UNIVERSITY OF CALIFORNIA
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TURFGRASS & LANDSCAPE RESEARCH FIELD DAY

September 12, 2019

Stephen T. Cockerham
1939-2018

UCR Turfgrass Science

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

CA TURFGRASS & LANDSCAPE FOUNDATION
"Keeping California Green and Growing"

UC RIVERSIDE — UNIVERSITY OF CALIFORNIA

College of Natural and Agricultural Sciences
UC Division of Agriculture and Natural Resources
Agricultural Experiment Station and Cooperative Extension

Department of Botany and Plant Sciences-072
Riverside, CA 92521-0124

Welcome to Field Day!

On behalf of the entire UCR Turfgrass and Landscape Team, welcome (back) to the 2019 UCR Turfgrass and Landscape Research Field Day. This marks the 12th consecutive year of this event under my watch. Time flies when you're having fun! We continue to strive to make Field Day one of the pinnacle events of our industry – a place where all come together annually to see old friends, share ideas, and learn about world-class research activities at UCR.

Unfortunately this past December, we lost Steve Cockerham, Director of Agricultural Operations Emeritus and one of the pillars of the UCR Turfgrass Program. Field Day 2019 is dedicated in memory of Steve and his many contributions to our program as well as the Turfgrass Industry, not only in California and the U.S. but also internationally. We miss him dearly, but also showcase today some of the turfgrass research that Steve remained involved with even after retirement and until his passing.

Today, you will see and hear about cutting edge new and longstanding research that addresses turfgrass selection, pest, water, and salinity management issues to help mitigate stresses on turf and landscape plants. For the eighth consecutive year, we welcome several of our industry partners under the Exhibitor's Tent. Please take the time to visit them and learn more about new products and services while enjoying complimentary food and beverages. Last but not least, while this handout serves to give you a brief synopsis of our current research activities for the research tours, you can read or print our full research reports in their entirety from our website, **turfgrass.ucr.edu**.

As you enjoy today's tours, please take a moment to thank those folks, mostly wearing green shirts with our Turfgrass Science logo, who assisted with preparation for this event. Special thanks go to my fellow Field Day planning committee members including Marco Schiavon, Peggy Mauk, Sue Lee, Steve Ries, Sherry Cooper, Julia Kalika, and Shannon Martin. Production of this publication, signs, and online reports would not have been possible without assistance from Mr. Toan Khuong (Associate Specialist). Staff and students from UCANR, Agricultural Operations and my lab have worked tirelessly to make this event possible and are deserved of your appreciation. Last but not least, very special thanks to all of our industry partners for their generous donations to our turf and landscape programs throughout the year, and especially for today's delicious food and beverages under the shade of tents!

Enjoy Field Day! And we hope to see you again next year on **Thursday, September 17, 2020.**

Sincerely,

James H. Baird, Ph.D.
Associate Specialist in Cooperative Extension and Turfgrass Science

In Memoriam

Stephen T. Cockerham

February 19, 1939 – December 30, 2018

Known as the humble farmer, Stephen T. Cockerham, 79, forty-year resident of Riverside, CA, passed away on December 30, 2018, at Riverside Community Hospital following complications from treatment for melanoma. Steve was born on February 19, 1939 in Elwood, Indiana to Theodore and Inez Cockerham. Steve is survived by his wife, Barbara, and their son, Fernando Gabela and wife Alicia, and two granddaughters, Jessica and Jackie, who reside in Diamond Bar. He has one younger sister, Joyce Valley (Duane), who lives in Pelican Rapids, Minnesota. His niece Jodie lives nearby in Norco. Nephews Scott and Randy reside in Minnesota. He has innumerable grand nieces and nephews in Minnesota as well. Also an integral part of the family system includes Laurie McLaughlin, Barbara's sister, and her daughters, Erin (Josh), Meaghan (Tony), and Kate (Matthew) and their children. Laurie lives two houses away from the Cockerham home. He was preceded in death by his son, Garrett Charles in 1985, and by his parents. Steve graduated in 1961 from Purdue University as an agronomist in turfgrass science. He later earned a MS in Turfgrass Science from New Mexico State University and an MBA from Southern Illinois University at Edwardsville. Steve served as a Peace Corps volunteer in El Salvador from 1962-64 where he met his wife of 54 years, Barbara, who was serving as a missionary secretary. They enjoyed spending time with other volunteers and driving around in a little blue jeep. He had an amazing 56-year career in turfgrass-related endeavors including 30 years consulting with the LA Coliseum beginning with the 1984 Olympics, assisting with the design of the Bank One Ballpark (Chase Field) in Arizona in the mid 1980s, and ensuring the quality of the multiple playing fields used for the 1994 World Cup. For five years (1979-1983) he was a farmer in Perris, CA with his own sod farm. From 1983 through 2009 he served at the University of California, Riverside as Superintendent of Agricultural Operations. During his tenure there he conducted extensive research and extension with his colleagues, especially Dr. Victor Gibeault, his best friend. His technical professional writing was highly valued in journals, books and extension publications. Steve loved to travel, especially throughout the Southwest including Four Corners. A recent valued moment was enjoying the Skywalk at the Grand Canyon. His hobbies included golf, photography, Purdue sports, reading and music from country to classical. He was noted for his dry wit and sense of humor. Steve's final resting place is at Olivewood Cemetery in Riverside.

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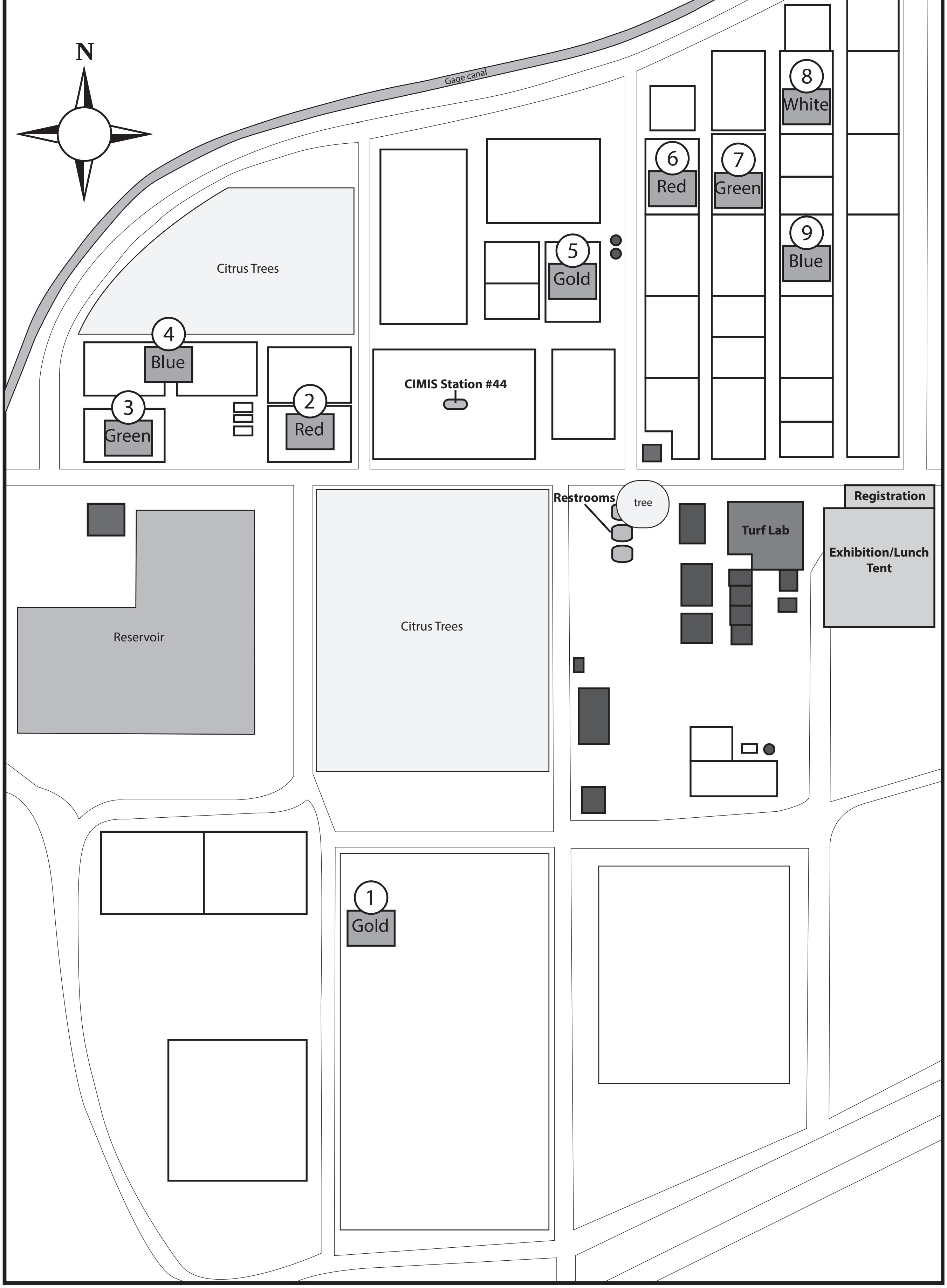


2019 Turfgrass and Landscape Research Field Day Agenda

7:00 AM — **Exhibitor set-up**

7:30-8:30 AM — **Registration and Trade Show**

8:30 AM — **Welcome; Introductions; Tribute to Steve Cockerham**
Peggy Mauk, Vic Gibeault, and Jim Baird

8:50-10:10 AM — **Group Field Tour**

Stop #1: **Improvement of Bermudagrass, Kikuyugrass, and Zoysiagrass for Winter Color Retention and Drought Tolerance**
Adam Lukaszewski, Marta Pudzianowska, and Christian Bowman

Stop #2: **PRE and POST Oxalis and Crabgrass Control in Bermudagrass Turf**
Jim Baird and Pawel Petelewicz

Stop #3: **USGA/NTEP Cool-Season Water Use Trial**
Marco Schiavon and Mingying Xiang

Stop #4: **Evaluation of Fungicides for Control of Anthracnose Disease on Annual Bluegrass Putting Greens and Plant Health Under Deficit Irrigation on Creeping Bentgrass Putting Greens**
Pawel Petelewicz and Jim Baird

10:10 – 10:40 AM — **Break and Trade Show**

10:40 – 12:00 PM — **Field Tour Rotation** (20 minutes per Stop; choose 4 Stops)

Stop #5 *Gold Tent*: **Management of Salinity and Rapid Blight Disease on Annual Bluegrass Putting Greens**
Jim Baird

Stop #6 *Red Tent*: **USGA/NTEP Warm-Season Water Use Trial**
Mingying Xiang

Stop #7 *Green Tent*: **How to Properly Irrigate Kurapia Groundcover**
Pawel Orlinski

Stop #8 *White Tent*: **Nitrogen Timing and Verticutting Effects on 'De Anza' Zoysiagrass**
Steve Ries

Stop #9 *Blue Tent*: **Wetting Agents for Water Conservation on Bermudagrass Turf**
Marco Schiavon

12:00 – 1:30 PM — **Barbeque Lunch and Trade Show**

1:30 PM — **Adjourn**

Please go on-line and fill out the evaluation form at http://ucanr.edu/turf2019eval or QR code.

Stop #1: Improvement of Bermudagrass, Kikuyugrass, and Zoysiagrass for Winter Color Retention and Drought Tolerance

Marta Pudzianowska, Christian Bowman, Adam J. Lukaszewski, and Jim Baird
Department of Botany & Plant Sciences
University of California, Riverside, CA 92521

Project Milestones Since Field Day 2018:

- ✔ Planted ca. 860 bermudagrass hybrids generated by open pollination and controlled crosses of selected collection accessions.
- ✔ Continued crossing of UCR bermudagrass accessions, with emphasis on genotypes possessing desirable winter color retention, early spring green-up, and drought tolerance.
- ✔ Continued evaluation ca. 1,000 bermudagrass and zoysiagrass accessions in replicate plots from University of Florida, Oklahoma State University, Texas A&M, and UCR for winter color retention.
- ✔ Planted 12 bermudagrass hybrids selected for roughs or lawns at The Preserve at Santa Lucia, Carmel and West Coast Turf in Coachella Valley.
- ✔ Selected 4 best performing bermudagrass hybrids out of 12 evaluated for 2 years.
- ✔ Planted large areas of 4 selected bermudagrass hybrids on fairways at Napa Golf Course and Almaden Country Club, San Jose to evaluate under traffic in comparison to Bandera, Celebration, Latitude 36, Santa Ana, Tifway II, TifTuf and Tahoma 31.
- ✔ Continued crossing of UCR kikuyugrass accessions selected for desirable quality traits, drought tolerance and winter color retention.
- ✔ Planted ca. 280 kikuyugrass hybrids obtained through crossing accessions collected in California and from old UCR collection.
- ✔ Planted 16 zoysiagrass experimental hybrids and 4 cultivars from Texas A&M at Napa Golf Course and Meadow Club, Fairfax in Northern California.

Background and Justification:

Despite attempts by the turfgrass industry to develop cool-season turfgrasses with improved drought tolerance, repeated testing in Riverside, CA (a Mediterranean climate characterized by hot, dry summers with less than 200 mm of annual rainfall) has demonstrated that even the most drought tolerant cool-season cultivars do not even come close to the warm-season species in terms of drought tolerance and water use efficiency. With water supplies in California uncertain, the future of turfgrass and other landscapes is shaky. Use of drought tolerant plant species should be at the forefront of water conservation management plans for golf courses and other landscapes. Warm-season or C4 grasses are better adapted to warmer, drier climates and use at least 20% less water compared to cool-season grasses, yet their use in California and abroad is limited primarily due to the aesthetics of winter dormancy. Thus, we strive to improve winter color retention in warm-season turfgrasses and hopefully greater acceptance of warm-season turfgrasses for regions where these grasses are adapted. In addition, drought tolerance is not created equal both among and within warm-season species. While buffalograss is considered to be among the most drought tolerant of the warm-season turfgrass species, the primary mechanism for this is drought avoidance by summer dormancy. In California, general observations are that bermudagrass retains the best quality and green color under drought or deficit irrigation, although differences within cultivars are less substantiated. Other warm-season species appear to possess “lesser” drought tolerance, but zoysiagrass and kikuyugrass are best able retain green color longer in response to cooler temperatures. Thanks to support from the California Turfgrass and Landscape Foundation (CTLF), United States Golf Association (USGA), Metropolitan Water District (MWD) of Southern California, and Western Municipal Water District (WMWD), we are able to continue this project with full speed ahead.

Project Objectives:

1. Develop bermudagrass, kikuyugrass, and zoysiagrass turf-type genotypes with improved winter color retention and drought tolerance for Mediterranean and arid climates.
2. Screen a large collection of bermudagrass and zoysiagrass genotypes from the University of Florida, Oklahoma State University, Texas A&M, and UCR for winter color retention and drought tolerance in Riverside CA.
3. Develop techniques to reduce kikuyugrass ploidy level to diploid by androgenesis to reduce aggressiveness and improve turf quality and playability characteristics.
4. Utilize Diversity Arrays Technology (DArT) markers to aid in breeding efforts and marker-assisted selection.

Bermudagrass:

Bermudagrass is commonly used throughout the southern U.S. and is considered the “go to” warm-season species for many golf courses and athletic fields in California. Its major disadvantage is winter dormancy. Our project focuses on this issue, with the primary goal of shortening winter dormancy (if it can be eliminated at all, it certainly would not be a single step process). For this purpose we established a collection of all seven Cynodon species in Riverside, by requesting samples from the USDA and several other sources. At present the collection approaches 135 accessions; all seven species are represented by at least one genotype each. The collection also includes a growing number of samples collected locally or donated to us by others. These are mostly from abandoned or heavily travelled sites, including a spot in Coachella Valley where no irrigation water was applied for at least three consecutive (and very dry) years. We continue intercrossing these species, having generated in the last 2 years ca. 1500 interspecific hybrids. Some of these were created by controlled one x one cross hybridization (both parents are known) using the detached tiller approach; many others were created by open pollination among the collection accessions. In this case only the female parent is known. The hybrids show variation for every observable characteristic, including the onset of winter dormancy and spring greenup. After evaluating hybrids and collection accessions for winter color retention and visual quality, they are being intercrossed on the assumption that the next generation hybrids may show reduced dormancy period. The best-looking hybrids created in previous years were tested in various environments including: the Coachella Valley Agricultural Research Station in Thermal, CA; Arizona Country Club in Scottsdale, AZ; and The Preserve Golf Club in Carmel, CA. Dramatic differences in their behavior were clearly evident and the best of these hybrids are being used in subsequent tests. 12 of our most promising hybrids and accessions selected in 2017 based on their performance in these tests were tested for 2 years in 3 different locations. They were evaluated in larger, replicated plots (for more realistic cultural care and better evaluation of quality characteristics) across several climatic zones in California. UCR entries included: 10-9, 15-4, 16-6, 17-8, TP1-1, TP1-2, TP3-2, TP5-4, TP6-3, BF1, BF2 and NRCC12. These were compared with four widely used or new cultivars: Bandera, Santa Ana, TifTuf and Tifway. Experiments were designed as randomized blocks with three replications. Three locations in California were chosen for establishing the trial: University of California, Riverside (Riverside, Inland Southern California); Coachella Valley (Thermal, Low Desert) and Fairfax (Northern California). Plots (5’ x 5’) were established from 2.5-inch plugs on May 22, 2017 in Riverside; June 14, 2017 in Coachella Valley; and June 22, 2017 in Fairfax. During the first year of the test, dynamics of establishment were measured and after obtaining full cover, visual turf quality, winter color retention, Normalized Difference Vegetation Index (NDVI) and Dark Green Color Index (DGCI, using Digital Image Analysis), flowering and scalping injuries were evaluated until June 2019. In spring 2018, plots at University of California Riverside and West Coast Turf were divided in two, to test suitability both for golf courses and lawns. For this purpose, half of each plot was mowed in 0.5 in 3 times a week and the other half in 2.0 in once a week.

