UNIVERSITY OF CALIFORNIA
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TURFGRASS & LANDSCAPE RESEARCH FIELD DAY

October 15, 2020

UCR Turfgrass Science

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

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

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 Virtual Field Day!

On behalf of the entire UCR Turfgrass and Landscape Team, welcome (back) to the 2020 UCR Turfgrass and Landscape Research Field Day. While this is the 13th consecutive year of this event under my watch, none of us could have imagined the kind of year that we have endured, which has prevented our in-person gathering in Riverside. Despite the pandemic, our research program has managed to continue to grow and prosper despite having no student help this year. This would not have been possible without the tireless work by our team – Marta Pudzianowska, Pawel Petelewicz, Mingying Xiang, Pawel Orlinski, Christian Bowman and Luiz Monticelli – and the continued support of our turfgrass industry during these trying times.

In this booklet you will learn 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. While this handout serves to give you a brief synopsis of our current research activities for the virtual research tours, you can read or print our full research reports in their entirety from our website, turfgrass.ucr.edu.

As you enjoy this virtual Field Day experience, I would like to acknowledge those who assisted with preparation for this event. Special thanks go to my fellow Field Day planning committee members including Peggy Mauk, Sue Lee, Steve Ries, Sherry Cooper, and Rachel Palmer. Production of this publication would not have been possible without assistance from Marta Pudzianowska. Staff from UCANR, Agricultural Operations and my lab have worked tirelessly to make this event possible and are deserved of your appreciation. And special thanks to Ricardo Vela and Miguel Sanchez, University of California News and Information Outreach in Spanish, for production of the videos. 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.

Enjoy this unique virtual Field Day adventure! And we **will** see you again in person next year on Thursday, September 16, 2021.

Sincerely,

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

Voice: 951-827-4619 · Fax: 951.827-4437 · WWW.PLANTBIOLOGY.UCR.EDU

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- West Coast Turf
- Western Municipal Water District
- Wilbur Ellis
- Wilshire Country Club
- USDA National Institute of Food and Agriculture

2020 Turfgrass and Landscape Research Field Day Agenda

8:30	**Welcome and Introductions** Jim Baird, *Dept. of Botany and Plant Sciences, UC Riverside and UC ANR*
8:40	*Video Stop #1* **Management of Salinity and Rapid Blight Disease on Annual Bluegrass Putting Greens** Jim Baird, *Dept. of Botany and Plant Sciences, UC Riverside and UC ANR*
9:00	*Video Stops #2 and #3* **Improvement of Bermudagrass, Kikuyugrass, and Zoysiagrass for Winter Color Retention and Drought Tolerance** Adam Lukaszewski, Marta Pudzianowska and Christian Bowman, *Dept. of Botany and Plant Sciences, UC Riverside*
	NTEP Bermudagrass Water Use and Zoysiagrass Trials Marta Pudzianowska and Christian Bowman, *Dept. of Botany and Plant Sciences, UC Riverside*
9:20	*Video Stops #4 and #5* **USGA/NTEP Warm-Season Water Use Trial** Mingying Xiang, *Dept. of Botany and Plant Sciences, UC Riverside*
	Product Testing for Water Conservation on Bermudagrass Turf Mingying Xiang, *Dept. of Botany and Plant Sciences, UC Riverside*
9:40	**Break**
9:45	*Video Stop #6* **PRE Crabgrass and POST Broadleaf Control in Turf** Pawel Orlinski, *Dept. of Botany and Plant Sciences, UC Riverside*
10:05	*Video Stop #7* **Evaluation of Fungicides for Control of Anthracnose Disease on Annual Bluegrass Putting Greens** Pawel Petelewicz, *Dept. of Botany and Plant Sciences, UC Riverside*
10:25	**Wrap up by Jim Baird**
10:30	**Adjourn to Exhibitor Rooms - attend to win prizes!**
10:30-11:30	**Virtual Trade Show**

Video Stop #1: Management of Salinity and Rapid Blight Disease on Annual Bluegrass Putting Greens

Mingying Xiang, Pawel Petelewicz, Pawel Orlinski, Luiz Monticelli, and Jim Baird
Department of Botany and Plant Sciences
University of California, Riverside, CA 92521

Introduction:

Increasing salinity issues caused by insufficient precipitation, drought, and increasing use of alternative non-potable sources of irrigation water are inevitable for turf and landscape plants in the southwestern United States. Most golf course superintendents in California who manage annual bluegrass putting greens are faced with managing salinity resulting from use of reclaimed irrigation water and/or salt accumulation during extended drought. Leaching and modification of soil physicochemical properties can help alleviate salinity stress. Overall, numerous products are purported to aid in salinity management, many of which have not been tested under non-biased, replicated experiments on turf.

Rapid blight, caused by the terrestrial slime mold *Labyrinthula terrestris*, was first discovered as a disease of turfgrass in the early part of this century. Since then, it has been found in at least 11 states in the U.S. including California. As the name implies, rapid blight symptoms appear quickly as water-soaked patches, which soon coalesce into large dead areas. In California, the disease is most severe on *Poa annua* greens, but also can be troublesome on *Poa trivialis* and perennial ryegrass in overseeded turf, particularly in Arizona. Almost always, rapid blight is associated with elevated sodium chloride caused by poor irrigation water and/or extensive periods without rainfall or sufficient leaching of salts. Historically, only a few fungicides have provided effective control of rapid blight, including pyraclostrobin (Insignia Intrinsic or Lexicon Intrinsic), trifloxystrobin (Compass), and mancozeb (Fore). More recently, our research identified penthiopyrad (Velista), fluazinam (Secure), chlorothalonil + acibenzolar (Daconil Action), and potassium phosphite (Appear II) as additional products with activity against this disease or salinity related stress.

Objectives:

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

Materials and Methods:

The study was conducted on a 5400-ft^2 research putting green that was constructed according to USGA recommendations in 2019. A 12-inch sand and peat rootzone mix was derived to simulate a mature putting green with a minimum allowable infiltration rate. Gravel and drainage were installed below the rootzone layer. The green was established with *Poa annua* var. *reptans* 'Two Putt' seed in the spring 2019 and thin or bare areas of turf following the 2019 study were seeded again in spring 2020. During the trial, turf was mowed at 0.156 inches 5 times/wk, lightly topdressed with sand weekly, and received Primo Maxx at 0.125 oz/M biweekly. Granular fertilizer (Best Micro Green 15-5-8 + 5% Fe; J.R. Simplot) was applied monthly at 0.5 lb N/M following solid tine aeration. Furthermore, ammonium sulfate was sprayed weekly at 0.125 lb N/M. To control diseases other than rapid blight, fungicides including Briskway, Banner Maxx II, Subdue Maxx, Medallion SC, Heritage WG, and Maxtima were applied alone or in various combinations every month throughout the study period. Scimitar insecticide was applied twice throughout the study period to control ants.

A total of 26 treatments including an untreated control were evaluated in this study. The list of products and timing of application is presented in Table 1. Treatments were initiated on May 22, 2020. Turf was irrigated daily with potable irrigation water (EC ≈ 0.5 dS/m) at 120% ET_o (reference evapotranspiration) replacement based on the previous day as determined by an on-site CIMIS weather station from May 18 to June 22 during the conditioning period. Starting from June 23, plots were irrigated with saline water (electrical conductivity = EC = 2.0 dS/m) at 120% ET_o. Irrigation salinity was increased to 3.0 dS/m on August 24, and then to 4 dS/m from September 16 until the end of the study in November. Moreover, irrigation replacement ranged from >200% to <60% ET_o throughout the study in order to help elevate soil salinity. Saline water was made by mixing salts in potable water within two 5000-gal storage tanks containing submersible pumps for mixing and agitation. Saline water ion composition was based on Colorado River water (personal communication, D.L. Suarez, USDA-ARS Salinity Laboratory) and contained elevated concentrations of salts including Na^+, Cl^-, and SO_4^{2-} but nominal HCO_3^- and CO_3^{2-}. Saline water used to irrigate plots was classified as very high in salinity. Total salinity of the water was chosen to simulate an extreme, but realistic irrigation salinity for turf in California (personal communication, M. Huck). Turf was watered by hand during the study to ensure uniform water distribution on the plots. The hose and nozzle used to hand water plots were calibrated every week by measuring water output to calculate irrigation flow rate and subsequent irrigation times.

All treatments were applied using a CO_2-powered backpack sprayer calibrated to deliver 2 gallons/M. Treatments were either watered in immediately after application according to company recommendations or later in the day after drying, as part of ET_o replacement for that day. Treatments were arranged in a randomized block design with 5 replicate plots each measuring 4 x 6 ft. Starting from May 21, plots were evaluated biweekly for: visual turf quality (1-9; 9 = highest), visual turf color (1-9; 9 = highest), visual turf green cover (0-100%), as well as disease cover (0-100%) when present. Also, soil electrical conductivity (ECe) and volumetric water content (0-100%) were recorded using a POGO Pro Sensor; Normalized Difference Vegetation Index (NDVI) was measured using a GreenSeeker handheld crop sensor.

Data collected throughout the study were analyzed using analysis of variance for each evaluated trait separately and means were compared using the Fisher's protected least significant difference (LSD) test at the 0.05 probability level ($P \leq 0.05$).

Results:

Soil EC was elevated from ca. 0.2 dS/m prior to saline irrigation to 0.8 dS/m by late September shortly after irrigation salinity was increased to 4 dS/m; however; none of the treatments resulted in statistically significant differences in soil EC to date (Table 2). It has proven very difficult to raise soil salinity of a sand-based root zone with ideal drainage, and thus reconstruction should be considered a major (albeit costly) management tool for salinity on putting greens. Soil volumetric water content ranged from 15-20% throughout most of the study and reflected our desire to apply minimal water and maintain deficit irrigation in hopes of increasing salinity stress (Table 3). More recently (partially evident by the Sep. 22 rating), we resorted to alternate cycles of excess irrigation to completely saturate the root zone followed by withholding irrigation until visible symptoms of wilt in hopes of increasing soil EC to better evaluate differences among treatments. These data will be included in the final published report.

Without producing critical soil EC levels due to optimal drainage, no signs of *Labyrinthula terrestris*, the causal agent of rapid blight disease, have been detected thus far. Furthermore, none of the treatments caused injury to annual bluegrass turf. The only significant treatment differences were observed during extended periods of record-breaking high temperatures above 100F between August 24 and September 8, including a high of 117F on September 5 (Figures 1 and 2). Thus far, it appears that weekly applications of treatments composed primarily of nutrients have had the greatest positive impact on turf quality, color, and cover (Tables 4-7). Specifically, treatments 19 (Brandt weekly fertilizer rotation with Daconil Action), and 18 (Brandt weekly fertilizer rotation) have produced the highest ratings. However, it should be pointed out that all of the treatments produced better results than the untreated control on most rating dates even though statistical differences were not always evident. Other treatments that ranked near the top for most ratings included (in no particular order): 21 (Harrell's tank-mix of Daconil Action, Activator + Salicylic acid, Fleet 100, and an experimental product); 2-4 (Locus Ag treatments); 7 (Ocean Organics tank mix); 16 (Brandt's biweekly tank-mixed mixed of fertilizer 1); 17 (Brandt's biweekly tank-mixed mixed of fertilizer 2); and 11 (Velista rotated with a tank mix of Appear II and Secure Action).

The trial will continue until early November, and we are making every attempt to further elevate soil salinity levels. Although salinity stress has been mild thus far, this study supports our previous research and clearly demonstrates that nutrition is an important component to salinity management. It is important to note that this study was not meant to be a competition among products or programs. Companies that took part in this study did not have the opportunity to learn about their competitors' treatments when formulating their own. Some treatments were very specific to rapid blight management while others targeted the effects of salinity on soil chemistry. Our research on salinity management is aiming to identify component products that ultimately will be combined in a comprehensive program to combat salinity stress and rapid blight disease.

Acknowledgments

Thanks to the California Turfgrass & Landscape Foundation (CTLF) and companies whose products were evaluated in this study for their financial support. We appreciate donations of greens mix and gravel by P.W. Gillibrand Co. and 'Two Putt' *Poa annua* var. *reptans* seed from Wilbur-Ellis. Thanks also to the University of Florida Rapid Turfgrass Diagnostic Service for disease diagnoses.

Table 1. Treatments tested in the trial in Riverside, CA. 2020.

