physiological health for stress tolerance, as it estimates transpirational cooling that is affected by root water uptake capacity.

- Canopy temperature will be measured using an infrared thermal camera (FLIR).
- Thermal images will be captured weekly during the trial, and imagery data will be processed using computer software.

Watch for the outcomes of year one of the Rutgers research team's trials in the next issue of *Foundation News*. ■

For further information, you can reach Dr. Huang at huang@sebs.rutgers.edu.

New Research Never Gets Old

you please make sure 2022 is the year we get back on track. If you want to know more about the Tri-State, please feel free to contact one of the chapter representatives on the back of this issue.

GIVING THANKS

I want to thank all of the past presidents and board members for their dedication in furthering the foundation's mission of building better golf and a safer environment through turfgrass research.

I would also like to wish longtime board members Chris Carson of Echo Lake Country Club and Stephen Finamore of Alpine Country Club all the best in their retirement and thank them for their above-and-beyond service to the Tri-State since its inception.

Special thanks as well to Blake Halderman of Brae Burn Country Club for his time as president of the Tri-State and his many years of service on the board. We have two more years to benefit from his wisdom, vision, and energy on the board.

Last but not least, I'd like to thank the current board of directors for their dedicated service. We have three new members I would like to introduce: Matt Kerens of Paramount Country Club (Hudson Valley GCSA), Jennifer Torres of Westlake Golf & Country Club (GCSA of New Jersey), and Kenneth Anson of Trump National Golf club of Philadelphia (GCSA of New Jersey), who will also be serving as a vice president.

As the new president, I look forward to furthering the foundation's many worthwhile endeavors and look forward to your support in 2022. I wish everyone the best for a safe, successful, and normal year ahead. If there is anything the Tri-State can do to help you succeed this year, be sure to reach out.

Tim Walker, CGCS
President
Tri-State Turf Research Foundation

A Fond Farewell to Rutgers' Dr. Bruce Clarke

Dr. Bruce Clarke, extension specialist in turfgrass pathology in Rutgers University's Department of Plant Biology, retired on January 1 after 40 years of service to the turfgrass industry. His career and many contributions to the Tri-State Turf Research Foundation and golf industry as a whole are so numerous that we can only scratch the surface here.

Dr. Clarke started at Rutgers as an undergraduate student, graduating in 1977 with a B.S. in Forestry Management. He went on to complete his Ph.D. in Plant Pathology in 1982, and then continued at Rutgers as assistant extension specialist. He served in numerous leadership roles in Rutgers Cooperative Extension (RCE) and the New Jersey Agricultural Experiment Station (NJAES). In 1994, he was named director of the Center for Turfgrass Science and held that position until the end of 2020. During that period, in 2005, he became the first occupant of the Ralph Geiger Endowed Chair in Turfgrass Science, an honor he held until 2011.

Recognized as a world authority in the field of turfgrass pathology, Dr. Clarke is perhaps best known in the tri-state region for his groundbreaking research on anthracnose, summer patch, dollar spot, and gray leaf spot. In fact, Dr. Clarke was among the first researchers on the scene when the Tri-State Turf Research Foundation was formed in 1992 at the height of the summer patch devastation. The solutions and best management practices he developed to counter these devastating turf ills have made our jobs more manageable and saved our golf facilities thousands upon thousands of dollars.

To aid his research efforts, from 1990 through 2015, Dr. Clarke raised over $4.5 million in grants from organizations such as the Tri-State Turf Research Foundation, the USGA, GCSAA, New Jersey Turfgrass Foundation, U.S. Department of Agriculture, and many more. The total external dollars raised for grants, contracts, and service income exceeded $12.6 million.

Dr. Clarke has shared his research and knowledge in numerous journal articles and publications, as well as talks at conferences and seminars. He also co-edited four books, including the second, third, and soon-to-be-released fourth edition of the *Compendium of Turfgrass Diseases*, as well as the second edition of *Turfgrass Patch Diseases Caused by Ectotrophic Root-infecting Fungi*.

For his outstanding achievements, Dr. Clarke has been recognized with many awards and honors, including the New Jersey Turfgrass Hall of Fame Award in 1996 and in 2014, GCSAA's Colonel John Morley Distinguished Service Award.

Turfgrass managers in the tri-state area and beyond will never forget all that Dr. Clarke has done for the turf industry. We thank Dr. Clarke for his many turf-saving contributions, and we wish him the very best in his retirement. ■

For further information on Dr. Clarke's distinguished career, you might check out the article that appeared in Rutgers' Newsroom / Bruce Clarke, Extension Specialist in Turfgrass Pathology, Retires from Rutgers After a Long and Distinguished Career : Newsroom.

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