The first year of the study showed that among evaluated hybrids TP 6-3, TP 3-2 and NRCC12 were the fastest growing accessions in Southern California sites, while 10-9 and 15-4 in Northern California sites (data not shown). Over 2 years of testing for fairways, TP 6-3 showed good visual turf quality and winter color retention, supported by high NDVI and DGCI values in all three areas, placing this hybrid in the highest position of the ranking (Table 1). High in the ranking was also 17-8 and cultivars Tifway 419 and Tiftuf. Bandera seems to be better adapted to cooler areas. Hybrids and cultivars showing good winter color tend to flower more, compared to those with poor color retention. Winter dormancy period and spring green-up were different for each of the top performers and year of trial, however visual evaluation of color never showed average month value below 5 (Figure 2.). Similarly, turf quality varied over 2 years of tests, but TP 6-3 and 17-8 were showing quality comparable to Tifway 419 and Tiftuf throughout the entire evaluation period. This test resulted in selecting 4 UCR hybrids and accessions (TP6-3, 17-8, BF2 and 10-9), based on their performance in various areas. These 4 top performers were used to produce sod at West Coast Turf farms and planted this year in large, not separated plots on 2 fairways at Napa Golf Course in Napa Valley and Almaden Country Club near San Jose along with Bandera, Celebration, Latitude 36, Santa Ana, Tifway II, TifTuf and Tahoma 31 (Almaden only) to test their performance under regular golf course maintenance and traffic. So far Latitude 36 and 17-8 show the best quality.

When tested for rough and lawns and mowed at 2.0 in, the best UCR entries were BF2 and 17-8 (Table 2), while the best commercial cultivars included Tifway 419 and Santa Ana. It is important to note that Santa Ana plots had to be re-established due to potential contamination, resulting in lower thatch production and scalping during the second year of the study.

In general, hybrids selected for fairways have dense texture and are prone to scalping, therefore all the hybrids used for fairway selection were screened again to find genotypes more suitable for higher mowing height. 12 of them were planted this year at West Coast Turf in Coachella Valley and at Preserve at St. Lucia golf course near Monterey along with Bandera, MidIron and Tifway II. They were also selected for better winter color retention, since hybrids used in the replicated test were selected while mowed at fairway height of cut. These hybrids, while mowed in 2 in, showed worse color retention in later evaluation steps between January and March 2019, compared to the same hybrids mowed in 0.5 in.

To evaluate drought tolerance of best performing and new bermudagrass hybrids, a new dry-down area has been established and performance of 76 hybrids and cultivars under drought stress is being evaluated. 76 accessions were planted from 2.5-inch plugs in three replicates on May 8, 2019, comprised of five commercial cultivars (Bandera, Celebration, Santa Ana, TifTuf, Tifway) and 71 locally generated hybrids (two of which participated in our previous 2015 study). Accessions were allowed to grow until July 31st, after which irrigation was shut-off (August 1st), marking the start of dry-down testing. Each plot was initially evaluated twice for genetic color, then bi-weekly for scalping injuries, percentage of the plant's green coverage, and NDVI. Our defined dry-down period is 48 days, after which irrigation will be turned on for one week to allow the plants a recovery period then shut-off again.

Preliminary evaluations show promise, with almost 75% of evaluated plots retaining at least 85% green coverage after the 24-d mark. At this point, it is difficult to say with certainty which accessions are performing the best; however, a few of our hybrids that have been included in the replicated trails study are performing on par with Celebration (Figure 5).

To establish the parentage of the existing hybrids, the collection and a sample of hybrids were genotyped using the DArT technology. The results were confusing, suggesting that some accession designations may be incorrect (e.g., some accessions group with species other than those listed); in several cases the accessions appear to be amphiploid, as they share markers of two (or even more, up to four) species originally known to be diploid. This makes tracking the parentage difficult. A second genotyping including new samples from the USDA, suggests that some accessions may be indeed designated incorrectly, since they grouped closely with USDA samples, but with species other than listed, as in the first genotyping results. Analysis also showed that our best hybrids grouped together with *C. transvaalensis* accessions. Currently, morphological traits and DArT grouping of these confusing accessions is being compared in order to designate them correctly. Accessions that grouped according to assigned species were replanted in a new area.

Table 1. Ranking of twelve bermudagrass hybrids and three commercial cultivars – fairway height (0.5 in mowing height)

	Quality (1-9)			Color (1-9)			NDVI (0-0.99)			DGCI (0-1)			Flowering (1-9)			Scalping Injury (1-9)		**General ranking**
	UCR	WCT	MC	UCR	WCT	MC	UCR	WCT	MC	UCR	WCT	MC	UCR	WCT	MC	UCR	WCT	
10-9	13	12	5	11	9	9	10	6	9.5	9	3	6	9.5	4	2	11	3	**132**
15-4	8	13	9	7	11	10	7	11	9.5	8	10	8	5	7	5	6	5	**139.5**
16-6	10	8	10	13	7	13	12	10	11	11	11	11	8	9	3.5	7	12	**166.5**
17-8	5	2	3	6	1	5	2	2	2	2	2	4	1	15	12	5	8	**76.5**
TP1-1	15	14	11	15	15	11	15	15	14	16	15	16	14	6	3.5	16	11	**222.5**
TP1-2	11	9	15	12	13	15	14	14	15	13	12	15	4	8	1	9.5	15	**195.5**
TP3-2	12	10	14	14	12	14	13	12	12	14	13	10	11	13	8	12	13	**207**
TP5-4	16	16	16	16	16	16	16	16	16	15	14	14	6.5	5	8	13	16	**235.5**
TP6-3	1	3	4	1	2	2	1	1	3	1	1	5	13	11	13	3.5	6.5	**72**
BF1	2	7	6	2	5	8	5	5	4	5	4	2	6.5	1	8	8	9	**87.5**
BF2	4	5.5	8	3	6	4	6	8	6	6	5	7	2.5	2	10	9.5	10	**102.5**
NRCC12	14	15	13	10	14	12	11	13	8	12	16	13	16	16	15	15	4	**217**
Bandera	9	11	7	8	10	3	8	9	7	4	7	3	12	10	6	14	14	**142**
Santa Ana	7	4	12	9	8	6	9	3	13	10	6	12	9.5	15	14	2	1.5	**140.5**
Tif Tuf	3	1	2	4	4	1	3	4	5	7	9	9	15	12	16	1	1.5	**97.5**
Tifway 419	6	5.5	1	5	3	7	4	7	1	3	8	1	2.5	3	11	3.5	6.5	**78**

UCR – University of California Riverside, WCT – West Coast Turf, Thermal, MC – Meadow Club, Fairfax

NDVI - Normalized Difference Vegetation Index, DGCI - Dark Green Color Index

- hybrids with the highest ranks

Table 2. Ranking of twelve bermudagrass hybrids and three commercial cultivars – rough/lawn (2.0 in mowing height)

	Quality (1-9)		Color (1-9)		NDVI (0-0.99)		DGCI (0-1)		Flowering (1-9)		Scalping injury (1-9)		**General ranking**
	UCR	WCT	UCR	WCT	UCR	WCT	UCR	WCT	UCR	WCT	UCR	WCT	
10-9	8	10	9.5	11	6	10	6	8	6	6	6	4	**90**
15-4	12	14	9.5	11	7	11	4	10	4	4	9	7	**102**
16-6	11	11	12	12	11	12	11	12	12	5	11	15	**134.5**
17-8	7	6	3	2	2	4	2	6	5	13	4.5	6	**60.5**
TP1-1	14	15	16	16	14	14	15	13	14	8.5	14	13	**166**
TP1-2	13	7	13	9	15	15	14	11	9	8.5	13	14	**141**
TP3-2	10	13	14	13	12	13	12	14	15	11	11	13	**150**
TP5-4	16	16	15	14	16	16	16	15	10	7	16	16	**173**
TP6-3	4	9	1	7	1	2	1	4	7	15	7.5	8	**66**
BF1	5	4	5	3	8	5	10	3	2	3	7.5	9.5	**65**
BF2	2	3	2	5	5	6	5	5	1	2	2	9.5	**47.5**
NRCC12	15	12	11	15	13	9	13	16	16	16	15	2	**153**
Bandera	9	8	8	5	10	8	8	2	8	10	13	11	**99.5**
Santa Ana	1	1	4	8	3	3	3	1	11	15	1	1	**51.5**
Tif Tuf	3	2	7	1	4	1	9	9	13	12	4.5	3	**68.5**
Tifway 419	6	5	6	5	9	7	7	7	3	1	3	5	**64**

UCR – University of California Riverside, WCT – West Coast Turf, Thermal, MC – Meadow Club, Fairfax

NDVI - Normalized Difference Vegetation Index, DGCI - Dark Green Color Index

- hybrids with the highest rank

Figure 1. Quality of best performing accessions and cultivars during 2 years of study in 3 locations, fairway

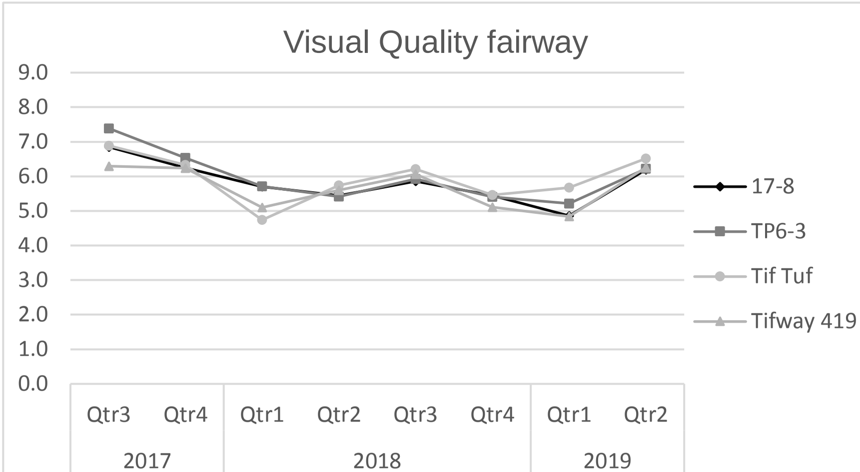


Figure 2. Color changes of best performing accessions and cultivars during 2 winter seasons in 3 locations, fairway

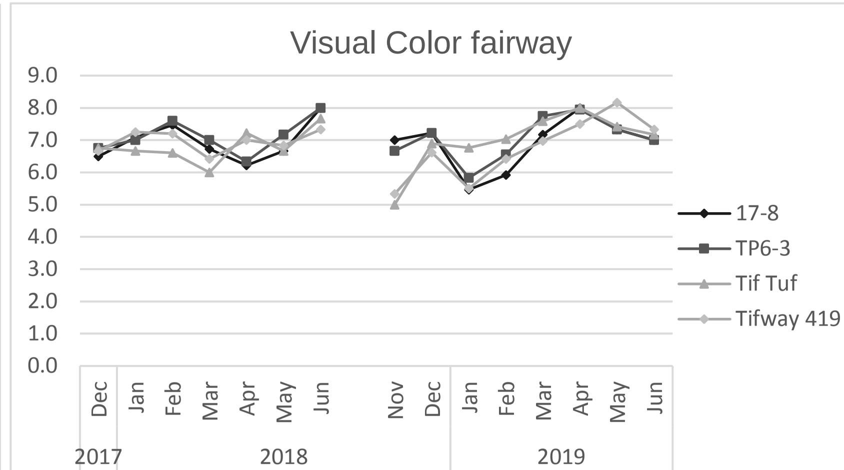


Figure 3. Quality of best performing accessions and cultivars during 2 years of study in 3 locations, rough/lawn

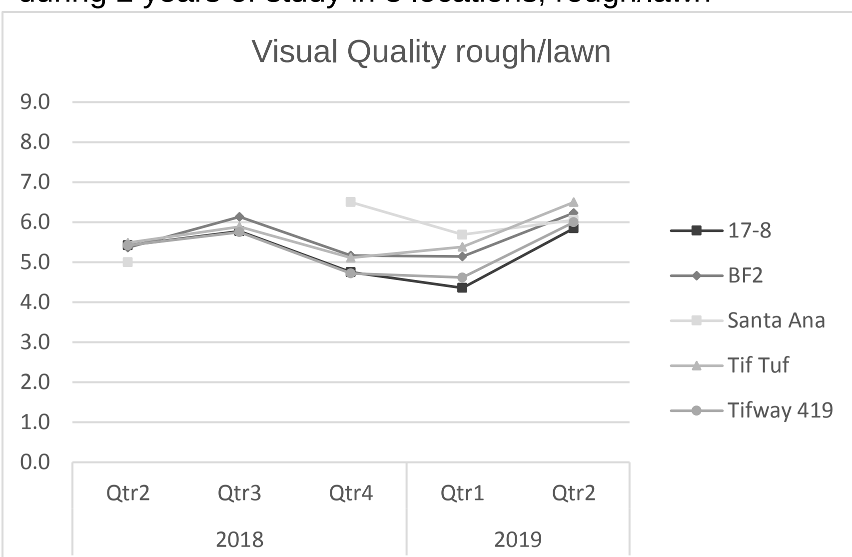


Figure 4. Color changes of best performing accessions and cultivars during winter season in 3 locations, rough/lawn

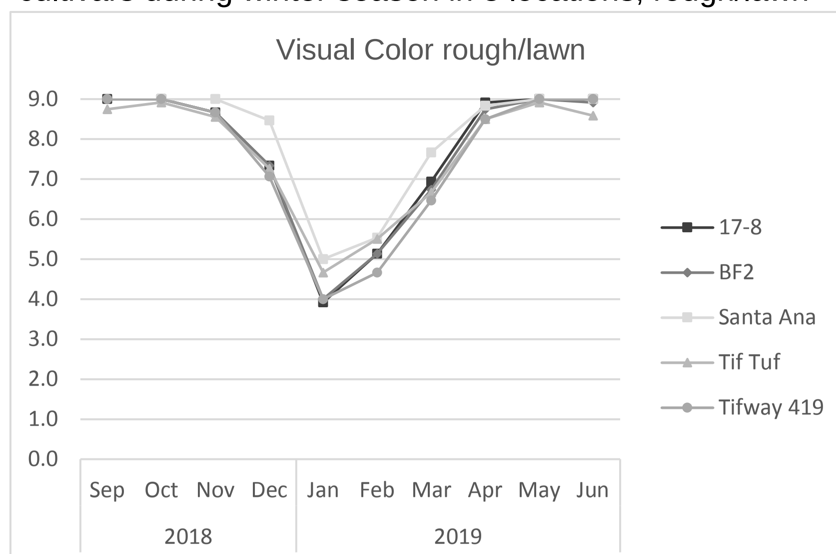


Figure 5. Comparison of percent green coverage in response to drought stress in established hybrid genotypes to commercial cultivars

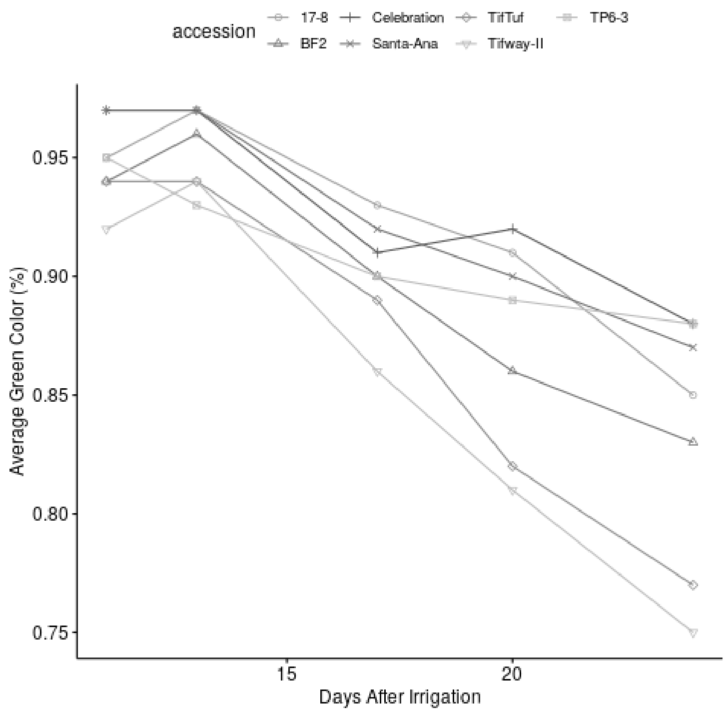
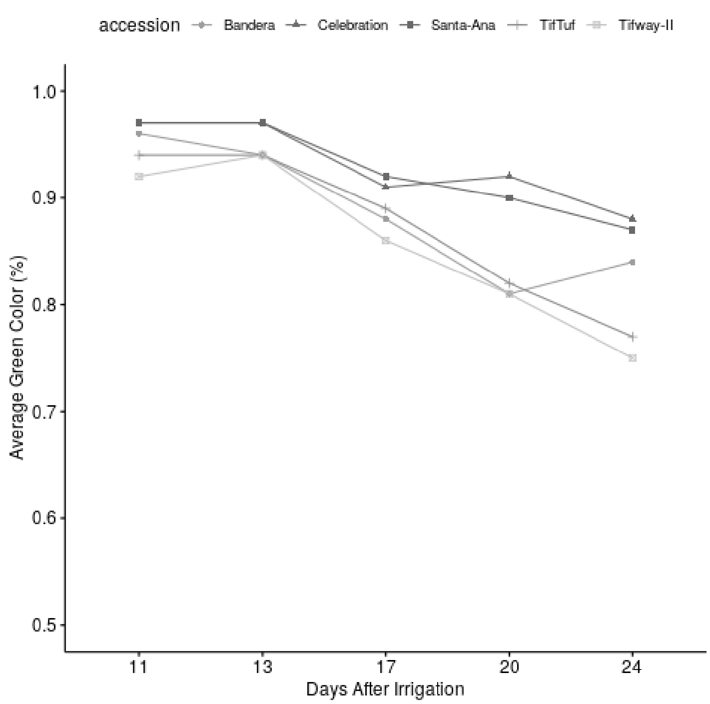