No.	Treatment	Type	Active ingredient / Analysis (NPK)	Company	Rate		No. of apps	Freq. (wks)	Application timing
1	Untreated Control	-	-	-	-	-	-	-	-
2	Experimental SLP	surfactant	*unspecified / classified*	Locus	5.43	ml/M	6	4	CGKOSW
3	Experimental SLP	surfactant	*unspecified / classified*	Locus	10.86	ml/M	6	4	CGKOSW
4	Experimental rotation	n/a	*unspecified / classified*	Locus	n/a		6 (12)	4 (2)	AEIMQU
5	Signature XTRA Stressgard	fungicide	aluminum tris	Bayer	4.00	oz/M	12	2	ACEGIKMOQSUW
	Exteris Stressgard	fungicide	fluopyram, trifloxystrobin	Bayer	6.00	oz/M			
6	UCR 005	*unspecified*	*unspecified / classified*	Nufarm	n/a		12	2	ACEGIKMOQSUW
7	XP Extra Protection	*unspecified*	*unspecified / classified*	Ocean Organics	6.00	oz/M	12	2	ACEGIKMOQSUW
	Stress Rx	*unspecified*	*unspecified / classified*	Ocean Organics	6.00	oz/M		2	
	OO-NT	*unspecified*	*unspecified / classified*	Ocean Organics	n/a	oz/M		2	ACEGIKMOQSUW
	DeSal	*unspecified*	*unspecified / classified*	Ocean Organics	0.38	oz/M		2	ACEGIKMOQSUW
8	Appear II	fungicide	potassium phosphite	Syngenta	6.00	oz/M	12	2	ACEGIKMOQSUW
9	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	oz/M	12	2	ACEGIKMOQSUW
	Appear II	fungicide	potassium phosphite	Syngenta	6.00	oz/M			
10	Secure Action	fungicide	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	oz/M	12	2	ACEGIKMOQSUW
	Appear II	fungicide	potassium phosphite	Syngenta	6.00	oz/M			
11	Velista	fungicide	penthiopyrad	Syngenta	0.50	oz/M	6 (12)	4 (2)	AEIMQU
	Appear II	fungicide	potassium phosphite	Syngenta	6.00	oz/M	6 (12)	4 (2)	CGKOSW
	Secure Action	fungicide	fluazinam, acibenzolar-S-methyl	Syngenta	0.50	oz/M			

12	Puric Salute	soil amendment	humic acids from leonardite	Wilbur-Ellis	0.50	gal/A	12	2	ACEGIKMOQSUW
	Nutrio Unlock	soil amendment	*microbes*	Wilbur-Ellis	1.00	pint/A			
13	Puric Salute	soil amendment	humic acids from leonardite	Wilbur-Ellis	1.00	gal/A	12	2	ACEGIKMOQSUW
	Nutrio Unlock	soil amendment	*microbes*	Wilbur-Ellis	1.00	pint/A			
14	Puric Salute	soil amendment	humic acids from leonardite	Wilbur-Ellis	0.50	gal/A	12	2	ACEGIKMOQSUW
	Link Fourtiplex	fertilizer	2-0-3, 0.7% humic acids from leonardite	Wilbur-Ellis	3.00	oz/M			
15	Puric Salute	soil amendment	humic acids from leonardite	Wilbur-Ellis	0.50	gal/A	12	2	ACEGIKMOQSUW
	Link Fourtiplex	fertilizer	2-0-3, 0.7% humic acids from leonardite	Wilbur-Ellis	3.00	oz/M			
	Link Quality Plus	fertilizer	5-20-20 + Fe, Mn	Wilbur-Ellis	6.00	oz/M			
16	GRIGG Gary's Green Ultra	fertilizer	14-2-3 + Mg, B, Cu, Fe, Mn, Zn	Brandt	12.00	oz/M	12	2	ACEGIKMOQSUW
	GRIGG Turftopia	fertilizer	5-0-5 + Mn, Mo, Zn	Brandt	6.00	oz/M			
	GRIGG PK Plus	fertilizer	3-5-17 + B, Co, Mo	Brandt	6.00	oz/M			
	GRIGG Kelplex	fertilizer	1-2-2 + Fe	Brandt	2.00	oz/M			
17	BRANDT ManniPlex Grow	fertilizer	12-0-6 + Cu, Fe, Mn	Brandt	12.00	oz/M	12	2	ACEGIKMOQSUW
	BRANDT MegAleX	fertilizer	3-0-0	Brandt	6.00	oz/M			
	BRANDT Mega-Phi	fertilizer	2-0-16	Brandt	17.00	oz/M			
	BRANDT Seaweed Max	fertilizer	0-0-2	Brandt	2.00	oz/M			
18	GRIGG Gary's Green Ultra	fertilizer	14-2-3 + Mg, B, Cu, Fe, Mn, Zn	Brandt	9.00	oz/M	12 (24)	2 (1)	ACEGIKMOQSUW
	GRIGG Turftopia	fertilizer	5-0-5 + Mn, Mo, Zn	Brandt	18.00	oz/M			
	BRANDT MegAleX	fertilizer	3-0-0	Brandt	3.00	oz/M		2 (1)	BDFHJLNORTVX

	GRIGG Gary's Green Ultra	fertilizer	14-2-3 + Mg, B, Cu, Fe, Mn, Zn	Brandt	9.00	oz/M	12 (24)		
19	GRIGG Gary's Green Ultra	fertilizer	14-2-3 + Mg, B, Cu, Fe, Mn, Zn	Brandt	9.00	oz/M	12 (24)	2 (1)	ACEGIKMOQSUW
	BRANDT MegAleX	fertilizer	3-0-0	Brandt	3.00	oz/M			
	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	2.00	oz/M			
	GRIGG Turftopia	fertilizer	5-0-5 + Mn, Mo, Zn	Brandt	3.00	oz/M	12 (24)	2 (1)	BDFHJLNORTVX
	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	2.00	oz/M			
	GRIGG Gary's Green Ultra	fertilizer	14-2-3 + Mg, B, Cu, Fe, Mn, Zn	Brandt	9.00	oz/M			
20	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	oz/M	12	2	ACEGIKMOQSUW
	Title Phyte	fertilizer	0-0-30	Harrell's	3.00	oz/M			
	Activator+Salicylic acid	*unspecified*	salicylic acid	Harrell's	0.18	oz/M			
	H01	*unspecified*	*unspecified / classified*	Harrell's	0.51	oz/M			
	Fleet 100	surfactant	polyoxyalkylene polymers	Harrell's	2.00	oz/M			
21	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	oz/M	12	2	ACEGIKMOQSUW
	H02	*unspecified*	*unspecified / classified*	Harrell's	3.00	oz/M			
	Activator+Salicylic acid	*unspecified*	salicylic acid	Harrell's	0.18	oz/M			
	H01	*unspecified*	*unspecified / classified*	Harrell's	0.51	oz/M			
	Fleet 100	surfactant	polyoxyalkylene polymers	Harrell's	2.00	oz/M			
22	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	oz/M	12	2	ACEGIKMOQSUW
	Title Phyte	fertilizer	0-0-30	Harrell's	3.00	oz/M			
	Activator+Salicylic acid	*unspecified*	salicylic acid	Harrell's	0.18	oz/M			
	Fleet 100	surfactant	polyoxyalkylene polymers	Harrell's	2.00	oz/M			

23	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	oz/M	12	2	ACEGIKMOQSUW
	H02	*unspecified*	*unspecified / classified*	Harrell's	3.00	oz/M			
	Activator+Salicylic acid	*unspecified*	salicylic acid	Harrell's	0.18	oz/M			
	Fleet 100	surfactant	polyoxyalkylene polymers	Harrell's	2.00	oz/M			
24	Daconil Action	fungicide	chlorothalonil, acibenzolar-S-methyl	Syngenta	3.50	oz/M	12	2	ACEGIKMOQSUW
	Soil Surge	fertilizer	17-0-0	Harrell's	1.50	oz/M			
	Cal Plus	fertilizer	3-0-0 + Ca, Mg, B	Harrell's	3.00	oz/M			
	Fleet 100	surfactant	polyoxyalkylene polymers	Harrell's	2.00	oz/M			
25	BioFlora *Chlorella vulgaris*	*unspecified*	Chlorella Vulgaris microalgae species	Global Organics	20.00	% v/v	24	1	A-X
26	Daconil Action	fungicides	chlorothalonil, acibenzolar-S-methyl	Syngenta	2.00	oz/M	24	1	A-X

A	5/19/20	M	8/11/20
B	5/26/20	N	8/18/20
C	6/2/20	O	8/25/20
D	6/9/20	P	9/1/20
E	6/16/20	Q	9/8/20
F	6/23/20	R	9/15/20
G	6/30/20	S	9/24/20
H	7/7/20	T	9/29/20
I	7/14/20	U	10/6/20
J	7/21/20	V	10/13/20
K	7/28/20	W	10/20/20
L	8/4/20	X	10/27/20

Table 2. Treatment effects on soil electrical conductivity on annual bluegrass irrigated with saline water. Riverside, CA.

Treatment	Electrical Conductivity (ECe)									
	Initial	2 WAIT	4 WAIT	6 WAIT	8 WAIT	10 WAIT	12 WAIT	14 WAIT	16 WAIT	18 WAIT
	5/20/20	6/1/20	6/15/20	6/29/20	7/13/20	7/27/20	8/10/20	8/24/20	9/8/20	9/22/20
1	0.17	0.16	0.14	0.3	0.34	0.38	0.4	0.49	0.47	0.53
2	0.16	0.18	0.15	0.3	0.3	0.28	0.36	0.42	0.5	0.59
3	0.19	0.19	0.17	0.35	0.34	0.34	0.36	0.55	0.63	0.69
4	0.21	0.17	0.16	0.36	0.41	0.44	0.49	0.58	0.62	0.68
5	0.2	0.16	0.18	0.34	0.4	0.37	0.38	0.52	0.62	0.62
6	0.16	0.17	0.15	0.31	0.35	0.32	0.38	0.46	0.55	0.58
7	0.23	0.19	0.2	0.39	0.41	0.39	0.43	0.64	0.71	0.85
8	0.2	0.19	0.18	0.36	0.38	0.44	0.43	0.63	0.59	0.73
9	0.14	0.16	0.14	0.29	0.3	0.31	0.33	0.44	0.41	0.53
10	0.19	0.17	0.17	0.34	0.4	0.38	0.41	0.55	0.51	0.6
11	0.18	0.2	0.16	0.35	0.39	0.38	0.4	0.59	0.64	0.67
12	0.18	0.2	0.19	0.37	0.46	0.55	0.52	0.66	0.62	0.76
13	0.23	0.25	0.19	0.41	0.45	0.44	0.41	0.68	0.64	0.83
14	0.18	0.2	0.19	0.37	0.44	0.43	0.51	0.65	0.6	0.78
15	0.21	0.2	0.18	0.37	0.43	0.48	0.54	0.72	0.63	0.76
16	0.17	0.16	0.16	0.33	0.36	0.35	0.39	0.54	0.51	0.68
17	0.18	0.21	0.2	0.37	0.41	0.41	0.48	0.68	0.63	0.68
18	0.17	0.16	0.17	0.32	0.32	0.34	0.35	0.47	0.49	0.64
19	0.2	0.2	0.22	0.4	0.48	0.47	0.54	0.7	0.64	0.83
20	0.2	0.18	0.16	0.34	0.42	0.42	0.48	0.54	0.61	0.71
21	0.24	0.19	0.19	0.38	0.51	0.42	0.45	0.65	0.61	0.76
22	0.21	0.18	0.17	0.35	0.39	0.4	0.47	0.62	0.56	0.58
23	0.21	0.17	0.18	0.34	0.46	0.46	0.42	0.57	0.6	0.73
24	0.19	0.19	0.17	0.35	0.48	0.51	0.58	0.57	0.58	0.66
25	0.21	0.18	0.16	0.35	0.38	0.38	0.45	0.54	0.54	0.63
26	0.18	0.16	0.18	0.34	0.39	0.38	0.48	0.57	0.57	0.66

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

Table 3. Treatment effects on soil volumetric water content on annual bluegrass irrigated with saline water. Riverside, CA.

Treatment	Soil volumetric water content (%)									
	Initial	2 WAIT	4 WAIT	6 WAIT	8 WAIT	10 WAIT	12 WAIT	14 WAIT	16 WAIT	18 WAIT
	5/20/20	6/1/20	6/15/20	6/29/20	7/13/20	7/27/20	8/10/20	8/24/20	9/8/20	9/22/20
1	15.6	15.9	17.8	17.1	16.4	17.7	16.9	19.1	19.1	19.4
2	14.8	16.3	18.3	17.7	17.3	17.2	17.2	17.7	19.5	20.6
3	15.5	17.5	20.6	20.0	19.9	20.7	19.1	20.3	21.7	21.8
4	16.3	17.8	18.8	19.3	19.2	20.0	19.1	20.3	21.7	22.0
5	16.0	16.5	19.8	18.8	18.6	18.9	17.9	19.9	21.0	20.4
6	14.1	16.6	18.1	17.5	17.4	17.7	17.9	18.2	20.9	19.9
7	16.8	18.2	22.5	21.0	21.7	21.9	21.5	22.8	22.9	24.8
8	16.4	18.9	21.4	19.2	19.7	21.2	19.3	22.0	21.5	22.6
9	14.0	15.5	17.3	16.6	16.4	16.6	15.4	18.3	17.8	18.9
10	15.0	17.1	19.2	17.8	18.5	17.8	16.8	19.9	19.3	20.2
11	15.7	17.7	19.7	19.1	19.8	19.8	18.8	21.1	21.1	21.6
12	15.6	18.0	21.3	19.8	20.5	22.0	20.1	22.6	21.7	22.8
13	19.1	20.9	23.1	21.9	22.9	22.7	20.9	23.2	22.2	24.1
14	15.9	18.3	21.7	20.1	20.5	20.7	19.8	22.1	21.2	23.4
15	16.3	18.0	20.0	19.1	19.2	20.3	19.8	22.6	20.7	23.3
16	15.6	17.9	19.4	18.5	18.7	18.7	18.0	20.3	19.2	21.8
17	15.2	18.0	22.1	19.8	20.6	20.7	20.6	22.7	20.7	21.5
18	14.2	16.6	18.7	17.8	16.9	17.0	16.4	18.8	18.6	20.8
19	17.6	18.5	23.2	21.3	21.4	21.8	21.0	23.3	22.1	24.4
20	16.4	16.9	18.9	18.7	19.4	19.5	19.3	19.9	21.5	22.2
21	17.1	18.0	21.7	20.4	22.4	21.5	19.7	22.0	21.0	22.7
22	15.8	17.1	19.1	18.9	18.5	19.2	18.6	21.8	19.9	20.0
23	16.3	17.0	20.2	18.8	21.7	20.9	18.8	21.1	21.3	22.3
24	15.7	18.0	20.7	18.9	20.5	21.1	20.3	20.0	20.7	20.9
25	15.7	16.9	18.6	18.6	18.8	19.0	17.8	20.0	19.3	21.4
26	15.7	17.1	20.6	18.6	19.2	19.2	18.8	20.4	20.0	21.9

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

Table 4. Treatment effects on quality on annual bluegrass turf irrigated with saline water. Riverside, CA.