Figure 6. Comparison of percent green coverage in response to drought stress among commercial cultivars



Kikuyugrass:

Kikuyugrass is a warm-season species that originated from the east African Highlands and now inhabits every continent except Antarctica (Mears, 1970). It was first imported into California in the 1920s for soil erosion control on hillsides and riverbanks (Garner, 1925); however, it quickly spread to colonize much of coastal southern and central California. Today, kikuyugrass is officially considered as an invasive weed with sale and transport prohibited in several California counties. Furthermore, it is on the Federal Noxious Weed list, which restricts importation of germplasm into the country and across state boundaries (USDA, 2012). Kikuyugrass spreads aggressively by rhizomes, stolons, and seed (Youngner et al., 1971). Also found in Hawaii and scantly in Arizona, the species is well suited to Mediterranean climates like California because it can photosynthesize across a wide temperature range as evidenced by its superior winter color retention among the warm-season turfgrasses (Wilen and Holt, 1995). These characteristics have allowed kikuyugrass to invade areas including golf courses, athletic fields, and lawns, where it often becomes the dominant managed turfgrass species rather than attempts to selectively remove it (Gross, 2003). In previous years we have sampled kikuyugrass from throughout California, from our collection at UCR (ca. 20-25 yrs. old), as well as Hawaii and Australia. A total of 20,000 single nucleotide polymorphism (SNP) markers were discovered using the Diversity Arrays Technology sequencing (DArTseq) platform. The hierarchical plot, gap statistics, and the principal coordinate analysis showed that the 336 accessions separated into three main clusters. Seventy-seven percent of the total genetic variation was due to within population variation, while 23% represented among population variation. This means that there is relatively little variation among known sources of the grass. Accessions from Australia and Hawaii showed a much broader degree of genetic diversity than our California samples and would be valuable stock for breeding should such effort become feasible and the exchange of germplasm possible. The level of variation is not impressive, but it does offer hope that progress by selection is possible, even if no germplasm can be imported. Over the last 2 years, we established a collection of available genotypes representing the greatest genetic diversity, conducted dry down events to select for improved drought tolerance and evaluated them for turf quality and winter color retention. Last year, 105 seedlings established from seed stocks of the grass from about 20-25 years back were added to the collection and included in the evaluation. Based on obtained data, genotypes showing the best quality, drought tolerance and color retention were planted in pots and used for crossing. DArT results were employed to cross the most genetically distant genotypes. Ca. 280 kikuyugrass hybrids were obtained and planted in the field this year. Evaluation and crossing of the best genotypes is continued. For further evaluation of kikuyugrass under drought stress, a dry-down area with 38 different genotypes planted in 3 replicates was established in 2019. “Whittet” was used as a standard in this trial. The initiation of the dry-down testing will commence at the start of May 2020. Kikuyugrass is tetraploid (presumably autotetraploid). It is very vigorous and aggressive. Autotetraploids in general are larger and more vigorous than their diploid predecessors. We assume that ploidy reduction will automatically reduce vigor and plant size, perhaps creating turf with much finer texture, and less aggressive growth. Two attempts to reduce ploidy via androgenesis have been made. There is no known technology adapted to this species and the species appears to be recalcitrant. We managed to determine the best methods to collect the material and apply external stresses to induce the switch from gametophytic to sporophytic pathway of microspore development, however none of these microspores managed to survive and form a new plant. We must try this approach in different seasons; perhaps the microspores will be more amenable to manipulation than in summer. Our assumption in this approach is that reduction of ploidy level to diploid will reduce plant vigor and size. We cannot predict, however, if such diploids will be fertile. In Festulolium where we reduced the ploidy level from tetraploid to diploid (Kopecky et al., 2005), some diploid individuals were in fact fertile and could be intercrossed to generate viable populations. Whether this will work in kikuyugrass is an open question; much depends on the level of differentiation of the genomes in the tetraploid, of which there are no data available.

Zoysiagrass:

Zoysiagrass (Zoysia sp.) is generally considered to have optimal winter color retention among the warm-season turfgrasses. UCR has some tradition in breeding of Zoysiagrass. In the 1980's UCR released cv. 'El Toro', a Z. japonica accession developed by the late Dr. Victor B. Youngner (Gibeault, 2003). El Toro had a much faster establishment rate, better late season color and more rapid spring green-up than other Z. japonica grasses, and less thatch production. This release was followed by two cultivars, 'De Anza' and 'Victoria' which were created by a complex hybridization 'El Toro' x hybrid (Z. matrella x (Z. japonica x Z. tenuifolia). De Anza is known for very good winter color retention. Unfortunately, all but a handful of germplasm from those breeding efforts has disappeared and if the breeding is to be initiated again, a new germplasm collection has to be established. As described below, we have acquired sample accessions from existing germplasm collections and breeding programs to be screened under Southern California conditions for their winter color retention and other critical turf characteristics. If UCR reenters zoysiagrass breeding, early on progress will be slow, given the long establishment time for zoysiagrass. However, once interesting accessions are identified and hybrids are made (by us or other breeding programs), progress should accelerate rapidly.

Winter Color Retention Germplasm Evaluation:

In an effort to help expedite development of warm-season turfgrasses with improved winter color retention and drought tolerance, bermudagrass germplasm from Oklahoma State University and the University of Florida, zoysiagrass germplasm from Texas A&M University, and germplasm from other breeding programs is now under evaluation in Riverside, CA together with bermudagrass, zoysiagrass, and kikuyugrass germplasm from UCR. Replicate space plantings were established in fall 2016. Starting the winter 2017/2018 accessions are being evaluated for winter color retention and spring green-up, along with turf quality evaluation during the summer season. Ratings include visual ratings and NDVI. This year 16 advanced lines developed by Texas A&M and 4 cultivars, including De Anza and El Toro, were planted in cooperation with USGA at Meadow Club in Fairfax and Napa Golf Course. Once the plots are established, suitability for Northern California climate with emphasis on winter color retention will be evaluated.

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Acknowledgments:

Thanks to the CTLF, USGA, MWD, WMWD, West Coast Turf, Meadow Club, Arizona Country Club, Napa GC, Almaden GCC, and The Preserve at Santa Lucia for their support of this research.

Stop #2a: Preemergence Smooth Crabgrass Control in Bermudagrass Turf

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Objectives:

This study was conducted to evaluate and compare the efficacy of various granular formulations of preemergence herbicides for control of smooth crabgrass (*Digitaria ischaemum*) control in hybrid bermudagrass (*Cynodon* spp.) maintained as a golf course fairway or athletic field.

Materials and methods:

The study was conducted on mature hybrid bermudagrass (*Cynodon* spp.) 'GN-1' turf on a Hanford fine sandy loam. Turf was mowed 3 days/wk at 0.5 inches and received no fertilizer in 2019 season, either prior to the study initiation or throughout the trial. Herbicide treatments were applied on March 7, 2019 and April 18, 2019. Treatments were applied manually using hand-shakers to ensure uniform distribution within each plot area. Immediately following application, plots were irrigated to provide moisture required for their activation. Experimental design was a complete randomized block with 4 replications. Plot size was 5×7 ft with 1-ft alleys.

Starting from March 7, 2019 plots were evaluated weekly for smooth crabgrass cover (0-100%) other weeds present at the study initiation, and injury caused by treatments (0-10; 10=highest).

Results:

First crabgrass plants started emerging within the trial area after third week following initial application, mainly in untreated plots. On the fourth week the target weed cover within those plots already exceeded 15%. Starting from that date, crabgrass plants were developing quite rapidly and after another month the weed cover among those plots was already above 50% and increasing. Ultimately, crabgrass approached to full cover in the untreated area after twenty weeks from the time of initial treatment application.

All of the herbicide treatments used in the study provided satisfactory crabgrass emergence suppression (below the threshold of 10% weed cover) for twelve weeks after initial treatment application. Furthermore, there were no significant differences among herbicide treatments for thirteen weeks from the beginning of the study. First treatment that succumbed to crabgrass pressure was FreeHand 1.75 G allowing target weed to exceed the threshold level ca. fourteen weeks after the study began. The week after, Crew at 150 lbs/acre and Specticle G broke down under growing crabgrass pressure. Treatments that kept crabgrass emergence below the threshold level for the longest were Crew at 200 lbs/acre and the same product used at 150 oz/acre twice on a 6-week interval. Those two treatments were capable to withstand crabgrass pressure for eighteen weeks from the study initiation, being at the same time the most effective treatments in terms of the herbicidal longevity resulting in more than 50% of crabgrass suppression in comparison to untreated control by the most recent rating event. Target weed cover in remaining treatments ranged from 52% to 70% (Figure 1).

Other weeds identified within the trial area in the beginning of the study were: wild celery (*Cycospermum leptophyllum*), lesser swinecress (*Lepidium didymum*), clumpy ryegrass (*Lolium perenne*) and annual bluegrass (*Poa annua*). Most of those species checked out naturally within ten weeks from the trial initiation. Besides severe injury to annual bluegrass caused by FreeHand 1.75G and Specticle G, no other herbicide effects were observed on these species (data not shown).

In addition, no phytotoxicity was observed with Crew treatments while there was some occurrence of thinning and green up inhibition caused by FreeHand 1.75G and Specticle G (data not shown).

Acknowledgments:

Thanks to Corteva for supporting this research.

Table 1. Herbicide treatments tested in the preemergence smooth crabgrass control trial in Riverside, CA. 2019.

No.	Treatment	Active ingredient(s)	Company	Rate (lbs/acre)	Timing
1	Untreated Control	-	-	-	-
2	Crew	dithiopyr, isoxaben	Corteva	150	A
3	Crew	dithiopyr, isoxaben	Corteva	200	A
4	Crew	dithiopyr, isoxaben	Corteva	150	AB
5	FreeHand 1.75G	dimethenamid-P, pendimethalin	BASF	150	A
6	Specticle G	indaziflam	Bayer	150	A

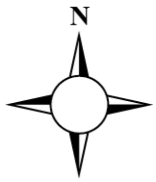
Application codes (timing):

A – 03/07/2019
B – 04/18/2019

Preemergence Smooth Crabgrass Control Trial Plot Plan

(12 G 1 SE)

101 **1**	102 **2**	103 **3**	104 **4**	105 **5**	106 **6**	107 **5**	108 **2**
201 **5**	202 **2**	203 **6**	204 **3**	205 **6**	206 **1**	207 **4**	208 **3**
301 **4**	302 **1**	303 **5**	304 **1**	305 **3**	306 **6**	307 **2**	308 **4**



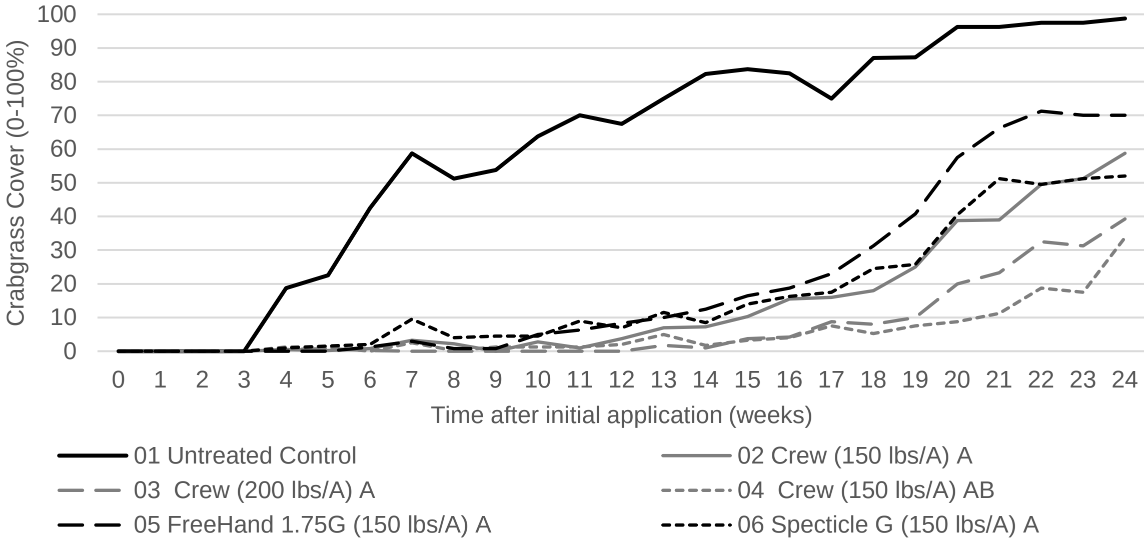


Figure 1. The effect of preemergence herbicide treatments on smooth crabgrass (*Digitaria ischaemum*) cover (0-100%) tested in Riverside, CA. 2019.

Stop #2a: Postemergence *Oxalis* Control in Bermudagrass Turf

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Objectives:

This study was conducted to evaluate and compare the ability of various herbicides for postemergence yellow woodsorrel (*Oxalis* sp.) control in hybrid bermudagrass (*Cynodon* spp.) maintained as a golf course fairway or athletic field.

Materials and methods:

The study was conducted on mature hybrid bermudagrass (*Cynodon* spp.) 'GN-1' turf on a Hanford fine sandy loam. Turf was mowed 3 days/wk at 0.5 inches and received no fertilizer in 2019 season, either prior to the study initiation or throughout the trial. Herbicide treatments were applied on 28-day intervals beginning on July 2, 2019 (except for Pylex which was initially applied on July 31, 2019) for a total of 2 applications and for UCR 005 treatment which was applied only once. Treatments were applied using a CO_2-powered backpack sprayer equipped with TeeJet 8002VS nozzles calibrated to deliver 1 gallon/1000 ft^2. Experimental design was a complete randomized block with 5 replications. Plot size was 4×6 ft with 1-ft alleys.

Plots were evaluated weekly for injury caused with treatments (0-10; 10=highest), yellow woodsorrel cover (0-100%), wild celery cover (0-100%) and smooth crabgrass cover (0-100%) beginning at the time of initial herbicide application. Also, percentage of weed control was determined for each species separately.

Results:

No significant or persisting turfgrass injury was observed with any of the employed herbicide treatments, although some preparations resulted in temporary turfgrass discoloration mainly manifested as slight turf brightening (Monument) or foliage bleaching (Pylex) (data not shown).

Ultimately, by August 28, the highest level of target weed control (close or equal to 100%) was provided with Monument 75WG and all UCR 003 treatments. Although, while Monument activity slowly but consistently decreased the amount of *Oxalis* plants within treated plots, UCR 003 treatments resulted in much faster eradication, exceeding the levels of 80% and 90% weed control two weeks after initial application. This level of control also remained until the most recent data collection date (Figure 1).

Tribute Total, Celsius WG, UCR 001 + UCR A and UCR 005 also resulted in progressive decrease in *Oxalis* cover (especially in the beginning of the trial). However, maximum control level provided with those treatments ranged from 74% to 85% and it did not last until the most recent data collection date, allowing *Oxalis* populations to recover (Figure 1). Furthermore, SpeedZone Southern, UCR 002 + UCR A did not provide any satisfactory target weed control throughout the study. The extent of *Oxalis* control with Pylex could not yet be ultimately determined for this report, since this treatment, due to lack of product at the time of the study initiation, was included for the first time with the second set of applications. Therefore, its efficacy is still under evaluation (data not shown).

Other weeds present within the study area when the experiment began included wild celery (*Cyclospermum leptophyllum*) and smooth crabgrass (*Digitaria ischaemum*). All of the treatments employed in the trial accelerated the natural dieback of wild celery plants but no treatment had significant activity on crabgrass. In addition, once the void was created after other weeds were removed, crabgrass took over the majority of the study area (data not shown).

Acknowledgments:

Thanks to BASF, Bayer and Syngenta for supporting this research and/or for providing products.

Table 1. Treatments tested in the postemergence Oxalis control trial in Riverside, CA. 2019.