Treatment	Turf quality									
	Initial	2 WAIT	4 WAIT	6 WAIT	8 WAIT	10 WAIT	12 WAIT	14 WAIT	16 WAIT	18 WAIT
	5/20/20	6/1/20	6/15/20	6/29/20	7/13/20	7/27/20	8/10/20	8/24/20	9/8/20	9/22/20
1	4.5	7	7.5	7.4	6.7	6.4	6	6.1 d	4.7	6.4
2	5.2	7.2	6.9	7.4	6.9	7	6.8	7.3 abc	5.6	7.1
3	4.4	6.8	7.9	7.5	6.9	6.6	6.7	7.0 bcd	5.6	6.8
4	4.6	6.2	7.4	7.2	6.8	7.2	6.6	7.0 bcd	6	7
5	4.9	7.2	7.6	7.6	7.1	7.1	7.2	6.8 cd	5.3	7
6	4.8	6.8	7.2	6.9	6.4	6.4	6	6.4 cd	5.3	6.5
7	4.7	7.4	7.4	7.4	7.1	7.1	6.6	7.0 bcd	5.8	7.2
8	5.4	7.2	7.4	7.6	6.7	6.6	6.6	6.5 cd	4.6	6.4
9	4	6.8	7.9	7.5	6.9	7.6	6.9	6.4 cd	4.6	6.8
10	4.7	6.4	7.4	7.6	6.8	7.1	6.5	6.4 cd	4.9	6.2
11	4.8	7.4	7.9	7.2	7.2	6.9	7.2	7.0 bcd	5.3	7
12	4.6	7.4	7.8	7.3	6.5	6.2	5.8	6.3 cd	5.2	6.7
13	4.8	7.2	7.9	7.2	6.4	6.4	6.6	6.7 cd	5.3	6.8
14	4.8	7.2	7.7	7.8	6.7	7.1	6.4	6.4 cd	4.7	6.8
15	4.6	7.4	7.8	7.5	7	6.8	6.8	6.5 cd	5.2	7.2
16	5.6	7.4	8.1	7.8	7.6	7.1	6.8	7.1 bcd	6	7
17	4.6	7.2	8.2	8	7	6.8	6.6	6.8 cd	5.5	7
18	4.8	6.8	8	7.5	7.7	7.8	7.8	8.1 ab	5.8	7.2
19	5.2	7.8	8	8.6	7.9	8.2	8.4	8.4 a	6.7	7.6
20	4	6.4	7.5	7.6	7	6.7	6.3	6.4 cd	4.5	6.6
21	4.6	7	8.4	7.5	6.9	7	7	7.3 abc	6.3	7.2
22	4.6	6.8	7.7	7.1	6.6	7	6.2	6.8 cd	4.8	6.8
23	4.8	7.6	7.9	7.7	6.9	6.8	6	6.7 cd	5.6	7
24	4.6	7	8.2	7.6	7.1	6.7	6.2	6.4 cd	5.3	7
25	5.3	6.8	7.5	7.2	6.8	6.9	6.7	6.7 cd	5.8	6.9
26	4.3	7	7.2	7.5	6.4	6.6	6.3	6.9 cd	5.2	7

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

Table 5. Treatment effects on visual green cover of annual bluegrass irrigated with saline water. Riverside, CA.

Treatment	Visual green cover									
	Initial	2 WAIT	4 WAIT	6 WAIT	8 WAIT	10 WAIT	12 WAIT	14 WAIT	16 WAIT	18 WAIT
	5/20/20	6/1/20	6/15/20	6/29/20	7/13/20	7/27/20	8/10/20	8/24/20	9/8/20	9/22/20
1	57.0	96.0	94.4	96.6	92.2	95.4	69.6	83.6	65.0 ef	90.0
2	63.6	96.0	97.0	96.0	92.8	95.0	92.0	96.8	82.2 abcd	98.4
3	62.0	98.2	95.6	99.2	97.2	96.4	94.6	93.2	81.4 abcd	95.8
4	53.0	92.6	94.4	97.6	94.8	95.6	92.0	94.8	79.2 abcde	97.2
5	69.0	97.6	94.8	98.8	95.8	97.4	95.4	93.6	76.6 abcdef	97.2
6	63.0	94.0	89.2	96.8	93.8	91.2	81.0	88.6	73.2 bcdef	94.6
7	61.0	97.0	84.4	98.8	98.2	99.0	78.2	90.6	83.4 abcd	97.6
8	63.0	94.0	96.0	97.8	95.2	94.0	87.6	91.0	63.0 f	89.0
9	58.6	94.0	95.6	98.6	94.8	97.6	90.4	92.6	71.0 def	95.8
10	62.0	96.0	94.0	98.8	95.2	98.0	92.2	92.0	65.6 ef	92.4
11	58.0	96.0	97.2	96.8	96.6	97.0	97.6	96.0	77.0 abcdef	97.6
12	60.0	94.0	96.0	97.2	93.0	94.6	73.0	90.6	76.6 abcdef	94.4
13	60.0	98.6	95.0	98.4	92.0	92.2	84.4	90.8	78.0 abcde	96.2
14	67.0	98.2	97.0	99.0	94.6	97.2	87.2	92.2	72.0 def	96.0
15	58.0	95.8	98.0	98.4	94.6	95.8	86.2	92.8	75.0 bcdef	97.4
16	67.0	97.0	94.6	99.6	98.2	97.2	90.0	94.2	87.0 ab	97.6
17	62.0	96.0	99.2	98.4	95.8	96.0	86.0	92.2	81.8 abcd	96.8
18	60.0	92.6	93.0	97.8	97.6	97.6	95.4	96.6	86.8 abc	97.8
19	65.0	99.0	90.4	99.8	97.4	99.4	93.6	98.4	89.8 a	100.0
20	54.0	93.2	92.0	97.8	95.0	96.4	87.2	91.8	65.0 ef	95.2
21	63.0	97.6	99.8	98.2	96.4	95.8	87.8	95.0	84.2 abcd	96.8
22	56.0	94.6	95.8	97.6	95.0	97.0	91.2	94.0	72.6 cdef	95.8
23	61.0	95.6	98.6	98.8	94.6	95.0	84.8	90.4	73.0 bcdef	94.6
24	59.6	96.0	99.2	99.4	95.6	95.6	88.2	89.6	76.0 abcdef	97.8
25	61.0	95.6	96.6	98.0	95.6	96.2	95.0	93.0	79.0 abcde	94.4
26	55.0	95.2	93.2	97.2	91.2	91.8	77.0	90.8	78.2 abcde	97.2

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

Table 6. Treatment effects on visual color of annual bluegrass turf irrigated with saline water. Riverside, CA.

Treatment	Visual turf color (1-9, 9 = darkest green)									
	Initial	2 WAIT	4 WAIT	6 WAIT	8 WAIT	10 WAIT	12 WAIT	14 WAIT	16 WAIT	18 WAIT
	5/20/20	6/1/20	6/15/20	6/29/20	7/13/20	7/27/20	8/10/20	8/24/20	9/8/20	9/22/20
1	5.2	6.8	6.8 c	7.2	6.7	7.4 ef	5.8 e	6.0 g	4.7 ef	8
2	6.2	7	6.8 c	7.4	7.2	8.2 abcde	7.0 cde	7.4 cde	5.8 abcd	7.9
3	5.6	6.8	6.9 bc	7.4	7.4	7.8 cdef	7.0 cde	6.9 defg	5.9 abcd	8
4	5.2	6.4	7.2 bc	7.4	7.1	8.1 bcde	6.8 cde	7.1 cdef	6.0 abcd	7.8
5	6.2	7.6	7.2 bc	7.8	7.1	8.0 bcdef	7.0 cde	6.9 defg	5.1 def	8
6	5.2	6.5	6.8 c	7.1	6.4	7.2 f	6.4 cde	6.7 defg	5.5 bcdef	8
7	5.6	7.2	7.0 bc	7.6	7.2	8.4 abcd	6.6 cde	7.1 cdef	6.0 abcd	8
8	6.2	6.8	6.8 c	7.9	7.3	7.6 def	6.6 cde	6.8 defg	5.2 cdef	8
9	5.2	7	7.0 bc	7.8	7.3	8.6 abc	7.0 cde	6.5 efg	5.1 def	8
10	5.2	6.4	7.0 bc	8	7	8.1 bcde	7.0 cde	6.5 efg	4.5 f	8
11	5.6	7.2	6.8 c	7.4	7.8	7.7 def	7.4 abcd	6.9 defg	5.2 cdef	7.8
12	6	6.6	7.0 bc	7.2	6.5	7.4 ef	5.8 e	6.4 fg	5.6 abcde	8
13	5.8	6.8	7.4 b	7.7	7.1	7.4 ef	6.6 cde	6.8 defg	5.3 bcdef	8
14	5.6	7.8	7.2 bc	7.6	7.2	7.9 cdef	6.2 de	6.6 defg	5.8 abcd	7.9
15	5.8	7.2	6.7 c	7.5	6.8	7.7 def	6.8 cde	7.2 cdef	5.6 abcde	8
16	6.2	7	7.2 bc	7.7	7.6	8.2 abcde	7.6 abc	7.9 abc	6.3 ab	8.2
17	5.2	7.4	7.0 bc	8	7.3	8.1 bcde	7.4 abcd	7.2 cdef	6.2 abc	8
18	5.2	7.4	7.4 b	8	8.1	8.8 ab	8.4 ab	8.4 ab	6.1 abcd	8.3
19	6.2	8	8.0 a	8.5	7.9	9.0 a	8.6 a	8.8 a	6.6 a	7.9
20	5.4	7.2	7.0 bc	7.7	6.9	7.8 cdef	6.6 cde	6.8 defg	5.1 def	7.8
21	5.6	7.8	7.2 bc	7.8	7.6	8.2 abcde	7.4 abcd	7.5 bcd	6.2 abc	8
22	5.2	6.4	7.2 bc	7.3	7	8.0 bcdef	6.6 cde	6.7 defg	4.7 ef	7.8
23	5.8	7.6	7.2 bc	7.6	7	7.6 def	6.4 cde	6.6 defg	5.6 abcde	8
24	5.4	7.4	7.0 bc	7.6	7	7.9 cdef	7.2 bcd	7.0 cdef	5.3 bcdef	8
25	6	7	7.0 bc	7.5	7	7.8 cdef	7.1 bcde	7.1 cdef	5.8 abcd	8
26	5.4	7	7.2 bc	7.6	7.2	7.8 cdef	6.4 cde	7.4 cde	5.3 bcdef	8.2

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

Table 7. Treatment effects on NDVI on annual bluegrass irrigated with saline water. Riverside, CA.

Treatment	NDVI									
	Initial	2 WAIT	4 WAIT	6 WAIT	8 WAIT	10 WAIT	12 WAIT	14 WAIT	16 WAIT	18 WAIT
	5/20/20	6/1/20	6/15/20	6/29/20	7/13/20	7/27/20	8/10/20	8/24/20	9/8/20	9/22/20
1	0.58	0.81	0.79	0.75	0.72	0.73	0.69	0.72	0.70 f	0.75 e
2	0.59	0.82	0.79	0.76	0.78	0.76	0.78	0.8	0.77 abcde	0.79 abcd
3	0.61	0.83	0.81	0.76	0.75	0.75	0.77	0.8	0.79 abc	0.79 abcd
4	0.54	0.82	0.81	0.76	0.76	0.76	0.77	0.8	0.78 abcd	0.80 abc
5	0.62	0.82	0.81	0.77	0.78	0.74	0.77	0.8	0.76 abcdef	0.79 abcd
6	0.57	0.83	0.8	0.75	0.77	0.76	0.77	0.79	0.75 bcdef	0.78 bcd
7	0.59	0.82	0.79	0.77	0.78	0.76	0.76	0.78	0.79 abc	0.80 abc
8	0.62	0.83	0.8	0.75	0.76	0.75	0.75	0.77	0.72 def	0.78 cde
9	0.59	0.83	0.81	0.76	0.75	0.76	0.76	0.77	0.76 abcdef	0.79 abcd
10	0.58	0.82	0.8	0.75	0.76	0.77	0.77	0.79	0.74 cdef	0.78 cde
11	0.62	0.83	0.82	0.78	0.78	0.78	0.79	0.8	0.77 abcde	0.79 abcd
12	0.57	0.83	0.8	0.77	0.75	0.74	0.73	0.78	0.77 abcdef	0.78 bcd
13	0.62	0.83	0.81	0.77	0.78	0.75	0.77	0.8	0.77 abcde	0.79 abcd
14	0.6	0.84	0.81	0.76	0.75	0.75	0.74	0.79	0.76 abcdef	0.79 bcd
15	0.58	0.83	0.81	0.77	0.77	0.75	0.76	0.78	0.77 abcde	0.79 abcd
16	0.63	0.83	0.82	0.76	0.77	0.77	0.76	0.81	0.80 abc	0.81 abc
17	9.11	0.83	0.82	0.77	0.77	0.77	0.79	0.8	0.80 abc	0.81 abc
18	0.61	0.82	0.82	0.75	0.77	0.75	0.78	0.81	0.81 ab	0.81 ab
19	0.65	0.84	0.82	0.79	0.8	0.8	0.81	0.83	0.82 a	0.82 a
20	0.59	0.83	0.81	0.77	0.77	0.75	0.76	0.77	0.71 ef	0.76 de
21	0.63	0.83	0.82	0.78	0.77	0.75	0.77	0.79	0.80 abc	0.79 abcd
22	0.59	0.83	0.81	0.77	0.77	0.77	0.79	0.8	0.78 abcd	0.80 abc
23	13.1	0.83	0.83	0.77	0.76	0.74	0.74	0.76	0.72 def	0.79 bcd
24	0.6	0.83	0.82	0.76	0.75	0.75	0.78	0.8	0.78 abcd	0.81 abc
25	0.6	0.81	0.81	0.75	0.76	0.75	0.77	0.79	0.77 abcde	0.80 abc
26	0.53	0.83	0.81	0.75	0.73	0.74	0.74	0.8	0.78 abcd	0.80 abc

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

Figure 1. Overview of annual bluegrass green on Sept. 5, 2020 during the salinity study. A record high temperature of 117F was recorded on that day. Riverside, CA**.**

Figure 2. Selected treatments shown on September 5, 2020 in the salinity study on annual bluegrass. Treatment 18 (Brandt weekly fertilizer rotation) is on the left, 19 (Brandt weekly fertilizer rotation with Daconil Action) is in the middle, and the untreated control is on the right. Flags denote plots borders. A record high temperature of 117F was recorded on that day. Riverside, CA.

Video Stop #2: Improvement of Bermudagrass, Kikuyugrass, and Zoysiagrass for Winter Color Retention and Drought Tolerance

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Justification and Objectives:

Repeated testing in Riverside, CA has demonstrated that even the most drought tolerant cool-season grasses cannot compete with warm-season species in water use efficiency. California has been experiencing drought for several years, affecting water availability and price. Extending the use of warm-season grasses, already better adapted to arid climates, and their further improvement for the drought stress resistance can help tackle this issue. The warm-season turfgrass breeding program at University of California, Riverside (UCR) was re-established in 2012, by planting a bermudagrass collection and first crosses among collection accessions to develop improved hybrids. In 2016 a collection of kikuyugrass was established and 3 years later the first hybrids were planted. The main goal of the program is to develop new, improved genotypes of these two species. At the same time, extensive testing of zoysiagrass and some other species is also underway, in cooperation with other breeding programs in the United States. In bermudagrass and kikuyugrass the emphasis is on drought tolerance (hence reduced irrigation). However, winter dormancy hampers the replacement of cool-season with warm-season grasses so selection is also aimed at the reduction of the winter dormancy period. New cultivars with improved winter color retention would likely increase acceptance of warm-season grasses, therefore it is also crucial in our breeding efforts.

Project milestones since Field Day 2019:

- Planted 864 new bermudagrass hybrids generated by open pollination of selected collection accessions.
- Continued one-on-one crosses of bermudagrass accessions generating hybrids with highest quality and winter color retention.
- Continued testing of bermudagrass hybrids in trials established in previous years in Riverside, Coachella Valley and Northern California.
- Established new study including UCR bermudagrass hybrids and commercial check in Las Vegas, NV.
- Continued evaluation of kikuyugrass hybrids.
- Continued evaluation of zoysiagrass in cooperation with Texas A&M and University of Florida.
- Planted more than 600 lines of bermudagrass, zoysiagrass, St. Augustine grass and seashore paspalum developed by several US breeding programs, including UCR bermudagrass lines, within Specialty Crop Research Initiative funded by United States Department of Agriculture (USDA).

Bermudagrass:

Previously conducted crosses and test trials identified two superior hybrids with better or comparable quality, drought tolerance and winter color retention relative to commercially available cultivars. The two hybrids known currently under their experimental codes UCR 17-8 and UCR TP 6-3 will be registered and released as cultivars in the upcoming months. While these two lines, along with other top performing hybrids and commercial checks, are in advanced tests at UCR and at golf courses in California and Nevada, early testing and selection of new, continuously developed hybrids is being performed.

The studies initiated in previous years and being currently evaluated include:

- A fairway study with four best performing UCR bermudagrass hybrids and seven commercial cultivars at the Napa Golf Course, Napa, CA (Figure 3).
- A drought study with 71 UCR hybrids and five commercial cultivars at UCR, Riverside, CA.
- An evaluation study of 12 UCR hybrids and 3 commercial cultivars (‘Bandera’, ‘Midiron’ and ‘Tifway II’) suitable for roughs/lawns at the West Coast Turf sod farm in Coachella Valley and at Santa Lucia Preserve, Carmel-by-the-sea, CA (Figure 4).

Bermudagrass fairway study:

To evaluate bermudagrass suitability for Northern California, test plots were established at Napa Golf Course (Napa, CA). This study includes four UCR hybrids selected in earlier trials and seven commercial cultivars (‘Bandera’, ‘Celebration’, ‘Latitude 36’, ‘Santa Ana’, ‘Tahoma 31’, ‘Tifway II’ and ‘TifTuf’). Plots were established on two fairways in May 2019; ‘Tahoma 31’ was added in October 2019. Large plots were planted with sod in the middle of the fairways to evaluate performance under regular golf course maintenance regimes and traffic. Evaluation of turfgrass quality (1-9; 9=best), color (1-9; 9=darkest green), density/texture (1-9; 9=highest density and fine texture) and uniformity (1-9; 9=highest) started in winter 2019/2020. All hybrids and cultivars, except for ‘Celebration’, showed high turf quality and dark green color, with ‘Latitude 36’ and UCR 17-8 receiving the highest scores for both traits. Lower quality of ‘Tahoma 31’ is probably a consequence of later planting. Most entries have fine texture and form dense and uniform turf stands, however ‘Latitude 36’ and UCR 17-8 showed the highest scores for uniformity.

Table 1. Turfgrass quality (1-9; 9=best), color (1-9; 9=darkest green), density/texture (1-9; 9=highest density and fine texture) and uniformity (1-9; 9=highest) of 4 UCR hybrids and 7 bermudagrass cultivars at Napa Golf Course, Napa, CA.

Name	Turf quality	Color	Density/texture	Uniformity
UCR 10-9	5.8 ab	6.4 ab	7.0 ab	7.0 ab
UCR 17-8	7.4 a	7.8 a	8.0 a	8.3 a
UCR BF2	6.6 a	7.0 ab	7.7 a	6.7 ab
UCR TP6-3	6.8 a	7.1 ab	7.0 ab	6.7 ab
Bandera	6.4 ab	7.3 ab	7.7 a	7.3 ab
Celebration	4.4 b	5.0 b	5.0 b	6.0 b
Latitude 36	7.5 a	7.6 a	8.0 a	8.3 a
Santa Ana	6.9 a	7.4 ab	8.0 a	7.3 ab
Tahoma 31	5.5 ab	5.7 ab	7.0 ab	6.7 ab
TifTuf	6.5 a	7.0 ab	7.3 a	7.3 ab
Tifway II	6.1 ab	6.6 ab	7.3 a	7.0 ab

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

Bermudagrass drought study:

To evaluate drought tolerance among the best performing new hybrids, a new dry-down area was established in May 2019. This included 76 accessions in three replicates each with five commercial cultivars (‘Bandera’, ‘Celebration’, ‘Santa Ana’, ‘TifTuf’, ‘Tifway II’) serving as checks, and 71 UCR hybrids. A preliminary dry-down study was conducted between August – October 2019. In 2020 the accessions were subjected to two subsequent dry-down periods (June 1 – August 6, 2020 and August 21 – October 20, 2020, respectively) followed by recovery periods (August 7-20, 2020 and October 21 – November 3, 2020, respectively). Each plot was evaluated for severity of scalping injuries (0 – 5; 5=severe), leaf firing (1 – 9; 9=no firing), percentage of the green coverage (0-100%; visual and digital image analysis), and NDVI over the course of both dry-down and recovery periods. The first dry-down period (June 1 – August 20) showed several hybrids outperforming ‘Celebration’, with a few of them retaining an average of 90% green coverage based on visual evaluations (Figure 1). Two of the top five performers also performed similarly during the preliminary evaluation in 2019, suggesting consistent patterns not related to maturity. Evaluations for the second dry-down period are underway, but many of the accessions appeared to enter dormancy quicker than they had in the first period. However, there are a few accessions that retain high percentages of green coverage, similar to those in the first period, suggesting that a two week recovery period is sufficient and that these accessions do in fact show good drought tolerance (Figure 1A).

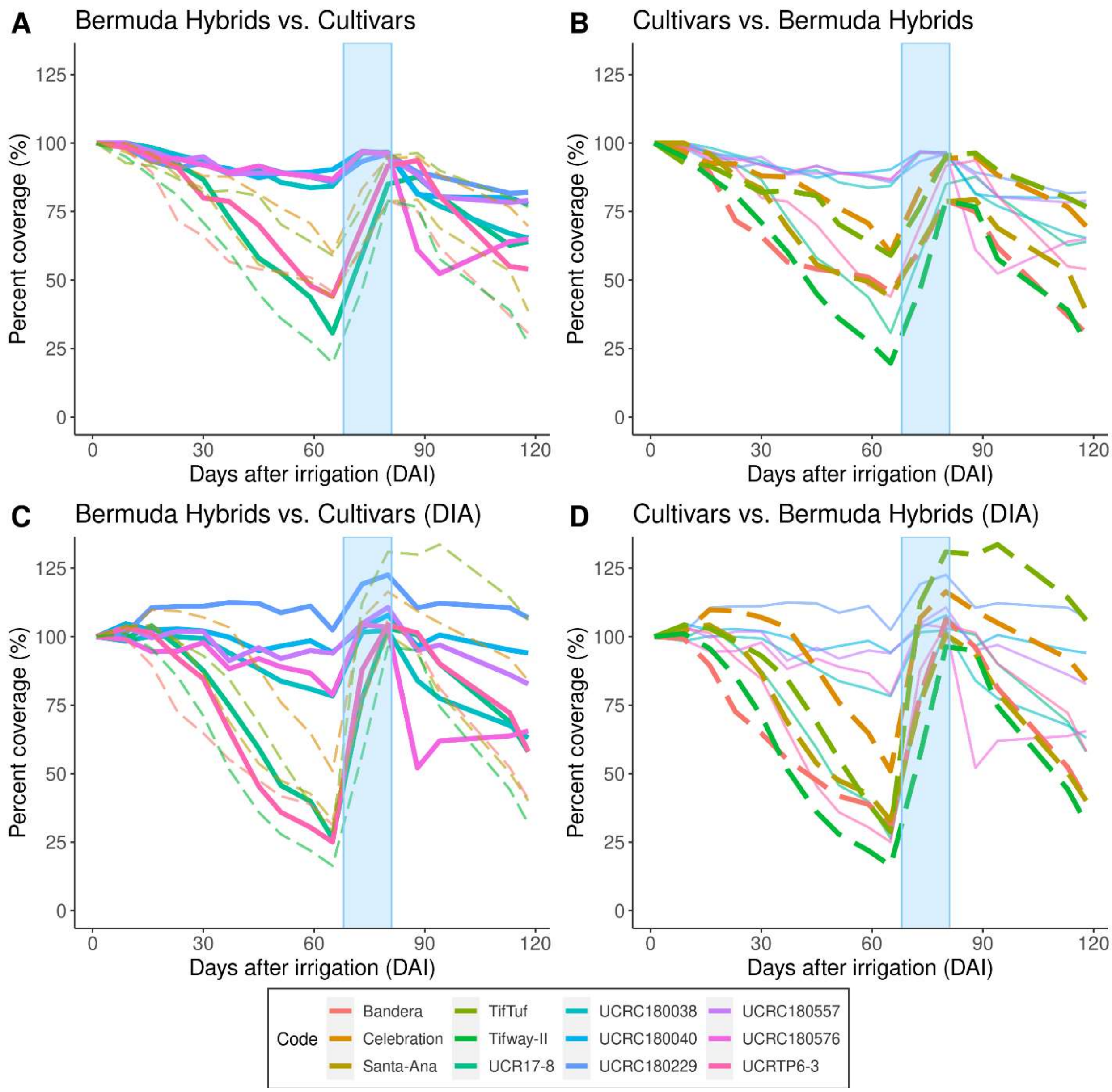

Figure 1. Performance of bermudagrass genotypes in response to a prolonged drought stress. Evaluation of the average percent coverage (0 – 100%) for selected bermudagrass accessions based on (A, B) visual evaluations, and (C, D) digital image analysis (DIA). Evaluations based on DIA were normalized to their respective values on the first day of the dry-down period (DAI=1). The blue region represents a recovery period following the first 65 day dry-down period (DAI=65), where irrigation was restored from 0% ET_0 to 150% ET_0 for 14 days. Comparisons are shown between UCR bermudagrass hybrids (solid lines) and commercial cultivars (dashed lines).