No.	Treatment	Active ingredient(s)	Company	Rate	Timing
1	Untreated Control	-	-	-	-
2	Monument 75WG	trifloxysulfuron-sodium	Syngenta	0.53 oz/A	AB
	Activator 90	*non-ionic surfactant*	Loveland	0.25 % v/v	AB
3	Tribute Total	thiencarbazone-methyl, foramsulfuron, halosulfuron-methyl	Bayer	3.20 oz/A	AB
	Activator 90	*non-ionic surfactant*	Loveland	0.25 % v/v	
4	Celsius WG	thiencarbazone-methyl, iodosulfuron-methyl-sodium, dicamba	Bayer	4.90 oz/A	AB
	Activator 90	*non-ionic surfactant*	Loveland	0.25 % v/v	
5	SpeedZone Southern	2,4-D, mecoprop-p, dicamba, carfentrazone-ethyl	PBI-Gordon	4.00 pints/A	AB
6	Pylex	topramezone	BASF	1.00 oz/A	BC
	MSO Concentrate	*methylated seed oil*	Loveland	0.50 % v/v	
7	UCR 001	*classified*	-	-	AB
	UCR A	*classified*	-	-	
8	UCR 002	*classified*	-	-	AB
	UCR A	*classified*	-	-	
9	UCR 003	*classified*	-	-	AB
10	UCR 003	*classified*	-	-	AB
11	UCR 003	*classified*	-	-	AB
12	UCR 004	*classified*	-	-	AB
13	UCR 004	*classified*	-	-	AB
14	UCR 005	*classified*	-	-	A

Application codes (timing):

A – 07/02/2019
B – 07/31/2019
C – 08/28/2019

Postemergence *Oxalis* Control Trial Plot Plan

(12 G 1 W)

114	113	112	111	110	109	108	107	106	105	104	103	102	101
12	**8**	**7**	**11**	**3**	**6**	**14**	**1**	**13**	**2**	**9**	**4**	**10**	**5**
214	213	212	211	210	209	208	207	206	205	204	203	202	201
2	**5**	**7**	**6**	**9**	**8**	**14**	**4**	**3**	**10**	**13**	**1**	**11**	**12**
314	313	312	311	310	309	308	307	306	305	304	303	302	301
10	**12**	**2**	**8**	**4**	**6**	**3**	**7**	**1**	**14**	**11**	**9**	**5**	**13**
414	413	412	411	410	409	408	407	406	405	404	403	402	401
9	**4**	**7**	**10**	**13**	**14**	**11**	**2**	**6**	**3**	**8**	**1**	**12**	**5**
514	513	512	511	510	509	508	507	506	505	504	503	502	501
14	**3**	**9**	**11**	**2**	**8**	**7**	**6**	**1**	**5**	**12**	**13**	**10**	**4**

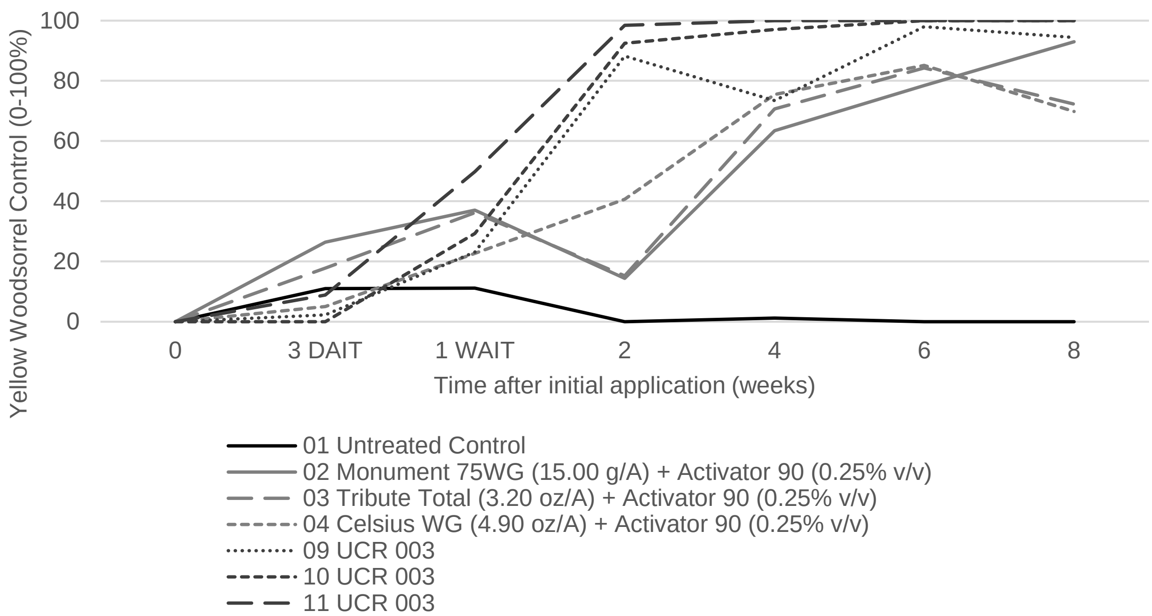

Figure 1. The effect of chosen best performing postemergence herbicide treatments on yellow woodsorrel (*Oxalis* spp.) control (0-100%) tested in Riverside, CA. 2019.

Stop #3: USGA/NTEP Cool-Season Water Use Trial

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Objectives:

The National Turfgrass Evaluation Program (NTEP) is designed to develop and coordinate uniform evaluation trials of turfgrass varieties and promising selections in the United States and Canada. Test results can be used by national companies and plant breeders to determine the broad picture of the adaptation of cultivars or experimental selections. Results can also be used to determine if a cultivar is well adapted to a local area or level of turf maintenance. The objective of the 2016 USGA National Cool-Season Water Use and Drought Resistance Test is to identify Kentucky bluegrass, tall fescue and perennial ryegrass cultivars that are best adapted to deficit irrigation and drought conditions.

Materials and Methods:

The study was seeded on November 1, 2016 and was established during winter 2016 and spring 2017 with abundant water. The entry list for the USGA/NTEP Cool-Season trial can be found in Table 1. Plots were irrigated using deficit irrigation, consisting of three irrigation regimes [80%, 60%, and 40% short crop reference evapotranspiration (ET_{os}) replacements] for about 4 months in 2017 (June 27 to October 21) and 2018 (June 1 to September 30), and watered at 100% ET_{os} replacement during the rest of the year. Deficit irrigation in 2019 was resumed on June 1 and will last until September 30. Plots are mowed at 2.5 in and fertilized with 0.5 lb N/month with a total of 5 lbs N annually. Visual quality (1-9, 9 = best) and percent green cover (digital image analysis) were taken weekly during deficit irrigation period.

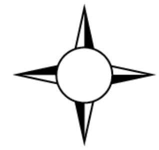
Results

As observed in 2017 and 2018, no cultivar was able to withstand three months of 40% ET_{os} replacement irrigation. Similarly, in 2019, no cultivar had acceptable turfgrass quality after 11 weeks of deficit irrigation at any ET_{os} levels (Table 2). At 80% ET_{os}, green cover ranged between 24.0% and 44.1% for Kentucky bluegrass and between 32.0% and 59.4% for tall fescue (Table 3). Several tall fescue cultivars had over 50% green cover including BAR FA 121095, DLFPS 321/3679, PST-R511, and Supersonic. There was no difference in quality within each species at 40% ET_{os}.

Table 1. Entry list for the 2016 National Cool-Season Water Use and Drought Resistance Test.

Entry Number	Species	Cultivar Name
1	Kentucky Bluegrass	Barserati
2	Kentucky Bluegrass	Barrari
3	Kentucky Bluegrass	Everest
4	Kentucky Bluegrass	Blue Note
5	Kentucky Bluegrass	Babe
6	Kentucky Bluegrass	NAI-13-132
7	Kentucky Bluegrass	NAI-13-14
8	Kentucky Bluegrass	Blue Devil
9	Kentucky Bluegrass	Dauntless
10	Kentucky Bluegrass	PST-K13-137
11	Kentucky Bluegrass	Orion
12	Kentucky Bluegrass	PST-K15-169
13	Kentucky Bluegrass	PST-K11-118
14	Kentucky Bluegrass	PST-K13-141
15	Kentucky Bluegrass	Midnight
16	Perennial Ryegrass	SR 4650
17	Tall Fescue	BarRobusto
18	Tall Fescue	BAR FA 121095
19	Tall Fescue	DLFPS 321/3677
20	Tall Fescue	DLFPS 321/3679
21	Tall Fescue	DLFPS 321/3678
22	Tall Fescue	Nonet
23	Tall Fescue	GO-AOMK
24	Tall Fescue	Supersonic
25	Tall Fescue	Titanium 2LS
26	Tall Fescue	Thor
27	Tall Fescue	Thunderstruck
28	Tall Fescue	RS4
29	Tall Fescue	Kingdom
30	Tall Fescue	MRSL TF15
31	Tall Fescue	Catalyst
32	Tall Fescue	Stetson II
33	Tall Fescue	PST-5SDS
34	Tall Fescue	PST-R511
35	Tall Fescue	Matisse

Plot plan of for the 2016 National Cool-Season Water Use and Drought Resistance Test.



80% ET

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
X	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19
5	9	7	1	11	15	13	2	12	3	14	6	10	8	4	X	16	32
17	24	20	29	34	21	18	26	19	22	28	33	35	31	27	30	25	23
6	4	8	12	10	3	15	11	13	7	2	14	1	5	9	16	X	28
25	22	30	23	19	17	24	21	33	31	18	29	20	26	32	35	27	34

40% ET

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
X	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19
5	9	7	1	11	15	13	2	12	3	14	6	10	8	4	X	16	32
17	24	20	29	34	21	18	26	19	22	28	33	35	31	27	30	25	23
6	4	8	12	10	3	15	11	13	7	2	14	1	5	9	16	X	28
25	22	30	23	19	17	24	21	33	31	18	29	20	26	32	35	27	34

ET 60%

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
X	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19
5	9	7	1	11	15	13	2	12	3	14	6	10	8	4	X	16	32
17	24	20	29	34	21	18	26	19	22	28	33	35	31	27	30	25	23
6	4	8	12	10	3	15	11	13	7	2	14	1	5	9	16	X	28
25	22	30	23	19	17	24	21	33	31	18	29	20	26	32	35	27	34

Table 2. Turf quality of each entry irrigated at 40%, 60% or 80% ET_{os} replacements on 8/22/2019. Riverside, CA.

Cultivar	Species	Turf quality		
		ET_{os}=0.4	ET_{os}=0.6	ET_{os}=0.8
Babe	Kentucky bluegrass	2.0	3.3	3.5
Barserati	Kentucky bluegrass	1.7	3.0	2.5
Barrari	Kentucky bluegrass	1.7	2.8	3.0
Blue Devil	Kentucky bluegrass	2.0	3.0	3.2
Blue Note	Kentucky bluegrass	2.2	3.0	3.2
Dauntless	Kentucky bluegrass	1.7	3.2	3.2
Everest	Kentucky bluegrass	2.2	3.0	3.2
Midnight	Kentucky bluegrass	2.3	2.8	3.5
NAI-13-132	Kentucky bluegrass	2.0	3.0	3.3
NAI-13-14	Kentucky bluegrass	1.7	3.0	2.8
PST-K11-118	Kentucky bluegrass	2.0	3.0	3.0
PST-K13-137	Kentucky bluegrass	2.0	3.0	3.5
PST-K13-141	Kentucky bluegrass	2.0	2.8	3.0
Orion	Kentucky bluegrass	1.7	3.0	3.2
PST-K15-169	Kentucky bluegrass	2.0	3.0	3.3
SR 4650	Perennial ryegrass	2.2	3.0	3.5
BAR FA 121095	Tall fescue	2.3	3.3	3.5
BarRobusto	Tall fescue	2.3	3.3	3.8
Catalyst	Tall fescue	2.2	3.0	3.3
DLFPS 321/3677	Tall fescue	2.5	3.0	4.0
DLFPS 321/3678	Tall fescue	2.3	3.2	3.5
DLFPS 321/3679	Tall fescue	2.5	3.0	4.0
GO-AOMK	Tall fescue	2.0	3.3	4.0
Kingdom	Tall fescue	2.2	3.0	3.3
Matisse	Tall fescue	2.0	3.3	3.3
MRSL TF15	Tall fescue	2.2	3.2	3.7
Nonet	Tall fescue	2.2	3.0	3.7
PST-5SDS	Tall fescue	2.2	3.0	3.7
PST-R511	Tall fescue	2.2	2.8	4.0
RS4	Tall fescue	2.3	3.3	4.0
Stetson II	Tall fescue	2.0	3.0	3.5
Supersonic	Tall fescue	2.2	3.0	4.2
Thor	Tall fescue	2.2	3.0	3.2
Thunderstruck	Tall fescue	2.0	3.2	3.3
Titanium 2LS	Tall fescue	2.0	3.2	3.8
LSD*		0.5	0.5	0.9

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 3. Green Cover of each entry irrigated at 40%, 60% or 80% ET_{os} replacements on 8/22/2019. Riverside, CA.

Cultivar	Species	Percent coverage		
		ET_{os}=0.4	ET_{os}=0.6	ET_{os}=0.8
Babe	Kentucky bluegrass	1.7	17.2	39.2
Barserati	Kentucky bluegrass	1.5	11.2	24.0
Barrari	Kentucky bluegrass	1.3	7.8	34.7
Blue Devil	Kentucky bluegrass	0.9	15.1	32.4
Blue Note	Kentucky bluegrass	1.8	11.2	40.3
Dauntless	Kentucky bluegrass	1.1	9.9	30.5
Everest	Kentucky bluegrass	1.6	15.8	34.8
Midnight	Kentucky bluegrass	3.1	12.7	44.1
NAI-13-132	Kentucky bluegrass	1.0	16.9	41.4
NAI-13-14	Kentucky bluegrass	1.2	19.8	33.6
PST-K11-118	Kentucky bluegrass	1.5	14.1	39.8
PST-K13-137	Kentucky bluegrass	1.3	17.1	37.2
PST-K13-141	Kentucky bluegrass	1.7	15.2	40.4
Orion	Kentucky bluegrass	1.7	16.8	32.4
PST-K15-169	Kentucky bluegrass	2.3	7.3	36.7
SR 4650	Perennial ryegrass	3.3	15.3	39.9
BAR FA 121095	Tall fescue	4.7	23.4	56.0
BarRobusto	Tall fescue	5.1	23.8	47.5
Catalyst	Tall fescue	1.6	12.4	39.0
DLFPS 321/3677	Tall fescue	6.5	17.7	44.8
DLFPS 321/3678	Tall fescue	4.7	19.7	49.9
DLFPS 321/3679	Tall fescue	4.5	18.3	50.9
GO-AOMK	Tall fescue	3.8	16.6	48.3
Kingdom	Tall fescue	2.3	15.7	39.1
Matisse	Tall fescue	2.1	24.1	47.1
MRSL TF15	Tall fescue	2.8	18.9	49.2
Nonet	Tall fescue	3.0	18.0	45.0
PST-5SDS	Tall fescue	2.1	15.1	47.2
PST-R511	Tall fescue	2.7	11.9	59.4
RS4	Tall fescue	4.9	22.8	47.2
Stetson II	Tall fescue	3.4	14.7	41.4
Supersonic	Tall fescue	4.5	18.8	59.4
Thor	Tall fescue	2.3	19.8	32.0
Thunderstruck	Tall fescue	2.9	15.4	34.3
Titanium 2LS	Tall fescue	3.5	17.0	45.6
LSD*		3.2	9.3	21.4

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$)

Stop #4a: Evaluation of Fungicides for Control of Anthracnose Disease on Annual Bluegrass Putting Greens

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Objectives:

This study was conducted to evaluate efficacy of 23 different fungicide treatments to control foliar and basal rot anthracnose (*Colletotrichum cereale*) and summer patch (*Magnaporthe poae*) diseases preventatively on annual bluegrass (*Poa annua*) maintained as a golf course putting green.

Materials and methods:

The study was conducted on mature annual bluegrass (*Poa annua*) 'Peterson's Creeping' turf on a Hanford fine sandy loam amended with sand. Green was established in 2007 from seed and plots have been originally inoculated with anthracnose spores grown in laboratory. In later years, inoculation was achieved through core aeration and dragging in order to spread the existing inoculum.

Turf was mowed 5 days/wk at 0.125 inches and received 0.125 lbs N/1000 ft^2 in liquid form every 14 days. Fungicide treatments were applied every 14 days beginning on June 6, 2019 (before disease symptoms were present) for a total of 8 applications. Treatments were applied using a CO_2-powered backpack sprayer equipped with TeeJet 8004VS nozzles calibrated to deliver 2 gallons/1000 ft^2. Experimental design was a complete randomized block with 6 replications. Plot size was 4×6 ft with 2-ft alleys.

Starting from June 10, plots were evaluated biweekly for visual turf quality and turf green color intensity (both 1-9; 9=highest), injury caused with treatments (0-10; 10=highest), loss of turfgrass stand cover (0-100%), anthracnose and summer patch diseases cover (0-100%), disease symptoms severity within the affected area (0-10; 10=highest), disease pressure, calculated from the two previously mentioned parameters, and Normalized Difference Vegetation Index (NDVI).

Results:

Although *Colletotrichum cereale* acervuli were first noted in the middle of June and anthracnose activity in untreated plots was already observed at the significant level (exceeding the threshold of 10% cover) in the beginning of July, the disease started spreading rapidly in August (data not shown), resulting in disease cover of more than 60% within untreated plots and ca. 2.5-point drop in turf visual quality (Table 2).

Except for UCR 007 treatment, which resulted in unacceptable injury to turf (above 3 on 0-10 scale) and persisting by the most recent rating before the publication (August 27; data not shown), the only phytotoxicity resulting from the use of fungicides was observed in the beginning of the study with its peak on June 17 (2 WAIT - prior to 2^{nd} application). On this date, significant turfgrass injury was observed with both Bayer Programs and UCR Programs No. 1-3 (containing Mirage Stressgard) and UCR Program No. 4 (Banner Maxx II). Although the injury with those treatments was statistically significant, none of them crossed the threshold of unacceptable injury level (Table 2) and all of them fully recovered by the next rating event (data not shown).

In this year's trial, the best treatment in terms of the lowest disease cover (below 10%) by the last data collection date was UCR Program No. 5, while statistically it was no different than: other UCR Programs (with exception of UCR Program No. 1), BASF Program No. 1, both Bayer Programs, Syngenta Program No. 2, standalone tank-mixes of Daconil Action, as well as UCR 005 (treatment 20) (Table 2). Among listed treatments there were also no significant differences in disease severity within the affected areas, thus no differences in disease pressure ratio.

No significant differences were shown between untreated control and any of the treatments employed in the study on the day of last rating, in terms of turfgrass visual quality, which generally have ranged from 4.0 to 6.5 (Table 2). Lack of those differences could be also associated with the occurrence of summer patch within the study area, which coverage of ranged from 8% to 20% on last data collection date. As in previous years, this pathogen was difficult to distinguish once both diseases became active since their symptoms can be similar in appearance. Therefore, due to high variability among replications, no significant differences were observed among employed treatments in terms of summer patch cover (Table 2).

Another aspect considered in this study was the impact of the employed fungicides on the intensity of turf green color. Subjective evaluation showed that, on August 27, the treatment that resulted in the darkest overall green color was the standalone tank-mix of Daconil Action with Secure Action and Primo Maxx. Nevertheless, both Bayer Programs and Syngenta Program No. 1, UCR Programs no. 2 through 5 as well as UCR 005 and remaining standalone Daconil Action tank-mix (including Appear II) were statistically comparable to this treatment.