A new study at the Shadow Creek Golf Course, Las Vegas, NV was initiated in July 2020. The study includes 21 UCR hybrids selected for superior quality and winter color retention and four commercial cultivars (‘Latitude 36’, ‘Santa Ana’, ’Tahoma 31’ and ‘TifTuf’). The objective of the study was to evaluate their suitability for harsher climates with lower winter temperatures.

Along with the studies described above, two large nurseries containing ca. 1600 hybrids were planted in 2018 and 2019 and are under evaluation. From this wide pool of lines, 48 promising hybrids were selected for further testing under fairway heights of cut, 19 hybrids were selected for roughs/lawns, and six hybrids for greens. Selected hybrids showed high quality and good winter color retention and will be tested against commercial cultivars at UCR and other locations. Another nursery of 864 hybrids was planted in June 2020 and will undergo the same evaluation and selection process.

Kikuyugrass:

Since establishing a germplasm collection of kikuyugrass in 2016, intensive evaluation, selection and crosses were conducted, which resulted in selecting accessions and hybrids for the drought tolerance study, along with all standard evaluation criteria. The nursery of 280 kikuyugrass hybrids obtained from crosses among the collection accessions was planted in 2019 and hybrids are being evaluated for reduced vigor, finer texture, lower seedhead production and color. This selection, so far, has identified 31 interesting hybrids. They will be planted next year in larger test plots for further evaluation. In addition to continued crosses between different genotypes, the best hybrids will be self-pollinated to perpetuate and enhance desirable traits.

Kikuyugrass drought study:

A drought tolerance study was performed in a manner similar to that in bermudagrass. The dry-down area was established in June 2019 comprised of 38 different accessions in three replicates each, using ‘Whittet’ selections and ‘AZ-1’ as commercial checks. Accessions were evaluated over two subsequent dry-down periods (June 1 – July 30, 2020 and August 15 – September 29, 2020) followed by recovery periods (July 31 – August 14, 2020 and September 30 – October 13, 2020, respectively). Each plot was evaluated for the percentage of the green coverage (0 – 100%; digital image analysis) and NDVI. Percent coverage determined through the digital image analysis was normalized to the first day of the dry-down study to provide a better evaluation of each stand as a whole. Results from the first dry-down period show a very robust recovery among the top five performers which maintained an average of 80% or more of green coverage over the duration of the dry-down period (Figure 2). Top performing accessions reached levels of green coverage similar to, or much higher, than their initial green coverage at the start of the dry-down. It is important to note, however, that almost all accessions entered dormancy at a much quicker rate after the start of the second dry-down.

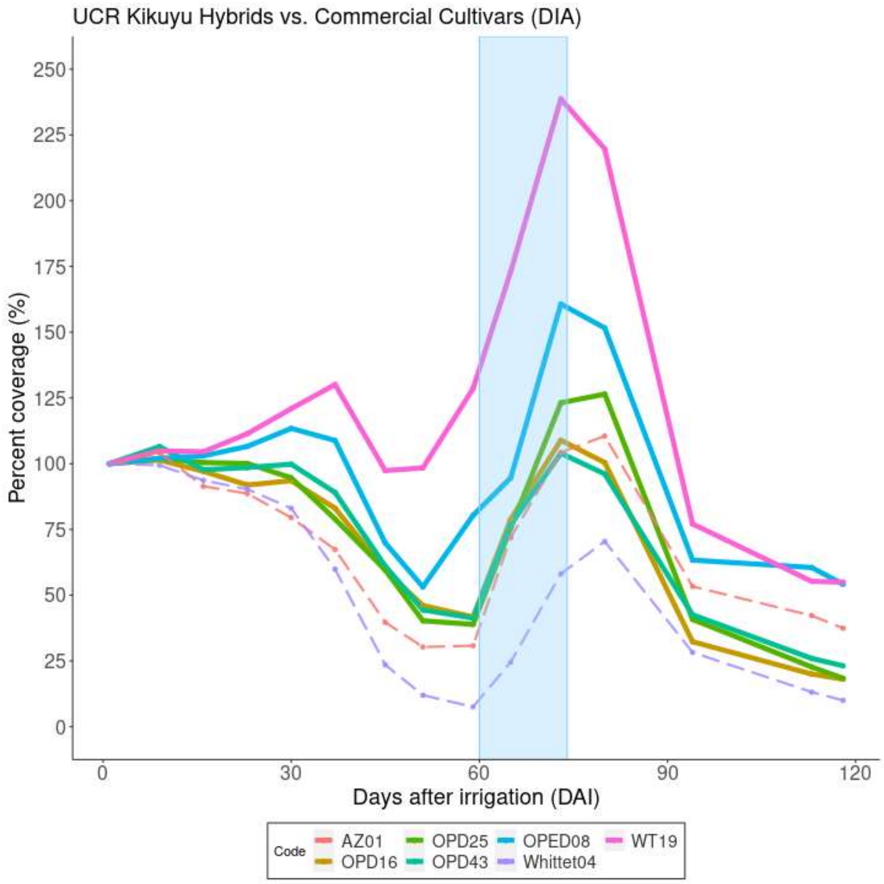

Figure 2. Performance of kikuyugrass genotypes in response to prolonged drought stress. Evaluation of average percent coverage (0 – 100%) for selected kikuyugrass accessions based on DIA. Evaluations based on DIA were normalized to their respective values on the first day of the dry-down period (DAI = 1). The blue region represents a recovery period following the first 60 day dry-down period (DAI = 60), where irrigation was restored from 0% ET_0 to 150% ET_0 for 14 days. Comparisons are shown between UCR kikuyugrass hybrids (solid lines) and commercial cultivars (dashed lines).

Cooperation with other breeding programs:

Currently three studies are underway in cooperation with other warm-season turfgrass breeding programs.

- Evaluation of bermudagrass and zoysiagrass accessions developed by Texas A&M, Oklahoma State University and University of Florida, launched in 2016. The study comprises more than 500 lines of each species and provides insight into their performance in California.
- Evaluation of 16 zoysiagrass lines developed by Texas A&M and four check cultivars at the Napa Golf Course (Napa, CA) and the Meadow Club (Fairfax, CA). The study was established in 2019, but due to long grow-in period in Northern California the first evaluation was possible only in summer of 2020 (Figure 5).

- The UCR turfgrass breeding program has joined a consortium of five warm-season grasses breeding programs: North Carolina State University (NCSU), Oklahoma State University (OSU), Texas A&M AgriLife (TAMUS), the University of Georgia (UGA), and the University of Florida (UF) under the Specialty Crop Research Initiative (SCRI) funded by USDA National Institute of Food and Agriculture (NIFA). Advanced lines of bermudagrass, zoysiagrass, seashore paspalum and St. Augustine grass developed by these breeding programs will be evaluated at UCR for overall performance, as well as for drought and salinity tolerance. Twenty most promising UCR bermudagrass lines, selected from all established nurseries, are included in the project and will be evaluated for the overall performance at all participating locations, and for drought tolerance at UGA. SCRI-NIFA trials were planted in June and July 2020, the evaluation of total of 189 lines of bermudagrass, 216 lines of zoysiagrass, 125 lines of St. Augustine grass and 90 lines of seashore paspalum will start next year.

Plans for the upcoming year include creation of new hybrids of both bermudagrass and kikuyugrass, establishing large areas of new test plots, but also more in depth studies of the metabolic and physiological processes underlying the mechanism of winter dormancy, which in the long term will help to expedite and more precisely develop new hybrids with reduced winter dormancy.

Acknowledgements

Thanks to the CTLF, USGA, MWD, WMWD, USDA NIFA, West Coast Turf, Meadow Club, Napa GC, The Preserve at Santa Lucia and Shadow Creek GC for their support of this research.

Figure 3. Bermudagrass fairway study at Napa Golf Course, 09/29/2020, Napa, CA. Bermudagrass plots (4 UCR hybrids and 7 cultivars) are surrounded by cool-season grasses.

Figure 4. Bermudagrass study testing suitability for roughs/lawns at West Coast Turf sod farm in Coachella Valley, 07/24/2020, Thermal, CA.

Figure 5. Zoysiagrass study of 16 zoysiagrass lines developed by Texas A&M and 4 cultivars at Napa Golf Course, 09/29/2020, Napa, CA.

Video Stop #3: NTEP Bermudagrass Water Use and Zoysiagrass Trials

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Objectives:

The National Turfgrass Evaluation Program (NTEP) facilitates evaluation of turfgrass species in various areas of the United States and Canada, providing valuable information for individuals, companies, researchers, and other entities in thirty countries. The program provides not only a broad picture of cultivar adaptation but also helps to determine adaptation to local environments. The importance of water saving in California cannot be overestimated and one of the solutions is to expand use of warm-season turfgrass species in the golf industry, athletic fields and home lawns. Bermudagrass and zoysiagrass trials are conducted at UCR to evaluate performance of those warm-season species in Southern California, but the approach for each of the studies is different. The objective of bermudagrass trial is to evaluate performance under deficit irrigation, but also winter color retention and spring green-up for fairway/tee use. The objective of zoysiagrass trial is to evaluate suitability for athletic fields and home lawns, also with focus on winter color retention and spring green-up, but without inducing additional stresses.

Materials and Methods:

The bermudagrass study was established on 06/27/2019 (vegetative entries) and 07/03/2019 (seeded entries) and is mowed in 5/8 in. The zoysiagrass study was established on 06/20/2019 with mowing height 2 in. List of entries in both trials is provided in Table 1. In both trials establishment rate (% ground cover), turfgrass quality (1-9; 9=best), spring green-up (1-9; 1=dormant), leaf texture (1-9; 9=finest), genetic color (1-9; 9=darkest green), fall/winter color retention (1-9; 1=dormant; starting second full year of the trial) are being evaluated. In addition, seedhead production (1-9; 1=no seedheads) is being evaluated in zoysiagrass trial and in bermudagrass trial deficit irrigation was initiated on 08/03/2020 at 40% evapotranspiration (ET_{os}) replacement. During this period turfgrass quality and percent green retention are being evaluated. Deficit irrigation study will be repeated every summer.

Results:

Significant differences were observed among all entries of both species in all evaluated traits.
In terms of overall turfgrass quality bermudagrass entries MSB-1017, 'TifTuf', OKC 1876, OKC 1873 and 2 local checks UCR TP6-3 and UCR 17-8 showed good performance (Table 2). These entries were characterized by rather fine leaf texture. MSB-1017, UCR 17-8 and UCR TP6-3 also greened up quickly in the spring. Other entries with fast green-up were UCR 10-9, MSB-1075 and FB 1628. Among seeded entries JSC 2013-10S, 'Monaco' and JSC 2013-10S showed the highest overall quality, fast spring green-up and darkest genetic color. Green cover under deficit irrigation on 09/28/2020 varied, with UCR 10-9 and MSB-1017 retaining cover above 90%. Other entries

with high green cover were MSB-1050, 'TifTuf', UCR 17-8 and FB 1903. Among seeded types, JSC 2013-10S and JSC 2013-12S retained the highest green cover.

Zoysiagrass showed high variation in leaf texture, with DALZ 1802 and DALZ 1807 being the finest, and FZ 1407 and DALZ 1603 the coarsest entries (Table 3). DALZ 1802, DALZ 1408, FZ 1727, 'Zeon' and FAES 1335 showed high overall turfgrass quality. DALZ 1802 and DALZ 1408 were characterized as fine, while the other three entries as medium leaf texture. FZ 1727 and DALZ 1802 were characterized also by fast spring green-up, together with 'Emerald'. Entries varied also in seedhead production. The lowest production was observed in DALZ 1802, DALZ 1808 and 'Emerald'. DALZ 1701 and DALZ 1806 were the darkest green entries when evaluated for genetic color, while 'Zeon' was the brightest. Zoysiagrass was slower to establish than bermudagrass. All bermudagrass entries reached 75% of plot cover within 86 days, except for UCR BF2, MSB-1026 and 'Tifway'. The fastest growing zoysiagrass entry was FZ 1410 (232 days after planting to reach 75%), while 'Meyer' and DALZ 1807 were the slowest (>467 and 408 days, respectively).

<u>Acknowledgments</u>

Thanks to the National Turfgrass Evaluation Program (NTEP) for support of this research.

Figure 1. Bermudagrass (left) and zoysiagrass (right) NTEP trials. Visible differences in green cover among bermudagrass entries and in leaf texture among zoysiagrass entries were apparent on 08/31/2020. Riverside, CA.

Table 1. Entry list for the 2019 National Bermudagrass Test and 2019 National Zoysiagrass Test. Riverside, CA.

Bermudagrass			Zoysiagrass		
No.	**Name**	**Type**	**No.**	**Name**	**Type**
1	Tifway	Vegetative	1	Meyer	Vegetative
2	Tiftuf	Vegetative	2	Emerald	Vegetative
3	OKC1666	Vegetative	3	Zeon	Vegetative
4	OKC1406	Vegetative	4	FZ 1410	Vegetative
5	Latitude 36	Vegetative	5	FZ 1368	Vegetative
6	OKC1876	Vegetative	6	FZ 1367	Vegetative
7	OKC1873	Vegetative	7	FZ 1440	Vegetative
8	OKC1682	Vegetative	8	FZ 1422	Vegetative
9	MSB-1048	Vegetative	9	FZ 1727	Vegetative
10	MSB-1075	Vegetative	10	FZ 1436	Vegetative
11	MSB-1026	Vegetative	11	15-TZ-11715	Vegetative
12	MSB-1050	Vegetative	12	16-TZ-12783	Vegetative
13	MSB-1017	Vegetative	13	16-TZ-13463	Vegetative
14	MSB-1042	Vegetative	14	UGA GZ 17-4	Vegetative
15	JSC 77V	Vegetative	15	Empire	Vegetative
16	JSC 80V	Vegetative	16	DALZ 1713	Vegetative
17	Tahoma 31	Vegetative	17	DALZ 1714	Vegetative
18	Astro	Vegetative	18	DALZ 1802	Vegetative
19	FB 1628	Vegetative	19	DALZ 1806	Vegetative
20	FB 1630	Vegetative	20	DALZ 1807	Vegetative
21	FB 1902	Vegetative	21	DALZ 1808	Vegetative
22	FB 1903	Vegetative	22	DALZ 1311	Vegetative
23	PST-R6TM	Seeded	23	DALZ 1408	Vegetative
24	PST-R6MM	Seeded	24	DALZ 1409	Vegetative
25	DLF-460/3048	Seeded	25	DALZ 1601	Vegetative
26	OKS2015-1	Seeded	26	DALZ 1603	Vegetative
27	OKS2015-3	Seeded	27	DALZ 1613	Vegetative
28	OKS2015-7	Seeded	28	DALZ 1614	Vegetative
29	JSC 2013-5S	Seeded	29	DALZ 1701	Vegetative
30	JSC 2013-7S	Seeded	30	DALZ 1707	Vegetative
31	JSC 2013-8S	Seeded	31	FAES 1319	Vegetative
32	JSC 2013-10S	Seeded	32	FAES 1335	Vegetative
33	JSC 2013-12S	Seeded	33	FZ 1327	Vegetative
34	Riviera	Seeded	34	FZ 1407	Vegetative
35	Monaco	Seeded	35	FZ 1721	Vegetative
36	UCR 17-8	Vegetative	36	FZ 1722	Vegetative
37	UCR TP6-3	Vegetative	37	FZ 1723	Vegetative
38	UCR BF2	Vegetative	38	FZ 1728	Vegetative
39	UCR 10-9	Vegetative	39	FZ 1732	Vegetative
			40	De Anza	Vegetative

Table 2. Turfgrass quality (1-9; 9=best), spring green-up (1-9; 1=dormant), leaf texture (1-9; 9=finest), genetic color (1-9; 9=darkest green) and green cover (%) under deficit irrigation on 09/28/2020 (latest rating date) of bermudagrass entries. Riverside, CA.

Name	Turf quality		Spring green-up		Leaf texture		Genetic color		Green cover 09/28/2020	
Tifway	5.5	b-h	6.3	a-f	6.0	a-c	6.7	a-g	61.7	b-i
Tiftuf	6.5	ab	6.3	a-f	6.7	b-d	6.7	a-g	88.2	a-d
OKC1666	5.3	c-i	7.3	a-e	6.7	b-d	5.0	e-g	80.8	a-g
OKC1406	4.6	f-l	6.7	a-f	6.7	b-d	6.3	b-g	60.6	d-i
Latitude 36	5.1	d-j	6.3	a-f	6.7	b-d	5.3	d-g	51.2	h-j
OKC1876	6.4	a-c	8.0	a-c	7.0	cd	7.3	a-e	81.4	a-g
OKC1873	6.4	a-c	7.3	a-e	6.3	a-d	6.3	b-g	71.4	a-h
OKC1682	6.1	a-d	8.0	a-c	6.7	b-d	7.7	a-d	69.4	a-i
MSB-1048	4.9	e-k	7.7	a-d	7.0	cd	8.0	a-c	63.5	b-i
MSB-1075	5.0	d-k	8.7	a	5.7	a-c	9.0	a	85.5	a-g
MSB-1026	5.1	d-j	7.0	a-e	6.3	a-d	9.0	a	83.9	a-g
MSB-1050	5.8	a-e	8.0	a-c	8.0	d	9.0	a	89.5	a-c
MSB-1017	6.7	a	8.7	a	6.7	b-d	8.3	ab	90.2	ab
MSB-1042	5.8	a-e	7.3	a-e	7.0	cd	7.7	a-d	82.9	a-g
JSC 77V	4.3	i-m	6.3	a-f	6.0	a-c	5.0	e-g	31.0	j
JSC 80V	4.9	e-k	6.0	b-f	6.3	a-d	4.3	g	61.0	c-i
Tahoma 31	5.4	c-i	7.7	a-d	6.7	b-d	8.0	a-c	80.9	a-g
Astro	4.4	h-m	5.3	d-g	5.3	a-c	4.7	fg	74.7	a-h
FB 1628	5.7	a-f	8.3	ab	6.0	a-c	8.3	ab	79.4	a-h
FB 1630	5.3	c-i	7.3	a-e	5.0	ab	7.3	a-e	71.6	a-h
FB 1902	5.1	d-j	7.3	a-e	5.7	a-c	7.0	a-f	82.4	a-g
FB 1903	5.4	b-h	7.0	a-e	5.7	a-c	8.3	ab	86.5	a-f
PST-R6TM	4.5	g-m	6.3	a-f	5.3	a-c	5.7	c-g	76.8	a-h
PST-R6MM	4.3	i-m	5.7	c-g	4.7	a	6.0	b-g	58.7	e-j
DLF-460/3048	4.0	j-m	4.3	fg	5.0	ab	6.0	b-g	75.3	a-h
OKS2015-1	3.4	m	3.3	g	4.7	a	6.3	b-g	70.3	a-i
OKS2015-3	4.1	j-m	5.0	e-g	5.3	a-c	6.7	a-g	41.8	ij
OKS2015-7	3.7	lm	4.3	fg	5.0	ab	6.7	a-g	64.2	a-i
JSC 2013-5S	5.3	c-i	7.3	a-e	5.0	ab	7.7	a-d	78.9	a-h
JSC 2013-7S	4.7	f-l	6.0	b-f	5.0	ab	8.0	a-c	59.2	e-j
JSC 2013-8S	5.0	d-k	7.0	a-e	4.7	a	6.3	b-g	57.9	g-j
JSC 2013-10S	5.5	b-g	6.7	a-f	4.7	a	7.7	a-d	84.8	a-g
JSC 2013-12S	4.9	e-k	6.0	b-f	5.3	a-c	7.3	a-e	81.1	a-g
Riviera	3.9	k-m	4.3	fg	5.0	ab	6.3	b-g	57.9	f-j
Monaco	5.5	b-h	6.7	a-f	5.0	ab	7.7	a-d	73.3	a-h
UCR 17-8	6.2	a-c	8.3	ab	6.7	b-d	8.0	a-c	87.1	a-e
UCR TP6-3	6.3	a-c	8.3	ab	7.0	cd	8.0	a-c	81.3	a-g
UCR BF2	5.5	b-g	7.0	a-e	5.7	a-c	7.0	a-f	82.4	a-g
UCR 10-9	6.0	a-e	8.7	a	5.0	ab	7.3	a-e	92.2	a

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

Table 3. Turfgrass quality (1-9; 9=best), spring green-up (1-9; 1=dormant), leaf texture (1-9; 9=finest), genetic color (1-9; 9=darkest green), seedhead production (1-9; 1=no seedheads) and establishment [Days after planting (DAP) to reach 75 % cover] of zoysiagrass entries. Riverside, CA.

Name	Turf quality		Spring green-up		Leaf texture		Genetic color		Seedhead production		DAP 75%
Meyer	3.9	i	4.3	hi	6.0	d-f	7.0	ab	4.0	a-f	>467
Emerald	6.0	a-f	8.3	ab	6.3	d-g	6.7	ab	1.2	a	313
Zeon	6.5	ab	7.8	a-d	6.7	e-h	5.0	b	1.3	ab	284
FZ 1410	5.6	b-h	6.3	b-i	3.7	ab	6.7	ab	3.0	a-e	232
FZ 1368	5.8	a-h	6.3	b-i	7.7	g-i	7.0	ab	2.5	a-d	313
FZ 1367	6.3	a-d	7.3	a-e	7.3	f-h	6.7	ab	5.3	c-h	284
FZ 1440	6.2	a-e	6.2	b-i	7.7	g-i	7.7	ab	5.0	b-h	284
FZ 1422	5.3	d-h	7.2	a-f	5.7	c-e	6.7	ab	1.5	ab	313
FZ 1727	6.6	ab	9.0	a	6.7	e-h	7.7	ab	5.7	d-h	284
FZ 1436	6.1	a-f	6.7	a-h	7.0	e-h	7.0	ab	3.8	a-f	284
15-TZ-11715	4.9	gh	5.5	c-i	5.7	c-e	6.0	ab	1.5	ab	284
16-TZ-12783	5.6	b-h	5.5	c-i	6.0	d-f	7.7	ab	1.5	ab	284
16-TZ-13463	5.1	f-h	4.0	i	7.0	e-h	8.0	ab	1.3	ab	284
UGA GZ 17-4	6.3	a-d	6.7	a-h	8.0	hi	6.0	ab	5.3	c-h	284
Empire	5.3	d-h	5.5	c-i	3.7	ab	7.0	ab	3.7	a-f	284
DALZ 1713	6.1	a-e	7.0	a-g	5.7	c-e	6.0	ab	4.2	a-g	313
DALZ 1714	5.4	c-h	4.7	f-i	6.0	d-f	6.0	ab	6.8	f-h	313
DALZ 1802	6.7	a	8.3	ab	9.0	i	7.7	ab	1.0	a	351
DALZ 1806	6.3	a-d	8.0	a-c	7.7	g-i	8.3	a	6.7	e-h	313
DALZ 1807	6.1	a-f	7.8	a-d	9.0	i	6.0	ab	1.3	ab	408
DALZ 1808	5.4	c-h	5.0	e-i	5.0	b-d	7.0	ab	1.2	a	284
DALZ 1311	5.6	b-h	4.5	g-i	3.7	ab	7.7	ab	2.0	a-d	284
DALZ 1408	6.7	a	7.8	a-d	7.0	e-h	8.0	ab	3.7	a-f	284
DALZ 1409	6.1	a-f	6.7	a-h	8.0	hi	6.3	ab	4.2	a-g	313
DALZ 1601	5.3	d-h	5.3	d-i	3.7	ab	7.3	ab	1.8	a-c	284
DALZ 1603	5.6	b-h	7.0	a-g	3.0	a	7.3	ab	2.0	a-d	284
DALZ 1613	5.7	a-h	5.8	b-i	6.0	d-f	6.7	ab	4.5	a-h	284
DALZ 1614	6.2	a-e	7.7	a-d	6.0	d-f	6.7	ab	4.0	a-f	313
DALZ 1701	5.5	b-h	6.7	a-h	5.7	c-e	8.3	a	4.3	a-g	313
DALZ 1707	5.0	gh	5.0	e-i	5.7	c-e	7.0	ab	5.5	c-h	313
FAES 1319	5.7	a-h	7.0	a-g	5.0	b-d	8.0	ab	2.5	a-d	284
FAES 1335	6.5	ab	7.2	a-f	6.0	d-f	5.7	ab	3.7	a-f	284
FZ 1327	4.9	gh	4.3	hi	4.3	a-c	7.7	ab	1.3	ab	313
FZ 1407	4.9	hi	5.0	e-i	3.3	a	7.0	ab	2.0	a-d	313
FZ 1721	5.8	a-h	8.0	a-c	7.3	f-h	7.3	ab	7.2	f-h	351
FZ 1722	5.9	a-h	6.5	a-i	6.7	e-h	7.0	ab	2.7	a-d	313
FZ 1723	5.8	a-h	6.5	a-i	6.7	e-h	5.3	ab	2.0	a-d	313
FZ 1728	6.0	a-g	7.7	a-d	8.0	hi	6.7	ab	8.2	h	313
FZ 1732	6.4	a-c	7.5	a-e	6.7	e-h	6.7	ab	7.8	gh	284
De Anza	5.1	e-h	5.8	b-i	6.3	d-g	5.7	ab	3.0	a-e	351

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

Video Stop #4: 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 organization 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 limited water is available. Warm-season turfgrasses are generally more drought-resistant than cool-season grasses. A total of 20 entries, including three species of warm-season grasses (bermudagrass, buffalograss, and zoysiagrass), were evaluated under deficit irrigation conditions (Table 1). The objective of this study was 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 June 22, 2018. Turfgrass was maintained under optimal irrigation conditions before and after the treatment period. Table 1 provides a list of entries for this study. From June 1 to October 15, 2019, turfgrass was irrigated at three short crop reference evapotranspiration (ET_{os}) replacements (60%, 45%, and 30% ET_{os}). Deficit irrigation treatment was resumed on June 15, 2020, and will be repeated in 2021. Turf is maintained under fairway conditions and mowed three times per week at 0.5 inches. Plots received 0.5lb N/month, 4.5 lbs N 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. For this report, data were presented for each month.