Finally, when considering turfgrass cover loss throughout the study being the result of the impact of the suboptimal conditions working together (with the emphasis on the disease activity), the only significant decrease was observed in untreated control, BASF Program No. 2 and UCR 005 (treatments 19 and 21) and it ranged from 11% to 20% by August 27, although in case of BASF Program No.2, observed loss of turf is mainly associated with severe scalping which occurred within some plots.

Acknowledgments:

Thanks to BASF, Bayer and Syngenta for supporting this research and/or for providing products.

Table 1. Treatments tested in the anthracnose control fungicide trial in Riverside, CA. 2019.

No.	Treatment	Active ingredient(s)	Company	Rate (oz/1000 ft^2)	Timing
1	Untreated Control	-	-	-	-
2	BASF Program No. 1				
	Navicon Intrinsic	mefentrifuconazole, pyraclostrobin	BASF	0.85	ADG
	Affirm WDG	polyoxin D zinc salt	Nufarm	0.90	BEH
	Signature XTRA Stressgard	aluminium-tris	Bayer	4.00	CF
3	BASF Program No. 2				
	Maxtima	mefentrifuconazole	BASF	0.60	ADG
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	BEH
	Affirm WDG	polyoxin D zinc salt	Nufarm	0.90	CF
4	Bayer Program No. 1				
	Mirage Stressgard	tebuconazole	Bayer	1.00	ACEG
	Daconil Weatherstik	chlorothalonil	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	4.00	
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
5	Bayer Program No. 2				
	Mirage Stressgard	tebuconazole	Bayer	1.00	AG
	Daconil Weatherstik	chlorothalonil	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	4.00	BDFGH
	Exteris Stressgard	fluopyram, trifloxystrobin	Bayer	4.00	CE
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
6	Syngenta Program No. 1				
	Heritage Action	azoxystrobin, acibenzolar-S-methyl	Syngenta	0.40	ACEG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BDFH
	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
7	Syngenta Program No. 2				
	Velista	penthiopyrad	Syngenta	0.50	ADG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BEH
	Heritage Action	azoxystrobin, acibenzolar-S-methyl	Syngenta	0.40	CF
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
8	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	A-H
	Appear II	potassium phosphite	Syngenta	6.00	
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	
9	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	A-H
	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	

	UCR Program No. 1				
10	Mirage Stressgard	tebuconazole	Bayer	1.00	AG
	Daconil Weatherstik	chlorothalonil	Syngenta	3.50	BDFH
	Chipco Signature	aluminium-tris	Bayer	4.00	BDFGH
	Affirm WDG	polyoxin D zinc salt	Nufarm	1.00	CE
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
	UCR Program No. 2				
11	Mirage Stressgard	tebuconazole	Bayer	1.00	AG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	5.30	BDFGH
	Affirm WDG	polyoxin D zinc salt	Nufarm	1.00	CE
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
	UCR Program No. 3				
12	Mirage Stressgard	tebuconazole	Bayer	1.00	AG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	5.30	BDFGH
	Affirm WDG	polyoxin D zinc salt	Nufarm	1.00	CE
	Lexicon Intrinsic	pyraclostrobin, fluxapyroxad	BASF	0.47	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
	UCR Program No. 4				
13	Banner Maxx II	propiconazole	Syngenta	2.00	AG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	5.30	BDFGH
	Affirm WDG	polyoxin D zinc salt	Nufarm	1.00	CE
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
	UCR Program No. 5				
14	Briskway	azoxystrobin, difenoconazole	Syngenta	0.50	AG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	5.30	BDFGH
	Affirm WDG	polyoxin D zinc salt	Nufarm	1.00	CE
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H
	UCR Program No. 6				
15	Maxtima	mefentrifuconazole	BASF	0.80	AG
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminium-tris	Bayer	5.30	BDFGH
	Affirm WDG	polyoxin D zinc salt	Nufarm	1.00	CE
	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	CE
	Primo Maxx	trinexapac-ethyl	Syngenta	0.10	A-H

16	UCR 001	*classified*	-	-	A-H
	UCR 002	*classified*	-	-	
	UCR 003	*classified*	-	-	
	UCR 004	*classified*	-	-	
17	UCR 001	*classified*	-	-	A-H
	UCR 002	*classified*	-	-	
	UCR 003	*classified*	-	-	
	UCR 004	*classified*	-	-	
18	UCR 005	*classified*	-	-	A-H
19	UCR 005	*classified*	-	-	A-H
20	UCR 005	*classified*	-	-	A-H
21	UCR 005	*classified*	-	-	A-H
22	UCR 006	*classified*	-	-	A-H
23	UCR 007	*classified*	-	-	A-H

Application codes (timing):

A – 06/06/2019
B – 06/19/2019
C – 07/03/2019
D – 07/18/2019
E – 07/31/2019
F – 08/14/2019
G – 08/28/2019
H – 09/14/2019

Anthracnose Disease Control Fungicide Trial Plot Plan

(12 G 4)

114	113	112	111	110	109	108		106	105	104	103	102	101
22	**6**	**4**	**17**	**2**	**7**	**10**		**11**	**3**	**1**	**9**	**23**	**21**
214	213	212	211	210	209	208	207	206	205	204	203	202	201
20	**8**	**18**	**5**	**19**	**16**	**13**	**15**	**12**	**14**	**7**	**4**	**6**	**9**
314	313	312	311	310	309	308	307	306	305	304	303	302	301
19	**5**	**13**	**1**	**16**	**22**	**10**	**15**	**23**	**2**	**14**	**11**	**8**	**21**
414	413	412	411	410	409	408	407	406	405	404	403	402	401
18	**3**	**17**	**12**	**20**	**9**	**21**	**6**	**13**	**19**	**1**	**15**	**4**	**23**
514	513	512	511	510	509				505	504	503	502	501
5	**11**	**2**	**7**	**17**	**3**				**16**	**14**	**10**	**12**	**22**
614	613	612	611	610	609				605	604	603	602	601
20	**8**	**18**	**4**	**9**	**15**				**21**	**11**	**23**	**5**	**7**
714	713	712	711	710	709	708	707	706	705	704	703	702	701
22	**2**	**14**	**12**	**18**	**1**	**20**	**10**	**17**	**6**	**16**	**13**	**8**	**19**
	813	812	811	810	809	808	807	806	805	804	803	802	801
	3	**7**	**4**	**11**	**6**	**8**	**2**	**18**	**10**	**1**	**14**	**5**	**17**
	913	912	911	910					905	904	903	902	901
	19	**23**	**21**	**22**					**15**	**20**	**9**	**13**	**16**
1014	1013	1012	1011	1010	1009				1005	1004	1003	1002	1001
12	**3**	**18**	**11**	**1**	**22**				**23**	**7**	**17**	**4**	**21**
1114	1113	1112	1111	1110	1109	1108	1107	1106	1105	1104	1103	1102	1101
14	**10**	**2**	**9**	**13**	**16**	**5**	**19**	**12**	**6**	**3**	**15**	**8**	**20**

Table 2. Effect of treatments on turfgrass visual quality (1-9; 9=highest), green color intensity (1-9, 9=highest), anthracnose disease cover (0-100%), summer patch cover (0-100%), turfgrass cover loss (0-100%) on August 27 and on turfgrass injury (0-10, 10=highest) on June 17 evaluated on annual bluegrass turf. Riverside, CA, 2019.

No.	Treatment	Visual quality	Color	Anthracnose cover	Summer patch cover	Turfgrass cover loss	Turfgrass injury
1	Untreated Control	4.0*	5.0 G*	64.2 A*	11.7*	19.8 A*	0.3 DE*
2	BASF Program No. 1	5.7	6.5 C-F	19.2 C-G	19.2	1.7 D	0.0 E
3	BASF Program No. 2	4.3	5.8 FG	31.7 B-F	15.0	12.5 AB	0.0 E
4	Bayer Program No. 1	6.2	7.7 A-D	13.3 FG	8.3	2.6 CD	1.8 C
5	Bayer Program No. 2	6.2	7.8 A-C	14.2 E-G	10.8	5.0 B-D	2.2 BC
6	Syngenta Program No. 1	5.2	7.0 A-F	33.3 B-F	13.3	5.8 B-D	0.2 DE
7	Syngenta Program No. 2	5.0	6.8 B-F	20.0 B-G	12.5	3.2 B-D	0.0 E
8	Daconil Action (3.5 oz/M) + Appear II (6.0 oz/M)**	6.0	7.8 A-C	12.5 FG	8.3	4.7 B-D	0.2 DE
9	Daconil Action (3.5 oz/M) + Secure Action (0.5 oz/M)**	6.3	8.3 A	12.5 FG	10.0	1.7 D	0.7 D
10	UCR Program No. 1	4.8	6.5 C-F	33.3 B-F	15.8	5.5 B-D	1.8 C
11	UCR Program No. 2	6.2	7.3 A-E	15.8 D-G	9.2	2.5 CD	2.0 C
12	UCR Program No. 3	6.0	7.2 A-F	13.3 FG	15.0	2.7 CD	2.7 AB
13	UCR Program No. 4	5.2	7.0 A-F	23.0 B-G	13.3	5.8 B-D	2.8 A
14	UCR Program No. 5	6.5	8.0 AB	7.5 G	12.8	1.0 D	0.5 DE
15	UCR Program No. 6	4.5	6.5 C-F	30.8 B-G	19.2	7.2 B-D	0.2 DE
16	UCR 001 + UCR 002 + UCR 003 + UCR 004	5.7	6.2 E-G	39.2 B-D	14.2	6.3 B-D	0.0 E
17	UCR 001 + UCR 002 + UCR 003 + UCR 004	5.3	6.0 E-G	43.3 AB	15.0	7.5 B-D	0.0 E
18	UCR 005	5.7	6.7 B-F	33.0 B-F	13.3	2.5 CD	0.0 E
19	UCR 005	4.8	6.2 E-G	33.3 B-F	17.5	11.9 A-C	0.0 E
20	UCR 005	5.2	6.3 D-G	27.5 B-G	10.8	7.6 B-D	0.0 E
21	UCR 005	4.0	5.8 FG	37.5 B-E	14.2	12.6 AB	0.0 E
22	UCR 006	5.5	7.0 A-F	33.3 B-F	7.5	6.3 B-D	0.0 E
23	UCR 007	3.8	5.0 G	42.5 A-C	15.0	6.4 B-D	2.7 AB

*Means followed by the same letter or not followed by any letter in a column are not significantly different (P=0.05).

**Treatments No. 8 and 9 also included Primo Maxx (0.1 oz/M) as the tank-mix component.

Stop #4b: Fungicide Plant Health Under Deficit Irrigation on Creeping Bentgrass Putting Greens

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Objectives:

This study was conducted to determine the ability of 11 different fungicide treatments to alleviate stress caused by deficit irrigation on creeping bentgrass (*Agrostis stolonifera*) maintained as a golf course putting green.

Materials and methods:

The study was conducted on mature creeping bentgrass (*Agrostis stolonifera*) 'Pure Distinction' turf on ca. 6-8 inches of sand/peat/soil conforming to USGA guidelines for rootzone mixes. Turf was mowed 5 days/wk at 0.110 inches and received 0.125 lbs N/1000 ft^2 in liquid form every 14 days as a blanket treatment prior to the study initiation. Fungicide treatments were applied every 14 days beginning on June 19, 2019 (before any stress conditions were introduced) for a total of 8 applications. In addition, all plots, except for untreated control, received 0.125 lbs N/1000 ft^2 as a tank-mix with fungicide applications. Treatments were applied using a CO_2-powered backpack sprayer equipped with TeeJet 8004VS nozzles calibrated to deliver 2 gallons/1000 ft^2. Experimental design was a complete randomized block with 4 replications. Plot size was 4×6 ft with no alleys.

Irrigation rate considered as a 'regular' (interpreted as sufficient to ensure undisturbed and healthy growth conditions prior to the introduction of any stress factor) for the experimental area was 100% of preceding week's ET_0 replacement. Following second application of fungicide treatments, plots received 'deficit' irrigation rate (80% of previous week's ET_0 replacement) for the period of 10 days (July 3 to July 12, 2019). On July 13, 2019 'regular' irrigation rate was restored and maintained until the end of the experiment. Throughout the whole trial, irrigation has been performed by hand with a hose/nozzle with a known output (gpm), in order to assure uniform water distribution.

Starting from June 18, plots were evaluated every two weeks for visual turf quality (1-9; 9=highest), turf green color intensity (1-9; 9=highest), injury caused with treatments (0-10; 10=highest), turfgrass stand cover (0-100%), localized dry spot cover (0-100%) and their severity within the injured area (0-10; 10 = highest), Normalized Difference

Vegetation Index (NDVI) using GreenSeeker instrument and volumetric soil water content (VWC) using time domain reflectometry (TDR).

Results:

No significant differences were observed among treatments in the beginning of the trial. Visually assessed turfgrass quality averaged at 6.6 and no localized dry spots (LDS) or other symptoms of unfavorable conditions impacting the plants were present at that time. This state persisted until the day when decreased irrigation rate was introduced to the turf (shortly after second treatment application) (Table 2).

Deficit irrigation lasted for 10 days and after this time the regular irrigation rate was brought back. Conspicuous decrease in overall turfgrass quality (which dropped to 4.9 in average) was noted during first rating event after the stress factor was removed (Table 2). This incident was accompanied by the rapid emergence of randomly located localized dry spots (LDS) and progressive turfgrass loss observed within the consecutive data collection dates. Average turfgrass cover reached the lowest level reported by the date of the report at six weeks after trial initiation and on this date (July 29) the average LDS cover reached the highest level of 29% of damaged area (that is 4 weeks after stress conditions were introduced and 2 weeks after the regular irrigation rate was reinstated). Although the average LDS area slowly decreased in subsequent ratings, overall turfgrass cover didn't show any signs of recovery and persisted until August 26 (Table 3). Furthermore, the general volumetric water content after the stress factor removal never dropped below 20%, indicating that no further water deficiency has been occurring within non damaged areas (data not shown).

In spite of all discussed circumstances, no significant separation among treatments was found throughout the trial in regard to the parameters evaluated. This is due in part to high variability within replications and highly random occurrence of damaged areas, with particular emphasis on untreated control plots (Table 2). Previous research conducted by UCR corroborates these results in that fungicides offer little or no plant health benefits during stress caused by deficit irrigation in a Mediterranean climate.

Acknowledgments:

Thanks to FMC and Syngenta for supporting this research and/or for providing products.

Table 1. Treatments tested in the plant health fungicide trial in Riverside, CA. 2019.

No.	Treatment	Active ingredient(s)	Company	Rate (oz/1000 ft^2)	Timing
1	Untreated Control (no-fert)	-	-	-	-
2	Fertilized Control*	-	-	-	-
3	Fame SC*	fluoxastrobin	FMC	0.36	A-H
4	Fame SC	fluoxastrobin	FMC	0.36	A-H
	UCR 001	*classified*	-	-	
5	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	A-H
6	Heritage Action	azoxystrobin, acibenzolar-S-methyl	Syngenta	0.40	A-H
7	Signature XTRA Stressgard	aluminium-tris	Bayer	4.00	A-H
8	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	A-H
9	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
10	Appear II	potassium phosphite	Syngenta	6.00	A-H
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	
11	Signature XTRA Stressgard	aluminium-tris	Bayer	4.00	A-H
	Daconil WeatherStik	chlorothalonil	Syngenta	3.60	
12	Appear II	potassium phosphite	Syngenta	6.00	A-H
	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	
13	Syngenta Rotation				
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	ACEG
	Appear II	potassium phosphite	Syngenta	6.00	
	Appear II	potassium phosphite	Syngenta	6.00	BDFH
	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	

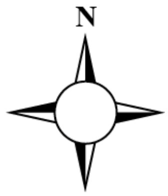
*All treatments except for 'Unfertilized Control' received 0.125 lbs N/1000 ft^2 every 2 weeks (tank mix or alone)

Application codes (timing):

A – 06/19/2019
B – 07/03/2019
C – 07/18/2019
D – 07/31/2019
E – 08/14/2019
F – 08/28/2019
G – 09/14/2019
H – 09/25/2019

Plant Health Fungicide Trial Plot Plan

(12 G 6 NW)



108 **8**	107 **7**	106 **6**	105 **5**	104 **4**	103 **3**	102 **2**	101 **1**
208 **9**	207 **10**	206 **11**	205 **12**	204 **13**	203 **8**	202 **4**	201 **7**
	307 **2**	306 **5**	305 **1**	304 **3**	303 **13**	302 **9**	
408 **11**	407 **6**	406 **12**	405 **10**	404 **9**	403 **7**	402 **1**	401 **8**
508 **4**	507 **13**	506 **6**	505 **11**	504 **2**	503 **5**	502 **12**	501 **3**
608 **10**	607 **5**	606 **9**	605 **7**	604 **13**	603 **6**	602 **4**	601 **8**
	707 **3**	706 **1**	705 **11**	704 **12**	703 **10**	702 **2**	

Table 2. Effect of treatments on turfgrass visual quality (1-9; 9=highest) evaluated on creeping bentgrass turf. Riverside, CA, 2019.