Results:

In summer 2019, the tested entries showed a wide range of variability among three ET_{os} levels. Similar results were observed in 2020 (Tables 2 and 3).

Before initiating the deficit irrigation treatments, variation of quality among the tested entries was observed on 6/12/20 (Table 2). At 60% ET_{os} replacement, FAES 1306, a UF experimental zoysiagrass, had an average quality of 8.7; however, Meyer zoysiagrass had a quality rating of 3.7.

During the first month of deficit irrigation treatments until 7/9/20, all entries except FAES 1307 showed acceptable quality (6 or above) at 30% ET_{os} replacement. A severe drop in quality across entries was recorded two months (8/13/20) after initiating the irrigation treatments. At this point, only two bermudagrasses, UCR 17-8 and TifTuf, were able to hold quality at an acceptable level. On 9/10/20, after three months of deficit irrigation, no entries had acceptable quality at 30% ET_{os} replacement. Several entries had quality above 6 at 45% ET_{os} replacement, including TifTuf, UCR 17-8, and Tahoma 31. Besides the aforementioned entries, FAES 1306, FB 1628, Dog Tuff, JSC 2009-6-s, Tifway, and Monaco had acceptable quality at 60% ET_{os} replacement. Green cover was correlated with quality, and results were presented in Table 3.

To be noted, one of the UCR experimental hybrids, UCR 17-8, showed good winter color retention when most other warm-season grasses were dormant in January 2020 (Figure 3).

In summary, among the tested entries in this study, bermudagrass was the most drought-resistant species compared to zoysiagrass and buffalograss. A few bermudagrasses, including UCR 17-8 and TifTuf, could maintain acceptable quality when irrigating at 45% ET_{os} replacement. Using turfgrasses like these could achieve significant water savings. This trial will continue to be evaluated in 2020 until mid-October and will be repeated in 2021.

<u>Acknowledgments</u>

Thanks to the National Turfgrass Evaluation Program (NTEP) and the US Golf Association (USGA) for financial support of this research.

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

Entry Number	Species	Cultivar	Establishment method
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

Table 2. Turf quality of warm-season turfgrasses under deficit ET_{os} levels in summer 2020. Riverside, CA.

	Turf Quality											
	6/12/20						7/9/20					
Cultivar	30% ET_{os}		45% ET_{os}		60% ET_{os}		30% ET_{os}		45% ET_{os}		60% ET_{os}	
ASC 118	4.3	J*	3.7	H	4.3	GIH	4.0	GF	5.0	EFD	5.3	HG
ASC 119	4.7	JI	4.0	H	4.0	IH	5.0	DFE	5.0	EFD	5.3	HG
Cody	4.3	J	4.3	HG	4.3	GIH	5.7	DCE	4.7	EF	5.0	H
Dog Tuff	7.0	BEDC	6.7	EDC	7.3	BC	6.3	BC	6.7	BDC	7.0	CED
FAES 1306	8.7	A	8.3	A	8.7	A	7.3	BA	7.0	BAC	8.0	B
FAES 1307	7.0	BEDC	6.0	EDF	6.7	DC	5.0	DFE	5.7	EFDC	6.3	FE
FB 1628	8.0	BA	8.0	BA	8.0	BA	8.0	A	8.7	A	9.0	A
JSC 2009-6-s	5.0	JIH	5.7	EF	5.0	GFH	6.0	DC	5.7	EFDC	6.0	FG
Meyer	4.3	J	4.3	HG	3.7	I	3.3	G	4.7	EF	3.7	I
Monaco	6.0	FEHG	5.3	GF	5.7	DFE	6.0	DC	5.7	EFDC	6.3	FE
OKC 1221	5.3	JIHG	6.0	EDF	7.0	BC	5.0	DFE	6.0	EDC	6.7	FED
Premier Pro	5.7	FIHG	6.3	EDF	7.0	BC	4.7	FE	5.7	EFDC	6.3	FE
Prestige	5.7	FIHG	5.7	EF	5.3	GFE	5.3	DCE	4.0	F	6.0	FG
Stellar	8.0	BA	7.7	BAC	7.0	BC	6.0	DC	7.0	BAC	7.0	CED
Tahoma 31	7.7	BAC	7.0	BDC	6.3	DCE	7.7	A	8.3	BA	8.0	B
TifTuf ™	6.0	FEHG	7.0	BDC	6.7	DC	7.7	A	8.3	BA	7.7	CB
Tifway	7.3	BDC	6.7	EDC	7.0	BC	7.3	BA	8.0	BA	7.3	CBD
UCR 17-8	8.7	A	7.7	BAC	7.0	BC	7.7	A	8.0	BA	7.3	CBD
UCR BF1	6.7	FEDC	6.7	EDC	6.7	DC	6.3	BC	7.0	BAC	7.0	CED
UCR BF2	6.3	FEDG	6.3	EDF	7.0	BC	6.3	BC	7.0	BAC	7.0	CED

(continued)

	Turf Quality											
	8/13/20						9/10/20					
Cultivar	30% ET_{os}		45% ET_{os}		60% ET_{os}		30% ET_{os}		45% ET_{os}		60% ET_{os}	
ASC 118	4.0	DC	5.0	FDEC	5.3	EDC	3.3	EDFC	4.0	FDE	4.7	EDC
ASC 119	3.3	ED	4.7	FDE	5.0	EDF	3.3	EDFC	4.3	FDE	4.7	EDC
Cody	4.3	DC	4.0	FE	5.0	EDF	3.7	EBDC	4.7	FDEC	5.3	BDC
Dog Tuff	5.3	BAC	5.7	BDAC	6.0	BDC	4.7	BAC	5.0	BDEC	6.0	BAC
FAES 1306	3.3	ED	4.3	FDE	7.3	A	2.8	EF	4.7	FDEC	6.7	BA
FAES 1307	2.3	E	3.7	F	4.5	EF	2.0	F	3.3	F	4.3	ED
FB 1628	4.7	BDC	6.3	BAC	7.0	BA	4.3	BDAC	5.0	BDEC	7.3	A
JSC 2009-6-s	4.0	DC	4.7	FDE	6.0	BDC	3.7	EBDC	5.3	BDAC	6.0	BAC
Meyer	2.3	E	4.3	FDE	4.0	F	2.0	F	3.7	FE	3.7	E
Monaco	4.3	DC	5.3	BDEC	6.0	BDC	4.0	EBDAC	5.0	BDEC	6.0	BAC
OKC 1221	4.3	DC	4.7	FDE	6.3	BAC	3.3	EDFC	3.7	FE	5.3	BDC
Premier Pro	3.3	ED	4.7	FDE	6.0	BDC	3.3	EDFC	3.3	F	5.3	BDC
Prestige	3.3	ED	3.7	F	4.7	EF	3.0	EDF	4.3	FDE	5.3	BDC
Stellar	3.3	ED	4.7	FDE	5.0	EDF	2.7	EF	4.0	FDE	5.3	BDC
Tahoma 31	4.8	BDC	7.0	A	7.0	BA	4.0	EBDAC	6.0	BAC	7.3	A
TifTuf ™	6.2	BA	6.7	BA	6.7	BA	5.0	BA	6.3	BA	7.3	A
Tifway	5.3	BAC	6.3	BAC	6.0	BDC	4.7	BAC	5.3	BDAC	7.0	A
UCR 17-8	6.7	A	6.7	BA	6.7	BA	5.3	A	6.3	BA	7.0	A
UCR BF1	4.3	DC	5.0	FDEC	6.0	BDC	4.0	EBDAC	6.7	A	6.7	BA
UCR BF2	4.0	DC	5.7	BDAC	6.0	BDC	4.0	EBDAC	6.3	BA	6.3	BA

*Means followed by the same letter in a column are not statistically different ($P < 0.05$).

Table 3. Green cover of warm-season turfgrasses under deficit ET_{os} levels in summer 2020. Riverside, CA.

Cultivar	Green cover (%)											
	6/12/20						7/9/20					
	30% ET_{os}		45% ET_{os}		60% ET_{os}		30% ET_{os}		45% ET_{os}		60% ET_{os}	
ASC 118	33.8	H	42.0	G	58.0	EF	35.9	IGH	54.9	HGF	61.8	D
ASC 119	50.1	G	38.8	G	57.0	EFG	45.9	EGHF	51.2	HG	60.9	D
Cody	44.1	HG	41.2	G	45.5	G	30.6	IH	39.4	H	43.5	E
Dog Tuff	84.9	BDAC	78.6	EBDAC	83.0	BAC	65.7	EDC	77.2	EBDACF	87.4	BA
FAES 1306	87.8	BAC	89.6	A	90.7	A	87.5	BA	87.9	BAC	92.4	A
FAES 1307	84.6	EBDAC	76.9	EBDAC	87.1	BA	58.2	EDF	67.6	EDGCF	78.9	BAC
FB 1628	88.7	BA	86.7	BA	87.8	BA	91.3	A	92.8	BA	93.2	A
JSC 2009-6-s	71.5	EF	71.9	EDC	76.2	BDC	58.8	EDF	70.6	EBDGCF	79.8	BAC
Meyer	51.0	G	56.4	F	47.2	FG	22.3	I	57.7	EHDGF	36.0	E
Monaco	77.6	EBDACF	70.6	EDF	79.6	BAC	82.2	BAC	79.4	BDAC	85.6	BA
OKC 1221	75.8	EBDCF	82.4	BDAC	84.1	BAC	53.8	EGDF	76.0	EBDACF	86.4	BA
Premier Pro	75.4	EBDCF	76.7	EBDAC	82.9	BAC	41.2	IGHF	56.8	EHGF	73.5	BDC
Prestige	67.7	F	66.0	EF	64.5	ED	41.4	IGHF	53.4	HG	68.0	DC
Stellar	84.7	EBDAC	85.3	BAC	84.7	BAC	68.4	BDC	78.6	EBDAC	86.4	BA
Tahoma 31	86.7	BDAC	85.7	BAC	86.2	BAC	92.1	A	93.2	A	85.5	BA
TifTuf ™	80.1	EBDACF	84.0	BDAC	80.2	BAC	89.1	A	92.3	BA	94.6	A
Tifway	80.4	EBDACF	77.8	EBDAC	79.4	BAC	83.7	BAC	87.8	BAC	86.7	BA
UCR 17-8	89.8	A	85.8	BAC	85.5	BAC	91.6	A	93.1	A	90.4	BA
UCR BF1	74.5	EDCF	76.8	EBDAC	74.4	DC	53.3	EGDF	77.4	EBDAC	81.0	BAC
UCR BF2	73.5	EDF	74.2	EBDC	79.2	BAC	55.9	EDF	81.6	BAC	80.9	BAC

(Continued)

Cultivar	Green cover (%)											
	8/13/20						9/10/20					
	30% ET_{os}		45% ET_{os}		60% ET_{os}		30% ET_{os}		45% ET_{os}		60% ET_{os}	
ASC 118	12.2	BC	36.4	BEDC	46.5	FDEC	12.0	BC	32.9	FBEDC	44.5	EGFH
ASC 119	8.1	C	21.0	EDC	50.7	BDEC	7.0	C	25.3	FBEDC	49.1	EGDF
Cody	12.4	BC	17.8	ED	29.1	FEG	17.5	BAC	29.3	FBEDC	40.1	GFH
Dog Tuff	21.5	BAC	49.0	BAC	71.1	BAC	20.8	BAC	44.9	BEDC	78.7	BA
FAES 1306	5.4	C	19.5	EDC	77.7	A	1.3	C	21.7	FEDC	79.9	BA
FAES 1307	2.2	C	11.5	ED	21.1	FG	1.3	C	17.3	FED	39.1	GH
FB 1628	19.9	BAC	56.6	BA	76.1	BA	20.3	BAC	50.4	BAC	78.6	BA
JSC 2009-6-s	14.5	BAC	35.4	BEDC	63.8	BAC	10.2	BC	47.1	BDC	70.9	BDAC
Meyer	0.7	C	18.4	ED	14.3	G	0.6	C	21.8	FEDC	24.9	H
Monaco	22.1	BAC	40.0	BDC	69.8	BAC	11.4	BC	34.9	FBEDC	70.4	BDAC
OKC 1221	19.7	BAC	25.7	EDC	62.5	BDAC	6.9	C	22.0	FEDC	63.4	EBDFC
Premier Pro	5.1	C	14.8	ED	62.3	BDAC	3.9	C	15.0	FE	72.9	BAC
Prestige	3.6	C	6.9	E	26.7	FEG	6.3	C	15.6	FE	35.1	GH
Stellar	1.5	C	9.3	E	26.2	FEG	1.4	C	11.7	F	51.1	EGDFC
Tahoma 31	12.0	BC	58.3	BA	61.4	BDAC	7.3	C	45.0	BEDC	75.7	BA
TifTuf ™	35.3	BA	60.1	BA	67.1	BAC	31.9	BA	53.2	BA	87.0	BA
Tifway	19.9	BAC	35.6	BEDC	50.7	BDEC	13.7	BC	33.7	FBEDC	65.0	EBDAC
UCR 17-8	40.9	A	72.1	A	70.8	BAC	39.5	A	79.6	A	87.3	A
UCR BF1	1.9	C	16.4	ED	28.2	FEG	3.5	C	41.5	FBEDC	67.8	EBDAC
UCR BF2	1.4	C	20.7	EDC	37.2	FDEG	1.2	C	41.4	FBEDC	77.6	BA

* Means followed by the same letter in a column are not statistically different ($P < 0.05$).