No.	Treatment	Visual Quality (1-9; 9 = highest)			
		2 WAIT	4 WAIT	6 WAIT	10 WAIT
1	Untreated Control (no fertilizer)	6.5	4.5	3.8	3.3
2	Fertilized Control	5.8	5.5	4.5	4.5
3	Fame SC (0.36 oz/M)	6.0	6.0	5.3	4.3
4	Fame SC (0.36 oz/M) + UCR 001	6.5	5.3	4.0	4.5
5	Insignia SC Intrinsic (0.7 oz/M)	6.8	4.3	3.3	3.5
6	Heritage Action (0.4 oz/M)	6.8	4.3	4.0	4.0
7	Signature XTRA** (4.00 oz/M)	6.5	5.0	3.5	2.3
8	Daconil Action (3.5 oz/M)	6.5	5.8	6.0	4.3
9	Secure Action (0.5 oz/M)	6.5	5.0	3.5	4.0
10	Appear II (6.0 oz/M) + Daconil Action (3.5 oz/M)	7.5	5.3	3.3	4.3
11	Signature XTRA** (4.00 oz/M) + Daconil WeatherStik (3.6 oz/M)	6.5	4.3	3.3	3.5
12	Appear II (6.0 oz/M) + Secure Action (0.5 oz/M)	7.3	4.3	3.0	3.5
13	Syngenta Rotation	6.8	5.0	3.5	4.3

*Means followed by the same letter in a column are not significantly different (P=0.05).
** Full name: Signature XTRA** Stressgard

Table 3. Effect of treatments on turfgrass cover (0-100%), localized dry spot cover (LDS; 0-100%) and volumetric soil water content (VWC; 0-100%) evaluated on creeping bentgrass turf. Riverside, CA, 2019.

No.	Treatment	Turfgrass Cover (0-100%)			
		2 WAIT	4 WAIT	6 WAIT	10 WAIT
1	Untreated Control (no fertilizer)	98.8	88.3	72.5	55.0
2	Fertilized Control	97.0	93.8	80.0	80.8
3	Fame SC (0.36 oz/M)	96.3	98.3	92.5	78.5
4	Fame SC (0.36 oz/M) + UCR 001	98.8	93.8	78.8	81.0
5	Insignia SC Intrinsic (0.7 oz/M)	100.0	85.0	60.0	70.5
6	Heritage Action (0.4 oz/M)	99.5	81.3	63.8	79.3
7	Signature XTRA** (4.00 oz/M)	98.8	91.0	72.5	53.8
8	Daconil Action (3.5 oz/M)	97.5	97.0	93.0	72.5
9	Secure Action (0.5 oz/M)	98.8	84.8	66.3	76.8
10	Appear II (6.0 oz/M) + Daconil Action (3.5 oz/M)	100.0	90.0	61.3	78.0
11	Signature XTRA** (4.00 oz/M) + Daconil WeatherStik (3.6 oz/M)	99.3	83.8	60.0	65.5
12	Appear II (6.0 oz/M) + Secure Action (0.5 oz/M)	100.0	76.3	52.5	63.0
13	Syngenta Rotation	100.0	95.0	68.8	81.8

No.	Treatment	LDS Cover (0-100%)			
		2 WAIT	4 WAIT	6 WAIT	10 WAIT
1	Untreated Control (no fertilizer)	0.0	13.3	28.8	22.5
2	Fertilized Control	0.0	22.5	20.0	11.0
3	Fame SC (0.36 oz/M)	0.0	2.0	7.8	6.3
4	Fame SC (0.36 oz/M) + UCR 001	0.0	13.8	22.5	5.5
5	Insignia SC Intrinsic (0.7 oz/M)	0.0	22.0	40.5	18.8
6	Heritage Action (0.4 oz/M)	0.0	19.5	36.3	10.8
7	Signature XTRA** (4.00 oz/M)	0.0	10.5	28.8	23.0
8	Daconil Action (3.5 oz/M)	0.0	0.0	4.3	7.5
9	Secure Action (0.5 oz/M)	0.0	15.0	34.5	24.5
10	Appear II (6.0 oz/M) + Daconil Action (3.5 oz/M)	0.0	20.0	41.3	22.3
11	Signature XTRA** (4.00 oz/M) + Daconil WeatherStik (3.6 oz/M)	0.0	27.5	41.3	31.5
12	Appear II (6.0 oz/M) + Secure Action (0.5 oz/M)	0.0	31.3	48.8	35.8
13	Syngenta Rotation	0.0	17.5	31.8	12.8

No.	Treatment	VWC (0-100%)			
		2 WAIT	4 WAIT	6 WAIT	10 WAIT
1	Untreated Control (no fertilizer)	33.2	24.6	27.6	23.0
2	Fertilized Control	32.5	24.5	29.2	34.2
3	Fame SC (0.36 oz/M)	35.3	32.2	28.9	32.2
4	Fame SC (0.36 oz/M) + UCR 001	37.7	23.4	28.2	32.2
5	Insignia SC Intrinsic (0.7 oz/M)	35.1	23.2	26.8	30.5
6	Heritage Action (0.4 oz/M)	35.8	18.1	22.6	30.9
7	Signature XTRA** (4.00 oz/M)	37.9	26.7	25.5	27.6
8	Daconil Action (3.5 oz/M)	36.7	35.6	26.4	34.6
9	Secure Action (0.5 oz/M)	40.9	24.4	25.5	31.3
10	Appear II (6.0 oz/M) + Daconil Action (3.5 oz/M)	39.2	24.1	28.5	38.0
11	Signature XTRA** (4.00 oz/M) + Daconil WeatherStik (3.6 oz/M)	35.1	17.8	29.5	34.4
12	Appear II (6.0 oz/M) + Secure Action (0.5 oz/M)	31.5	16.2	20.1	34.0
13	Syngenta Rotation	37.2	18.2	23.8	35.8

*Means followed by the same letter in a column are not significantly different (P=0.05).
** Full name: Signature XTRA** Stressgard

Stop #5: Management of Salinity and Rapid Blight Disease on Annual Bluegrass Putting Greens

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Objectives:

This study was conducted to evaluate various fungicide and fertility treatments for effective Rapid Blight (*Labyrinthula terrestris*) disease control and management of salinity on annual bluegrass maintained as a golf course putting green.

Materials and Methods:

A 5400-ft^2 research putting green was reconstructed in 2018-2019 conforming to USGA guidelines. A 12-in sand/peat/soil was chosen to simulate a mature putting green with minimum suggested infiltration rate. Furthermore, gravel and drainage were installed below the rootzone layer. The green was established with *Poa reptans* 'Two Putt' seed in the spring of 2019. During the trial, turf was mowed at 0.125 inches 5 times/week, topdressed biweekly with sand, and received Primo Maxx at 0.125 oz/1000 ft^2 as a blanket treatment every two weeks as well as the following rotation of fungicides (at lowest labeled rates) for control of diseases other than Rapid Blight:

- Briskway + Daconil WeatherStik
- Banner Maxx II + Subdue Maxx
- Briskway + Medallion SC
- Banner Maxx II + Subdue Maxx
- Briskway + Daconil WeatherStik
- Banner Maxx II + Subdue Maxx

Starting on July 24, 2019, plots were irrigated with saline water (2.0 dS/m) at 120% ET_{os} replacement using sprinkler system. Fungicide treatments were applied every 14 days beginning on July 21, 2019 (before disease symptoms were present) for a total of 8 applications. Fertility treatments were applied weekly, starting from August 1, 2019 for a total of 14 applications. All treatments were applied using a CO_2-powered backpack sprayer equipped with either TeeJet 8004VS nozzles calibrated to deliver 2 gallons/1000 ft^2 for fungicide applications or with TeeJet 8003VS nozzles and calibrated to deliver 1 gallon/1000 ft^2 for fertilizer applications. Treatments were arranged in a split-plot design with fungicide treatments randomized within fertilizer treated plots with 3 replications. The 60' × 90' area was divided into six 30' × 30' areas (whole plot) and sub-plot size was 4×6 ft with 2-ft alleys.

Starting from July 19, plots were evaluated biweekly for: visual turf quality (1-9; 9=highest), green color intensity (1-9; 9=highest), overall turf stand cover (0-100%), injury caused by treatments (0-10; 10=highest) , as well as disease cover (0-100%). In addition, volumetric water content (VWC) and soil electrical conductivity (EC_e) using POGO, Naturalized Difference Vegetation Index (NDVI) and Dark Green Color Index (DGCI), Cover and Density using Digital Image Analysis (DIA) were also evaluated.

<u>Results:</u>

By the most recent data collection event prior to this publication, the tank-mix of Daconil Action with Appear II resulted in the least amount of visible disease symptoms, not exceeding the level of 1% cover regardless of the fertility treatments, which had no significant impact on disease cover so far. However, the tank-mix of Secure Action with Daconil Action, as well as Compass, UCR 002, Mancozeb 80WD and Appear II alone resulted in comparable disease cover, which did not exceed 15%. Furthermore, disease pressure in untreated control was statistically no different from the aforementioned fungicide treatments (Table 2).

To be certain that disease symptoms corresponded to a pathogen or pathogens, samples were collected from the 6 untreated plots (individual sample consisted of 3 plugs, each 2.5 inches in diameter) on August 27 (6 WAIT) and sent to the University of Florida Rapid Turfgrass Diagnostic Service for analysis. Results have confirmed the presence of two pathogens: *Labyrinthula terrestris* (rapid blight) and *Curvularia* spp. (*Curvularia* leaf blight) in the majority of samples submitted.

Interestingly, by the date of last data collection (August 26), ECe did not exceed the level of 0.62 dS/m (maximum value for individual plots; data not shown) and it averaged in 0.25 dS/m throughout the trial area (ranging from 0.21 dS/m in Maxtima to 0.32 dS/m in UCR 002; treatment 17). However, no treatment separation ECe was shown thus far with either fertilizer or fungicides (Table 2).

Furthermore, no significant effect of fertility or fungicide treatment was shown on turfgrass visual quality, turfgrass cover and volumetric soil water content (data not shown). Although, some slight injury to turfgrass has been reported on August 26 and throughout the study, including untreated plots (regardless of the fertility treatment). Therefore, there is no certainty that the observed injury resulted directly from fungicide treatments. Nevertheless, injury level was significantly higher in UCR 002 (treatment 17), UCR 003 and Civitas when compared to other treatments (Table 2).

All treatments containing Appear II and/or Daconil Action, either alone or as a tank-mix component, resulted in the darkest, visually estimated turf color. On the other hand, fungicide treatments showed no impact on NDVI, while UMAXX resulted in slightly, but significantly higher NDVI in comparison to Calcinit-K (Table 2).

Statistical analysis also showed significant impact of both fertility and fungicide treatments on turfgrass cover evaluated using DIA and significant effect of fertility treatments on DGCI, but no effect of either of treatments on turfgrass stand density (also measured using DIA).

The lowest green cover was detected in untreated control plots and with UCR 002 (treatment 17) and UCR 003, but there has been no statistical differences between those treatments and Civitas, Compass, Insignia and the other UCR 002 treatment. In regard to fertility treatments, blocks treated with UMAXX showed significantly higher cover when compared to Calcinit-K. Highest DGCI has been shown with tank-mixes of Appear II with both Daconil Action and Secure Action, although Appear II alone was also statistically comparable to those treatments (Table 3).

Acknowledgments:

Thanks to the CTLF, BASF, FMC, Syngenta, Yara, and Simplot for supporting this research and/or for providing products. Thanks also to the University of Florida Rapid Turfgrass Diagnostic Service for disease diagnoses.

Table 1. Fertility treatments tested in the rapid blight control trial in Riverside, CA. 2019.

Sym.	Treatment	Analysis (NPK)	Company	Rate (lbs N/M)	Interval
A	Calcinit-K	14-0-3	YaraLiva	0.125	weekly
B	UMAXX	46-0-0	Koch	0.125	weekly

Table 2. Fungicide treatments tested in the rapid blight control trial in Riverside, CA. 2019.

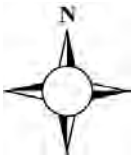
No.	Treatment	Active ingredient	Company	Rate (oz/M)	Timing
1	Untreated Control	-	-	-	-
2	Compass	trifloxystrobin	Bayer	0.20	A-H
3	Maxtima	mefentrifuconazole	BASF	0.80	A-H
4	Navicon Intrinsic	mefentrifuconazole, pyraclostrobin	BASF	0.85	A-H
5	Insignia SC Intrinsic	pyraclostrobin	BASF	0.50	A-H
6	Insignia SC Intrinsic	pyraclostrobin	BASF	0.70	A-H
7	Velista	penthiopyrad	Syngenta	0.50	A-H
8	Appear II	potassium phosphite	Syngenta	6.00	A-H
9	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	A-H
	Appear II	potassium phosphite	Syngenta	6.00	
10	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
	Appear II	potassium phosphite	Syngenta	6.00	
11	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
	Velista	penthiopyrad	Syngenta	0.50	
12	Secure Action	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	A-H
	Daconil Action	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	
13	Mancozeb 80WD	mancozeb	Lesco	6.00	A-H
14	CIVITAS TURF DEFENSE Pre-M1xed	mineral oil	Intelligro	17.00	A-H
15	UCR 001	*classified*	-	-	A-H
16	UCR 002	*classified*	-	-	A-H
17	UCR 002	*classified*	-	-	A-H
18	UCR 003	*classified*	-	-	A-H

Application codes (timing):

A – 07/21/2019
B – 08/01/2019
C – 08/15/2019
D – 08/29/2019
E – 09/14/2019
F – 09/26/2019
G – 10/10/2019
H – 10/24/2019

Rapid Blight Disease Control Trial Plot Plan

(12 F 4)



A (Trt A)

101	102	103	104	105	106
1	**2**	**3**	**4**	**5**	**6**
201	202	203	204	205	206
12	**11**	**10**	**9**	**8**	**7**
301	302	303	304	305	306
13	**14**	**15**	**16**	**17**	**18**

B (Trt B)

101	102	103	104	105	106
7	**11**	**18**	**12**	**9**	**13**
201	202	203	204	205	206
17	**14**	**3**	**16**	**1**	**15**
301	302	303	304	305	306
10	**2**	**6**	**8**	**4**	**5**

C (Trt B)

101	102	103	104	105	106
12	**4**	**9**	**14**	**17**	**11**
201	202	203	204	205	206
10	**15**	**2**	**13**	**5**	**8**
301	302	303	304	305	306
7	**1**	**6**	**18**	**3**	**16**

D (Trt A)

101	102	103	104	105	106
13	**5**	**16**	**2**	**18**	**7**
201	202	203	204	205	206
17	**1**	**9**	**6**	**3**	**11**
301	302	303	304	305	306
10	**12**	**4**	**15**	**8**	**14**

E (Trt A)

101	102	103	104	105	106
17	**3**	**16**	**7**	**1**	**18**
201	202	203	204	205	206
6	**10**	**8**	**2**	**12**	**4**
301	302	303	304	305	306
14	**11**	**5**	**13**	**9**	**15**

F (Trt B)

101	102	103	104	105	106
12	**8**	**2**	**10**	**6**	**13**
201	202	203	204	205	206
15	**5**	**14**	**9**	**3**	**11**
301	302	303	304	305	306
17	**4**	**18**	**1**	**7**	**16**

Table 2. Effect of fungicide treatments on disease cover (0-100%), soil electrical conductivity (EC_e; dS/m), turfgrass injury (0-10; 10=highest), turfgrass dark green color intensity (1-9; 9 = highest) and impact of fertility treatments on NDVI on August 26 evaluated on annual bluegrass 'Two Putt' turf. Riverside, CA, 2019.

No.	Treatment	Disease cover	EC_e	Turfgrass Injury	Color
1	Untreated Control	13.3 B-D*	0.21*	0.2 CD	4.8 D-F
2	Compass (0.20 oz/M)	10.0 B-D	0.21	0.2 CD	5.2 D-F
3	Maxtima (0.80 oz/M)	16.7 A-C	0.22	0.2 CD	5.7 C-E
4	Navicon Intrinsic (0.85 oz/M)	15.8 A-C	0.22	0.2 CD	5.2 D-F
5	Insignia SC Intrinsic (0.50 oz/M)	20.0 A-C	0.23	0.3 B-D	4.7 EF
6	Insignia SC Intrinsic (0.70 oz/M)	21.7 A-C	0.23	0.0 D	5.2 D-F
7	Velista (0.50 oz/M)	15.8 A-C	0.23	0.3 B-D	5.2 D-F
8	Appear II (6.00 oz/M)	15.2 B-D	0.24	0.0 D	7.0 AB
9	Daconil Action (3.5 oz/M) + Appear II (6.00 oz/M)	0.5 D	0.24	0.0 D	8.0 A
10	Secure Action (0.5 oz/M) + Appear II (6.00 oz/M)	30.8 A	0.24	0.0 D	6.7 BC
11	Secure Action (0.5 oz/M) + Velista (0.50 oz/M)	20.8 A-C	0.24	0.0 D	5.7 C-E
12	Secure Action (0.5 oz/M) + Daconil Action (3.5 oz/M)	6.7 CD	0.25	0.7 A-C	7.8 A
13	Mancozeb 80WD (6.00 oz/M)	15.0 B-D	0.25	0.0 D	5.7 C-E
14	CIVITAS TURF DEFENSE Pre-M1xed (17.00 oz/M)	21.7 A-C	0.25	0.8 AB	4.3 F
15	UCR 001	22.5 AB	0.27	0.2 CD	5.0 D-F
16	UCR 002	22.5 AB	0.30	0.0 D	4.8 D-F
17	UCR 002	10.0 B-D	0.30	0.8 AB	5.8 CD
18	UCR 003	24.2 AB	0.32	1.2 A	4.8 D-F

Sym.	Treatment	NDVI
A	Calcinit-K	0.62 B*
B	UMAXX	0.65 A

*Means followed by the same letter or by no letter in a column are not significantly different (P=0.05).

Table 3. Effect of fungicide and fertility treatments on green cover (DIA; 0-100%) and impact of fungicide treatments on DGCI (DIA) on August 26 evaluated on annual bluegrass 'Two Putt' turf. Riverside, CA, 2019.

No.	Treatment	Green Cover (DIA)	DGCI
1	Untreated Control	91.7 F*	0.42 D-H*
2	Compass (0.20 oz/M)	93.7 C-F	0.42 E-H
3	Maxtima (0.80 oz/M)	94.9 B-E	0.43 D-G
4	Navicon Intrinsic (0.85 oz/M)	95.8 A-C	0.43 C-F
5	Insignia SC Intrinsic (0.50 oz/M)	93.8 C-F	0.41 F-H
6	Insignia SC Intrinsic (0.70 oz/M)	95.2 A-D	0.42 E-H
7	Velista (0.50 oz/M)	95.3 A-C	0.42 D-H
8	Appear II (6.00 oz/M)	97.4 AB	0.44 BC
9	Daconil Action (3.5 oz/M) + Appear II (6.00 oz/M)	97.2 AB	0.46 A
10	Secure Action (0.5 oz/M) + Appear II (6.00 oz/M)	97.6 A	0.46 AB
11	Secure Action (0.5 oz/M) + Velista (0.50 oz/M)	95.5 A-C	0.43 C-F
12	Secure Action (0.5 oz/M) + Daconil Action (3.5 oz/M)	94.9 B-E	0.44 CD
13	Mancozeb 80WD (6.00 oz/M)	95.1 A-D	0.43 C-E
14	CIVITAS TURF DEFENSE Pre-M1xed (17.00 oz/M)	92.5 EF	0.41 H
15	UCR 001	95.5 A-C	0.43 C-E
16	UCR 002	92.7 D-F	0.41 GH
17	UCR 002	92.2 F	0.43 D-G
18	UCR 003	91.3 F	0.42 D-H

Sym.	Treatment	Cover (DIA)
A	Calcinit-K	93.8 B*
B	UMAXX	95.3 A

*Means followed by the same letter or by no letter in a column are not significantly different (P=0.05).

Stop #6: USGA/NTEP Warm-Season Water Use Trial

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Objectives:

The National Turfgrass Evaluation Program (NTEP) is one of the most well-known turfgrass research programs in the United States, Canada, and many other countries. The NTEP has been dedicated to evaluating new turfgrass genotypes and provides valuable data and resources to end-users. Water conservation is increasingly important when selecting turfgrasses, especially in the southwestern United States. Deficit irrigation is a common practice for water conservation in areas where water is limited. Warm-season turfgrasses are generally more drought resistant than cool-season grasses. Three species of warm-season grasses (bermudagrass, buffalograss, and zoysiagrass) were evaluated under deficit irrigation conditions to determine the amount of water needed to sustain acceptable turfgrass quality, and to identify cultivars best adapted to drought conditions.

Materials and Methods:

The study area was established on 22 June 2018. Plots were maintained under non-limiting irrigation. Table 1 provides a list of entries for this study. Starting 1 June 2019 and until the fall, plots will be irrigated at three short crop reference evapotranspiration (ET_{os}) replacements (60%, 45% and 30% ET_{os}). The study will be repeated in 2020 and 2021. Plots are maintained under fairway conditions and mowed 3 times per week at 0.5 in and fertilized with 0.5 lb N/M/month with a total of 4.5 lbs N/M annually. Visual turfgrass quality (1-9 scale, optimum color, density, texture, and uniformity) and percentage green cover (using digital image analysis through turf analyzer software) are recorded weekly during the deficit irrigation conditions.

Results

In summer 2019, the tested entries showed a wide range of variability at three ET_{os} levels. Overall, bermudagrass is the most drought resistant among the three species. On 15 Aug. 2019, cultivars such as Tahoma 31, TifTuf, UCR 17-8, FB 1628, and Dog Tuff had better turf quality across all three ET_{os} levels (Table 2). Similarly, Tahoma 31, TifTuf, UCR 17-8, and FB 1628 had higher percentage of green cover than other cultivars across all ET_{os} levels (Table 3). Eleven weeks after initiating the deficit irrigation, bermudagrasses UCR 17-8, and UCR BF1 (local standards) had acceptable quality at 45% ET_{os} (Table 2). Several bermudagrasses had acceptable quality at 60%

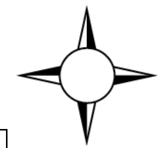
ET_{os}, including Dog Tuff, FB 1628, Monaco, Tahoma 31, TifTuf, Tifway, UCR 17-8, UCR BF1, and UCR BF2. One zoysiagrass, FAES 1306, had acceptable quality at 60% ET_{os} on 8/22/19.

Table 1. Entry list for the 2018 National Warm-Season Water Use and Drought Resistance Test. Riverside, CA.

Entry Number	Species	Cultivar Name	Seeded/vegetative
1	Bermuda	Tifway	Vegetative
2	Bermuda	Dog Tuff	Vegetative
3	Bermuda	ASC 118	Seeded
4	Bermuda	ASC 119	Seeded
5	Bermuda	OKC 1221	Vegetative
6	Bermuda	Premier Pro	Vegetative
7	Bermuda	Tahoma 31	Vegetative
8	Bermuda	TifTuf ™	Vegetative
9	Bermuda	JSC 2009-6-s	Seeded
10	Bermuda	Monaco	Seeded
11	Zoysia	Meyer	Vegetative
12	Zoysia	Stellar	Vegetative
13	Zoysia	FAES 1306	Vegetative
14	Zoysia	FAES 1307	Vegetative
15	Bermuda	FB 1628	Vegetative
16	Buffalo	Prestige	Vegetative
17	Buffalo	Cody	Seeded
18	Bermuda	UCR 17-8*	Vegetative
19	Bermuda	UCR BF1*	Vegetative
20	Bermuda	UCR BF2*	Vegetative

* Local standards from UCR Breeding Program.

Plot plan of for the 2018 National Warm-Season Water Use and Drought Resistance Test.



30% ET	1	2	3	4	5	6	7	8	9	20
30% ET	18	17	16	15	14	13	12	11	10	19
60% ET	7	9	8	1	11	15	13	2	12	20
60% ET	17	5	10	6	4	14	16	3	18	19
45% ET	6	4	14	12	10	16	15	11	13	20
45% ET	18	7	9	3	2	17	1	8	5	19
45% ET	1	2	3	4	5	6	7	8	9	20
45% ET	18	17	16	15	14	13	12	11	10	19
30% ET	7	9	8	1	11	15	13	2	12	20
30% ET	17	5	10	6	4	14	16	3	18	19
60% ET	6	4	14	12	10	16	15	11	13	20
60% ET	18	7	9	3	2	17	1	8	5	19
30% ET	1	2	3	4	5	6	7	8	9	20
30% ET	18	17	16	15	14	13	12	11	10	19
45% ET	7	9	8	1	11	15	13	2	12	20
45% ET	17	5	10	6	4	14	16	3	18	19
60% ET	6	4	14	12	10	16	15	11	13	20
60% ET	18	7	9	3	2	17	1	8	5	19

Table 2. Turf quality of warm-season turfgrasses under deficit ET_{os} levels on 8/15/2019 and 8/22/2019. Riverside, CA.

Cultivar	Turf quality					
	8/15/19			8/22/19		
	ET=30	ET=45	ET=60	ET=30	ET=45	ET=60
ASC 118	3.2	3.8	4.8	2.8	3.7	4.8
ASC 119	3.8	4.0	4.5	3.3	4.5	5.2
Cody	3.0	4.0	4.7	2.5	4.0	4.5
Dog Tuff	4.5	4.7	6.2	3.3	4.8	6.3
FAES 1306	2.5	4.2	5.8	2.8	4.7	6.2
FAES 1307	2.3	3.3	5.3	2.5	3.3	5.8
FB 1628	4.0	5.2	6.3	3.3	5.5	6.3
JSC 2009-6-s	3.0	3.3	5.7	2.8	3.7	5.7
Meyer	2.0	3.2	4.2	1.8	3.3	4.8
Monaco	3.3	4.2	5.7	2.8	4.0	6.0
OKC 1221	3.0	3.7	5.8	3.2	3.7	5.7
Premier Pro	2.8	3.2	4.3	2.8	3.8	5.0
Prestige	2.0	3.2	4.0	2.7	3.3	4.2
Stellar	2.3	3.3	5.0	2.5	3.8	4.8
Tahoma 31	3.7	5.0	7.0	3.2	5.0	6.7
TifTuf ™	4.7	5.2	6.3	3.7	5.0	6.8
Tifway	2.8	5.0	5.5	3.0	4.3	6.5
UCR 17-8	4.2	5.3	6.7	3.6	6.0	6.0
UCR BF1	3.0	5.0	7.0	2.7	6.3	7.0
UCR BF2	3.0	4.7	6.3	2.7	4.3	6.0
LSD*	1.2	1.1	2.1	1.0	1.2	1.0

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 3. Percent green cover of warm-season turfgrasses under deficit ET_{os} levels on 8/15/2019 and 8/22/2019. Riverside, CA.

Cultivar	Percent coverage					
	8/15/19			8/22/19		
	ET=30	ET=45	ET=60	ET=30	ET=45	ET=60
ASC 118	12.3	33.9	45.9	2.7	33.0	42.5
ASC 119	10.6	27.5	51.6	4.3	27.6	47.6
Cody	3.2	17.5	33.1	3.5	17.1	28.9
Dog Tuff	13.8	21.9	52.5	4.9	20.8	50.6
FAES 1306	0.2	7.0	51.3	0.6	11.3	52.8
FAES 1307	0.6	11.9	49.5	1.1	13.5	47.8
FB 1628	12.0	41.9	65.3	7.5	36.2	62.3
JSC 2009-6-s	1.9	16.0	58.7	1.9	11.9	52.7
Meyer	0.2	10.7	37.6	0.3	12.6	42.1
Monaco	2.3	21.4	65.6	3.2	20.4	59.7
OKC 1221	3.3	19.4	60.6	1.8	17.5	57.6
Premier Pro	0.9	4.4	29.7	0.7	7.0	35.9
Prestige	0.7	3.4	20.1	0.5	4.7	20.5
Stellar	0.3	12.5	36.7	0.0	12.9	33.6
Tahoma 31	4.1	50.8	79.4	3.2	43.1	72.9
TifTuf ™	17.9	35.3	66.2	13.8	30.8	62.3
Tifway	6.4	16.0	49.7	0.7	14.9	48.6
UCR 17-8	19.3	53.9	71.6	14.5	48.5	67.2
UCR BF1	0.5	27.3	62.9	0.7	33.3	64.1
UCR BF2	1.6	14.2	47.7	0.5	16.0	52.0
LSD*	16.5	23.5	19.6	10.4	21.5	16.7

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Stop 7: Water Use on Kurapia Groundcover

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Objective:

Kurapia (*Phyla nodiflora*) is a low growing, herbaceous, perennial dicot groundcover belonging to the *Verbenaceae*. Dense canopy and deep root system of this plant provide it with excellent drought tolerance. The objective of this study was to test different irrigation regimes and watering frequencies on Kurapia aesthetic appearance and its water use.

Materials and Methods:

Mature Kurapia established in 2015 was subjected to three different ET (evapotranspiration) replacements (30%, 45% and 60%) and three different irrigation frequencies (biweekly, weekly and twice a week). Soil was a Hanford fine sandy loam. Experimental design was a randomized block with 3 replications. Plot size was 10 ft x 20 ft with no alleys. Watering timings were based on ET from two previous weeks and on hose calibration done every week. Prior to initiating treatments on July 10th soil was saturated for two weeks. Plots were evaluated for visual quality (1 [worst] – 9 [best]), flowering cover (%), flowering uniformity (%), green cover (%) and volumetric water content (VWC %). All ratings with exception of visual quality and VWC were calculated using Digital Image Analysis.

Results:

Due to soil saturation prior to initiating treatments the values of all measured traits increased after 2 weeks. After that time a slow drop in visual quality was observed until 6th week of the study. Although the lowest drop was noticed for treatments watered twice a week, no significant differences among treatments could be observed (Table 1). Flowering cover increased for the first 4 weeks but separation among treatments started becoming evident by the 6th week of the study and was highest for plots watered at 60% ET twice a week. The same treatment also had the highest value of flowering uniformity. Significantly lower flowering cover could be observed only on treatments watered weekly with 30% or 45% ET replacement (Tables 2 and 3). All treatments had similar green cover values 6 weeks after irrigation treatments (73.1% - 77.8%) except treatment 4 (45% ET replacement watered biweekly) where green cover was just under 66% (Table 4). On average, higher VWC was observed on treatments watered twice a week (Table 5) but it is important to note that measurement was done always 3 days after most recent watering for those treatments whereas for treatments watered biweekly the measurement was taken after 13 days. Overall, it seems like none of the factors had a major impact on green cover of Kurapia within first 6 weeks whereas frequency of irrigation at the same time had stronger impact than ET replacement on both flowering cover and uniformity.

Acknowledgments:

Thanks to Kurapia Inc. for supporting this research.

Table 1. Effects of irrigation treatments on Kurapia visual quality. Riverside, CA. 2019.

Treatment	ET replacement	Irrigation frequency	7/10/2019	7/23/2019	8/5/2019	8/19/2019
1	30%	Biweekly	7.3 a	7.3 a	6.2 a	5.3 a
2	30%	Weekly	6.7 a	7.0 a	5.8 a	5.0 a
3	30%	Twice a week	7.0 a	7.3 a	6.3 a	5.7 a
4	45%	Biweekly	7.0 a	7.3 a	5.3 a	4.3 a
5	45%	Weekly	7.0 a	7.3 a	6.2 a	5.3 a
6	45%	Twice a week	7.0 a	7.3 a	5.8 a	6.3 a
7	60%	Biweekly	6.3 a	7.7 a	5.7 a	5.7 a
8	60%	Weekly	7.0 a	7.3 a	6.0 a	5.7 a
9	60%	Twice a week	6.5 a	7.7 a	6.7 a	6.3 a

Means followed by the same letter in a column are not significantly different (P=0.05).

Table 2. Effects of irrigation treatments on Kurapia flowering cover. Riverside, CA. 2019.

Treatment	ET replacement	Irrigation frequency	7/10/2019	7/29/2019	8/5/2019	8/19/2019
1	30%	Biweekly	7.7 a	19.5 a	22.1 a	12.8 ab
2	30%	Weekly	8.3 a	15.9 a	18.1 a	11.9 b
3	30%	Twice a week	7.0 a	19.3 a	21.9 a	16.0 ab
4	45%	Biweekly	10.7 a	15.8 a	16.5 a	13.2 ab
5	45%	Weekly	12.0 a	13.8 a	15.7 a	12.6 b
6	45%	Twice a week	10.0 a	17.5 a	20.4 a	15.4 ab
7	60%	Biweekly	8.1 a	17.8 a	21.1 a	14.8 ab
8	60%	Weekly	9.7 a	16.0 a	16.9 a	14.3 ab
9	60%	Twice a week	10.2 a	15.5 a	19.6 a	17.9 a

Means followed by the same letter in a column are not significantly different (P=0.05).

Table 3. Effects of irrigation treatments on Kurapia flowering uniformity. Riverside, CA. 2019.

Treatment	ET replacement	Irrigation frequency	7/10/2019	7/29/2019	8/5/2019	8/19/2019
1	30%	Biweekly	0.51 a	0.71 a	0.70 ab	0.78 ab
2	30%	Weekly	0.50 a	0.72 a	0.61 b	0.65 b
3	30%	Twice a week	0.54 a	0.77 a	0.77 ab	0.86 ab
4	45%	Biweekly	0.47 a	0.76 a	0.71 ab	0.71 ab
5	45%	Weekly	0.63 a	0.83 a	0.77 ab	0.77 ab
6	45%	Twice a week	0.23 a	0.77 a	0.74 ab	0.78 ab
7	60%	Biweekly	0.43 a	0.85 a	0.84 a	0.82 ab
8	60%	Weekly	0.61 a	0.84 a	0.75 ab	0.78 ab
9	60%	Twice a week	0.45 a	0.83 a	0.84 a	0.87 a

Means followed by the same letter in a column are not significantly different (P=0.05).

Table 4. Effects of irrigation treatments on Kurapia green cover. Riverside, CA. 2019.

Treatment	ET replacement	Irrigation frequency	7/10/2019	7/29/2019	8/5/2019	8/19/2019
1	30%	Biweekly	92.1 a	78.2 a	72.3 a	73.1 ab
2	30%	Weekly	91.6 a	81.7 a	76.8 a	76.5 a
3	30%	Twice a week	92.9 a	78.9 a	74.4 a	74.6 ab
4	45%	Biweekly	88.9 a	81.0 a	75.0 a	65.9 b
5	45%	Weekly	87.8 a	82.0 a	76.2 a	76.1 a
6	45%	Twice a week	89.7 a	79.5 a	74.3 a	76.4 a
7	60%	Biweekly	91.1 a	80.6 a	73.4 a	76.6 a
8	60%	Weekly	90.1 a	80.7 a	76.5 a	77.8 a
9	60%	Twice a week	89.1 a	82.1 a	76.2 a	75.9 a

Means followed by the same letter in a column are not significantly different (P=0.05).

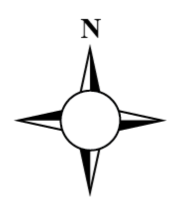
Table 5. Effects of irrigation treatments on Kurapia soil VWC. Riverside, CA. 2019.

Treatment	ET replacement	Irrigation frequency	7/10/2019	7/29/2019	8/5/2019	8/19/2019
1	30%	Biweekly	33.7 a	23.4 a	14.0 a	9.9 abc
2	30%	Weekly	31.7 a	21.7 a	14.3 a	7.7 bc
3	30%	Twice a week	34.0 a	24.9 a	19.9 a	13.7 abc
4	45%	Biweekly	28.2 a	19.9 a	10.6 a	3.5 c
5	45%	Weekly	25.9 a	18.6 a	11.8 a	7.0 bc
6	45%	Twice a week	30.3 a	23.4 a	17.8 a	14.9 ab
7	60%	Biweekly	25.9 a	24.3 a	13.0 a	8.3 bc
8	60%	Weekly	25.1 a	23.2 a	17.0 a	12.3 abc
9	60%	Twice a week	28.6 a	25.0 a	19.3 a	20.1 a

Means followed by the same letter in a column are not significantly different (P=0.05).

Plot plan

1	2	3
6	5	4
7	8	9
9	5	2
8	3	6
7	4	1
7	9	3
6	2	1
5	4	8



Stop #8: Nitrogen Timing and Verticutting Effects on 'De Anza' Zoysiagrass

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Background and Objectives:

Zoysiagrass (*Zoysia spp.*) is well adapted to most regions in California, but is largely unused because of winter dormancy that characteristic of the warm-season turfgrasses or general preference for bermudagrass (*Cynodon spp.*), which comparatively is more tolerant to drought and disease and possesses greater recuperative ability. In general, zoysiagrass has better winter color retention than bermudagrass and 'De Anza' zoysiagrass was developed by UCR with improved winter color retention among other desirable traits. 'De Anza' was produced by hybridizing 'El Toro' (another UCR cultivar) with a zoysiagrass hybrid selection (*Z. matrella* x (*Z. japonica x Z. tenuifolia*). As with most warm-season turfgrasses, thatch management is an important aspect of zoysiagrass maintenance and quality. Previous research has demonstrated that mowing height, verticutting, and N fertilization affect zoysiagrass thatch production and management as well as winter color retention. This study aimed at fine-tuning those practices with emphasis on N fertilization and verticutting combinations and frequencies.

Materials and Methods:

The study was conducted on mature zoysiagrass 'De Anza' established from sod in 2014. Turf was mowed three times weekly at 0.5 in. and irrigated according to warm-season replacement of reference evapotranspiration. Treatments applied in 2019 mimicked that of 2018 and are shown in Table 1. Turf quality was evaluated periodically on a scale of 1-9, 9 = best.

Table 1. Verticutting and nitrogen fertilizer timing on 'De Anza' zoysiagrass in 2019. Riverside, CA.

Treatment	Verticutting timing		Fertilization timing (1 lb N/1000 ft^2)		
A	6/24/2019				
B	6/24/2019		6/24/2019	7/22/2019	8/19/2019
C	6/24/2019	8/19/2019	6/24/2019	7/22/2019	8/19/2019
D			6/24/2019	7/22/2019	8/19/2019
E					

Results:

Summer N fertilization had a greater positive effect on turf quality and winter color retention compared to verticutting, although the combination of both management practices was often statistically similar (Table 2). Similar results were observed in 2018 (data not shown). Overall, these data suggest that ‘De Anza’ is best managed with as little as 3 lbs N/M/yr and one verticutting event to alleviate thatch during summer months when turf is actively growing.

Table 2. Turf quality (1-9, 9 = best) in response to verticutting and nitrogen fertilizer treatments on ‘De Anza’ zoysiagrass. 2018-19. Riverside, CA.

Treatment	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
A	1.9 c	1.9 b	1.8 c	2.3 c	2.5 bc	2.9 b	2.3 c	2.2 c	2.3 b
B	3.9 ab	3.1 a	2.9 ab	3.1 ab	3.6 a	4.9 a	5.3 a	6.4 a	7.0 a
C	3.1 bc	2.4 b	2.8 ab	3.3 a	3.3 ab	4.7 a	4.1 ab	5.4 b	6.3 a
D	4.6 a	3.3 a	3.1 a	2.9 abc	3.0 abc	4.3 ab	4.7 ab	6.6 a	7.0 a
E	2.0 c	2.1 b	2.2 bc	2.5 bc	2.3 c	3.4 ab	3.3 bc	2.4 c	2.3 b

Means followed by the same letter in a column are not significantly different (P=0.05).

Plot plan

N

E	B	D	C
C	E	B	E
A	D	E	A
B	A	C	B
D	C	A	D

Stop #9: Wetting Agents for Water Conservation on Bermudagrass Turf

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Justification and Objectives:

Previous research has demonstrated that wetting agents are among the most important chemistries for turfgrass water conservation. Furthermore, Revolution (Aquatrols) and TriCure AD (Mitchell Products) have proven to be among the top products for reducing localized dry spots (LDS) under deficit irrigation. However, treating large areas such as golf course fairways with Revolution is not affordable for many golf course managers. In this study, we aimed to identify alternative wetting agents that can help conserve water on large scale areas such as bermudagrass fairways subjected to 45, 55, and 65% short crop evapotranspiration (ET_{os}) irrigation replacement.

Methods:

The study is conducted on mature hybrid bermudagrass 'Tifway II' established by sod in 2017. The 60' x 90' field is divided into 12 20' x 20' plots. From June through October each year, plots receive either 45, 55, or 65% of previous week ET_{os} by hand watering to maximize water distribution uniformity as determined by an on-site CIMIS station. Hose output is calibrated weekly to minimize error from changing pressure. Treatments are arranged in a split-plot design with twelve wetting agent treatments (plot size 24 ft^2) randomized within ET_{os} replacement plots and 4 replicates. Treatments (Table 1) are applied according to company recommendations beginning on May 23 in 2018, and May 24 in 2019. Treatments are tested against an untreated control and Revolution that will serve as "UCR standard". A 2-wk 'conditioning period' followed first application, with deficit irrigation starting on June 6 in 2018 and June 7 in 2019. The study receives 5 lb N/M/year and is mowed three times/week at 0.5 in. Spray treatments are applied using a CO_2-powered hand boom sprayer equipped with TeeJet 8004VS nozzles and output of 2 gal/M. One week after first treatment and then every two weeks, plots are evaluated for turfgrass quality on a scale from 1 = worst to 9 = best, Normalized Difference Vegetation Index (NDVI) using a handheld GreenSeeker sensor, volumetric soil water content (VWC) using time domain reflectometry (TDR), and dark green color index (DGCI) as well as percent cover using Digital Image Analysis (DIA). Leaf samples are collected monthly from May until October to determine proline content in the tissues. Double ring infiltrometer test is also performed monthly from May until October. Visual turf quality and % green cover using DIA will also be taken to measure the effect of wetting agent products on bermudagrass dormancy and green-up in late fall and early spring.

Results

In 2019, differences are most commonly found between products tested and untreated control. (Tables 2, 3, and 4).

On 7/11/19, plots treated with Passage and Revolution had better quality than those treated with MPX-5 at 45% ET_{os} (Table 2). As observed until 8/22/2019, acceptable quality was always sustained at 65% ET_{os} including control.

For percentage green cover, on 7/11/19, Vivax had negative effects on bermudagrass compared with all other treatments excluding Tricure and Forte+ CounterAct Retain at 65% ET_{os} (Table 3). Similarly, on 7/25/2019 and at 65% ET_{os}, Hydro 90 + Symphony had higher green cover than Vivax. On 8/8/19, for 45% ET_{os}, products like Forte +Brilliance, and Tricure had greater positive impact on bermudagrass than Revolution. And at 65% ET_{os}, Hydro 90 + Symphony and Passage worked better than Vivax; Hydro 90 + Symphony also worked better than Forte +CounterAct Retain.

For NDVI, on 7/11/19 at 45% ET_{os}, no differences have been recorded among products (Table 4). And for 55% ET_{os}, products such as Revolution and Tricure showed better effects than Cascade Plus, MPX-5, and Zipline. At 65% ET_{os}, most products worked better than Vivax. No differences have been recorded among products at all ET_{os} levels on 7/25/19 and at 45% and 55% ET_{os} levels on 8/8/19. At 65% ET_{os} on 8/8/19, Vivax performed worse than most other products such as Aquimax Turf Lateral, Cacade Plus, Hydro 90 + Symphony, Passage, Tricure, and Zipline. On 8/22/19, plots treated with Vivax had lower NDVI value compared to Forte+ Brilliance, Forte+CounterAct Retain, Hydro 90+ Symphony, Passage, and Zipline.

Overall, among the tested products, Vivax had less impact on 'Tifway II' bermudagrass compared with most other products under deficit irrigation conditions.

Acknowledgments

Thanks to the CTLF for funding this research and Aquatrols, Exacto, Harrell's, Mitchell Products, Numerator Tech, and Precision Laboratories for providing products.

Table 1. Treatment list for the wetting agent trial (2018-2019) at UCR.

Treatment	Rate	Company	Frequency (weeks)
Untreated control	--	--	
Revolution	6 oz/M	Aquatrols	4
ACA001	4 oz/M	Aquatrols	4
TriCure AD	6 oz/M	Mitchell Products	4
MPX-5	3 oz/M	Mitchell Products	4
Forte + CounterAct Retain	0.37 oz/M + 3 oz/M	Simplot	4
Forte + Brilliance	0.37 oz/M + 3 oz/M	Simplot	4
Aquimax Turf Lateral	8 oz/M (initial)/ 4 oz/M (subsequent)	Exacto	4
Passage	6 oz/M	Numerator Tech	4
Vivax	5 oz/M	Precision Laboratories	4
Cascade Plus	8 oz/M (initial)/ 4 oz/M (subsequent)	Precision Laboratories	4
Hydro90+Symphony	3 oz/M + 3 oz/M	Harrell's	4

Table 2. Visual quality (1-9, 9 = best) of wetting agent treated 'Tifway II' bermudagrass hand-watered at 45%, 55% and 65% ET_{os}. Riverside, CA.

	Turf quality											
	7/11/19			7/25/19			8/8/19			8/22/19		
Treatment	45	55	65	45	55	65	45	55	65	45	55	65
Untreated control	6.0	6.5	6.6	5.0	5.3	6.1	4.5	4.8	6.1	3.6	4.9	5.6
Aquimax Turf Lateral	6.5	7.0	7.0	5.6	6.9	6.8	6.0	6.6	7.3	5.0	6.1	6.8
Cascade Plus	6.4	6.9	7.0	6.3	6.8	7.0	6.3	6.9	7.3	5.1	6.0	6.8
Forte +Brilliance	6.4	7.0	7.0	5.9	7.0	7.0	6.4	6.6	7.1	4.8	6.9	7.0
Forte +CounterAct Retain	6.6	6.8	6.8	6.0	6.6	7.0	6.3	6.5	6.9	4.9	6.1	6.9
Hydro 90 + Symphony	6.6	6.9	7.0	6.3	6.9	7.0	6.5	6.8	7.4	5.1	6.5	7.0
MPX-5	6.1	7.0	6.9	5.8	6.6	7.0	6.1	6.6	7.1	5.1	5.8	6.6
Passage	6.8	7.0	7.0	6.3	6.8	7.0	6.3	6.9	7.3	4.8	6.6	6.9
Revolution	6.8	7.0	7.0	6.1	6.8	6.8	6.3	6.9	7.1	4.5	6.3	6.6
Tricure	6.6	7.0	6.9	5.9	6.9	6.8	6.1	6.9	7.3	4.8	6.6	6.8
Vivax	6.6	7.0	6.6	6.1	6.9	6.6	6.3	6.9	6.8	5.0	6.6	6.1
Zipline	6.6	6.8	7.0	6.0	6.6	6.8	6.0	6.6	7.1	4.8	6.4	6.9
LSD	0.6	0.3	0.4	1.0	0.4	0.5	0.6	1.1	0.7	0.8	0.6	0.7

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 3. Percent green cover of wetting agent treated plots hand-watered at 45%, 55% and 65% ET_{os}. Riverside, CA.

	Percent green cover											
	7/11/19			7/25/19			8/8/19			8/22/19		
Treatment	45	55	65	45	55	65	45	55	65	45	55	65
Untreated control	70.1	79.2	83.4	45.5	63.3	76.5	22.5	41.9	69.2	19.5	37.4	59.8
Aquimax Turf Lateral	82.0	87.4	84.3	71.0	85.4	83.5	47.6	72.0	78.0	32.7	54.3	65.2
Cascade Plus	83.2	84.7	88.3	72.3	82.6	86.5	55.0	70.2	78.6	36.8	53.0	65.5
Forte +Brilliance	81.2	86.6	85.1	71.5	86.5	84.7	60.3	73.6	77.0	35.5	63.5	67.0
Forte +CounterAct Retain	79.1	83.7	81.9	71.1	83.0	82.2	50.2	71.0	72.6	31.5	58.7	62.9
Hydro 90 + Symphony	83.2	86.3	87.9	73.7	85.1	88.5	57.3	72.8	80.3	38.9	57.6	68.1
MPX-5	79.2	85.5	84.5	70.4	84.2	84.2	49.9	74.1	76.5	32.6	60.6	64.9
Passage	82.1	85.4	85.6	74.8	86.2	85.2	55.3	73.2	79.5	31.5	63.4	65.9
Revolution	82.9	87.8	84.3	72.3	86.9	84.9	45.0	72.8	77.1	27.2	58.3	65.1
Tricure	81.7	88.1	81.6	73.6	85.6	83.6	60.3	71.5	79.3	39.1	62.6	68.8
Vivax	85.9	86.5	78.8	74.8	86.3	80.8	55.3	77.0	72.4	31.9	63.5	60.1
Zipline	81.8	84.9	86.2	71.3	85.1	86.3	55.5	74.2	78.3	29.7	60.2	68.1
LSD	12.8	3.7	5.0	23.5	15.6	7.0	14.6	16.1	7.0	11.9	12.9	6.9

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

Table 4. NDVI of wetting agent treated plots hand-watered at 45%, 55% and 65% ET_{os}. Riverside, CA.

	NDVI											
	7/11/19			7/25/19			8/8/19			8/22/19		
Treatment	45	55	65	45	55	65	45	55	65	45	55	65
Untreated control	0.61	0.65	0.67	0.49	0.54	0.65	0.39	0.48	0.57	0.35	0.47	0.57
Aquimax Turf Lateral	0.66	0.70	0.70	0.57	0.66	0.67	0.50	0.58	0.64	0.45	0.54	0.60
Cascade Plus	0.67	0.68	0.71	0.55	0.65	0.67	0.54	0.59	0.64	0.47	0.55	0.62
Forte +Brilliance	0.66	0.70	0.70	0.58	0.67	0.66	0.54	0.61	0.63	0.46	0.59	0.61
Forte +CounterAct Retain	0.65	0.70	0.69	0.57	0.66	0.66	0.50	0.60	0.61	0.44	0.56	0.59
Hydro 90 + Symphony	0.67	0.70	0.69	0.60	0.65	0.68	0.54	0.61	0.64	0.48	0.57	0.61
MPX-5	0.64	0.69	0.69	0.59	0.67	0.66	0.50	0.60	0.61	0.45	0.56	0.59
Passage	0.67	0.70	0.70	0.57	0.66	0.68	0.52	0.62	0.64	0.44	0.59	0.60
Revolution	0.67	0.72	0.70	0.56	0.68	0.68	0.49	0.61	0.63	0.42	0.58	0.59
Tricure	0.67	0.72	0.68	0.60	0.68	0.66	0.54	0.61	0.64	0.46	0.57	0.61
Vivax	0.67	0.71	0.66	0.58	0.66	0.65	0.53	0.62	0.60	0.46	0.58	0.55
Zipline	0.66	0.69	0.71	0.55	0.64	0.69	0.51	0.61	0.64	0.43	0.56	0.62
LSD	0.06	0.02	0.03	0.10	0.07	0.04	0.07	0.07	0.03	0.06	0.06	0.04

*To determine statistical differences among entries, subtract one entry's mean from another entry's mean. Statistical differences occur when this value is larger than the corresponding LSD value ($P < 0.05$).

CIMIS Data Sep. 2018 – Aug. 2019

Los Angeles Basin-U.C. Riverside - #44

Month Year	Tot ETo (in)	Tot Precip (in)	Avg Sol Rad (Ly/day)	Avg Vap Pres (mBars)	Avg Max Air Tmp (F)	Avg Min Air Tmp (F)	Avg Air Tmp (F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (F)	Avg Wind Speed (mph)	Avg Soil Temp (F)
Sep 2018	5.86	0	518	15.7	90.1	60.8	73.5	84	31	56	56.3	3.7	73.8
Oct 2018	4.3	0.96 K	406 K	12.4 K	80.3 K	56.7	67.5	79	33	55 K	48.4 K	4 K	68.2
Nov 2018	3.13	0.84 K	316 K	7.9	74.4	49.5	61.3	66	26	44	35.3	3.4 K	59.3
Dec 2018	2.24 K	1.01	254	8.1 K	66.7 K	45.1	54.6	81	33	56 K	37.9 K	3.5	54.1
Jan 2019	2.29	2.59	262 K	8.4 K	66	45.8	55.2 K	77	38	55 L	37 L	3.9 K	52.3
Feb 2019	2.37	4.63	322 K	8	61.3	42.2	51.2	82	40	61	37.8	3.7	51.9 K
Mar 2019	4.36	1.46	443 K	9.5 K	70.6	49.4 K	59.4	76	36	56 K	42.4 K	3.9 K	58.4
Apr 2019	5.9 K	0.06	545 K	10.9	77.6 K	54.1 K	64.7 K	78	33	53 K	46.4 K	4.4 K	64.8
May 2019	4.95	0.97	521 K	12.8	71.2 K	52.6 K	60.8	91	50	70	50.9	4.1 K	66.9
Jun 2019	6.49 K	0.02	636 K	15.5	83.1 K	60 K	69.7 K	87 K	42 K	64 K	56.2 K	4.3 K	73.4
Jul 2019	8.03	0.01 K	696 K	16	91.2	62.7	75.8	81	32	53	57.1	4.1	74.9
Aug 2019	7.68 K	0	649 K	15.2	93.3	62.5	76.6	81	25	49	55.7	3.8	74.3
Totals/Avgs	57.60	12.55	464	11.7	77.2	53.5	64.2	80	35	56	47	3.9	64.4

M – All Daily Values Missing	K – One or More Daily Values Flagged
J – One or More Daily Values Missing	L – Missing and Flagged Daily Values

W/m^2 = 2.065 Ly/day	25.4 mm = inch	C = 5/9 * (F -32)

m/s = 2.24 mph	kPa = 10 mBars

Save the Date

UCR Turfgrass & Landscape
Research Field Day

Thursday, September 17, 2020

See you then!