30% ET_{os}. **60% ET_{os}.** **45% ET_{os}**

Figure 1. A total of 20 entries of bermudagrass, zoysiagrass, and buffalograss under irrigation at 30%, 45%, or 60% ET_{os}. Photo was taken on September 22, 2020. Riverside, CA.

30% ET_{os}. **45% ET_{os}.** **60% ET_{os}**

A: UCR 17-8 (Bermudagrass); B: TifTuf (Bermudagrass); C: Meyer (Zoysiagrass); D: Cody (Buffalograss)

Figure 2. Photos of representative cultivars and a local experimental selection. Irrigation treatments were initiated on June 15, 2020 and pictures were taken on September 24, 2020. Riverside, CA.

Figure 3. Plot picture on January 3, 2020. The bottom right plot is UCR 17-8, bermudagrass experimental cultivar from UCR. Riverside, CA.

Video Stop #5: Product Testing for Water Conservation on Bermudagrass Turf

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Justification and Objectives:

Previous research has demonstrated that wetting agent products are among the most important chemistries for turfgrass water conservation. Considering cost, treating large areas such as golf course fairways with certain wetting agent products may not be affordable to many golf courses. Furthermore, the novel mineral oil product developed by Intelligro, named CIVITAS, has shown significant effects on turfgrass pest management. However, little information is available on its impact on water conservation. This study aimed to investigate the application rates and schedules of two wetting agent products and CIVITAS to conserve water on large areas such as bermudagrass fairways. To evaluate these, the study area was subjected to 55, 65, and 75% reference evapotranspiration (ET_o) irrigation replacements.

Methods:

The study was conducted on mature hybrid bermudagrass 'Tifway II' established by sod in 2017. The 60' x 80' field is divided into 12 20' x 20' main plots. From June through October 2020, plots receive either 55, 65, or 75% of previous week ET_o determined by an on-site CIMIS station. Treatments were arranged in a split-plot design with 11 treatments, including an experimental product and untreated control (plot size 24 ft^2), and randomized with four replicates within ET_o replacement plots. Treatments are presented in Table 1. Product application started on June 3, and treatments were applied every two, three, or four weeks thereafter. Following a 2-wk 'conditioning period', deficit irrigation treatments started on June 17, 2020. The study receives 5 lb N/M/year and is mowed three times/week at 0.5 in. Treatments were applied using a CO_2-powered hand boom sprayer equipped with TeeJet 8004VS nozzles and 2 gal/M output. One day before the first treatment and then every two weeks, plots were evaluated for visual turfgrass quality (1 to 9 scale, 1 = worst to 9 = best), visual color (1 to 9 scale, 1 = straw color, 9 = dark green color), volumetric soil water content (VWC) using time domain reflectometry (TDR). For this report, data were presented for each month.

Results:

Turf quality

On 7/14/20, two weeks after the deficit irrigation treatments, no differences were observed among treatments at 65% and 75% ET_o replacements (Table 2). At 55% ET_o replacement, treatment 3 (CIVITAS at 4.5 oz/M, applied every 2 wks) had higher quality than the untreated control. And the remainder of the treatments were comparable to the untreated control.

On 8/11/20, treatment 11 (CIVITAS at 8.5 oz/M, applied every 3 wks) showed better quality than the untreated control at all ET_o replacements (Table 2). At 55% and 75% ET_o replacements, among the CIVITAS treatments, treatment 11 had better quality than any biweekly treatments. This was likely due to the timing of application, as treatment 11 was applied one week before rating events, while the other two treatments were applied two weeks before. At 65% ET_o replacement, differences were observed among the Hydro-Inject wetting agent treatments, where the biweekly application at 1 oz/M had lower quality than the monthly application at 2 oz/M. Opposite results were recorded at 75% ET_o replacement.

On 9/9/20, 10 weeks after initiating deficit irrigation, the untreated plot had an average quality of 5.5 at 55% ET_o replacement, while all products tested in this study maintained acceptable turf quality (Table 2). Except for treatments 2 (CIVITAS at 8.5 oz/M, applied every 2 wks), 4 (UCR 001), 6 (Hydro-Inject at 1 oz/M, applied every 2 wks), and 9 (Passage at 2 oz/M, applied every 2 wks), the remainder of treatments had higher quality than the untreated control at 55% ET_o replacement. No differences were observed for different rates and application frequencies among any products at 55% or 75% ET_o replacements. At 65% ET_o replacement, plots treated with treatment 5 (Hydro-Inject at 2 oz/M, applied every 4 wks) had better quality than treatment 6 (Hydro-Inject at 1 oz/M, applied every 2 wks).

No differences were observed among the Passage treatments at any ET_o replacements during the all rating dates.

Color

On 7/14/20, at 55% ET_o replacement, treatments 2 (CIVITAS at 8.5 oz/M, applied every 2 wks), 3 (CIVITAS at 4.5 oz/M, and applied every 2wks), and 4 (UCR 001) had greener color than the majority of wetting agent treatments, including treatments 5 (Hydro-Inject at 2 oz/M, applied every 4 wks), 6 (Hydro-Inject at 1 oz/M, applied every 2 wks), 7 (Hydro-Inject at 1 oz/M, applied every 4 wks), 8 (Passage at 4 oz/M, applied every 4 wks), and 9 (Passage 2 oz/M, applied every 2 wks). At 65% ET_o replacement, treatments 3 (CIVITAS at 4.5 oz/M, and applied every 2wks) and 4 (UCR 001) had better color than treatments 1 (untreated control), 5 (Hydro-Inject at 2 oz/M, applied every 4 wks), 6 (Hydro-Inject at 1 oz/M, applied every 2 wks), 10 (Passage at 2 oz/M, applied every 4 wks), and 11 (CIVITAS at 8.5 oz/M, applied every 3 wks). No differences were observed at 75% ET_o replacement.

On 8/11/20, at 55% ET_o replacement, treatment 11 (CIVITAS at 8.5 oz/M, applied every 3 wks) had greener color than most of the treatments except for treatment 2 (CIVITAS at 8.5 oz/M, applied every 2 wks), and 4 (UCR 001). At 65% ET_o replacement, treatment 11 (CIVITAS at 8.5 oz/M, applied every 3 wks) had better color than the majority of treatments besides treatments 2 (CIVITAS at 8.5 oz/M, applied every 2 wks), 3 (CIVITAS at 4.5 oz/M, and applied every 2 wks), 5 (Hydro-Inject at 2 oz/M, applied every 4 wks), and 10 (Passage at 2 oz/M and applied every 4 wks). At 75% ET_o replacement, all treatments looked comparable to the untreated control.

On 9/9/20, except for treatment 2 (CIVITAS at 8.5 oz/M, applied every 2 wks), the remainder of treatments improved color compared to the untreated control at 55% ET_o replacement. At 65% ET_o replacement, except for treatment 6 (Hydro-Inject at 1 oz/M, applied every 2 wks), the remainder of treatments had similar color. No differences were observed at 75% ET_o replacement.

Soil volumetric water content

On 7/14/20 and 8/11/20, all products had similar VWC compared to the untreated control at all ET_o replacements. Surprisingly, at 75% ET_o replacement on both dates, treatment 7 (Hydro-Inject at 1 oz/M, applied every 4 wks) had higher VWC than 5 (Hydro-Inject 2 oz/M, applied every 4 wks). Plots treated with treatment 10 (Passage at 2 oz/M and applied every 4 wks) had lower soil moisture than treatment 9 (Passage 2 oz/M, applied every 2 wks). On 8/11/20 only, treatment 5 (Hydro-Inject at 2 oz/M, applied every 4 wks) improved soil moisture compared to treatment 6 (Hydro-Inject at 1 oz/M, applied every 2 wks) at 65% ET_o replacement.

On 9/9/20, only treatment 5 (Hydro-Inject at 2 oz/M, applied every 4 wks) improved VWC compared to both the untreated control and treatment 6 (Hydro-Inject at 1 oz/M, applied every 2 wks) at 65% ET replacement. No other differences were recorded.

In summary, Civitas products often showed improvement in turf quality and color, especially when the product was applied one week before plots were evaluated. Minor differences were recorded among the two rates. For the wetting agent treatments, the reduced vs. full rate showed no differences with Hydro-Inject and only minor differences with Passage at the 4-week application frequency. All tested products could maintain acceptable quality for at least 12 weeks when irrigated at 55% ET_o replacement, better than the untreated control.

This trial will continue to be evaluated until late October 2020. The same study is being replicated at the Ft. Lauderdale Research & Education Center, University of Florida.

Acknowledgments

Thanks to Intelligro for funding this research, and Harrell's and Numerator Technology for providing products.

Table 1. List of treatments in bermudagrass deficit irrigation study. 2020. Riverside, CA.

No.	Treatment	Rate (oz/M)	Company	Frequency (weeks)
1	Untreated Control	n/a	n/a	n/a
2	CIVITAS	8.5	Intelligro	2
3	CIVITAS	4.5	Intelligro	2
4	UCR 001	n/a	n/a	n/a
5	Hydro-Inject	2	Harrell's	4
6	Hydro-Inject	1	Harrell's	2
7	Hydro-Inject	1	Harrell's	4
8	Passage	4	Numerator Tech	4
9	Passage	2	Numerator Tech	2
10	Passage	2	Numerator Tech	4
11	CIVITAS	8.5	Intelligro	3

Table 2. Visual quality of 'Tifway II' bermudagrass treated with various products and irrigated at 55%, 65%, and 75% ET_o. Riverside, CA.

	Turf quality														
	7/14/20				8/11/20						9/9/20				
Trt	55% ET_o		65% ET_o	75% ET_o	55% ET_o		65% ET_o		75% ET_o		55% ET_o		65% ET_o		75% ET_o
1	6.8	BC*	7.5	7.4	6.5	B	6.9	BC	8.1	B	5.5	B	7.0	AB	7.9
2	7.4	AB	7.3	7.3	6.5	B	7.8	AB	8.3	B	6.0	AB	7.4	AB	7.9
3	7.6	A	7.9	7.8	6.3	B	7.5	ABC	8.0	BC	6.4	A	7.3	AB	7.9
4	7.3	AB	7.6	7.5	7.0	AB	7.6	AB	8.1	B	6.3	AB	7.0	AB	8.0
5	6.4	C	7.3	7.6	6.1	B	7.8	AB	7.6	C	6.4	A	7.5	A	7.8
6	6.6	BC	7.1	7.4	6.5	B	6.5	C	8.1	B	6.3	AB	6.5	B	8.0
7	7.0	ABC	7.3	7.5	5.8	B	7.0	BC	8.0	BC	6.4	A	7.0	AB	8.0
8	6.8	BC	7.3	7.5	6.5	B	7.1	BC	8.0	BC	6.5	A	7.1	AB	7.9
9	6.9	ABC	7.4	7.5	6.3	B	7.0	BC	8.1	B	6.3	AB	7.5	A	7.8
10	7.1	ABC	7.6	7.4	6.8	AB	7.3	BC	8.0	BC	6.6	A	7.0	AB	8.0
11	7.1	ABC	7.6	7.8	8.0	A	8.5	A	8.8	A	6.8	A	6.8	AB	8.0

*Means followed by the same letter in a column are not statistically different ($P < 0.05$).

Table 3. Visual color of 'Tifway II' bermudagrass treated with various products and irrigated at 55%, 65%, and 75% ET_o. Riverside, CA.

	Color														
	7/14/20					8/11/20						9/9/20			
Trt	55% ET_o		65% ET_o		75% ET_o	55% ET_o		65% ET_o		75% ET_o		55% ET_o		65% ET_o		75% ET_o
1	7.0	AB*	7.3	B	7.3	6.8	BDC	7.3	B	7.9	AB	4.1	C	7.5	A	7.9
2	7.6	A	7.5	AB	7.6	7.1	BA	7.8	AB	7.8	B	4.8	BC	7.6	A	7.9
3	7.6	A	8.0	A	7.6	6.5	BDC	7.8	AB	8.0	AB	6.9	A	7.8	A	7.9
4	7.6	A	8.0	A	7.6	7.0	BAC	7.3	B	7.5	B	6.5	A	7.6	A	8.0
5	6.6	B	7.3	B	7.4	5.8	D	8.0	AB	7.9	AB	6.3	A	7.8	A	7.9
6	6.9	B	7.0	B	7.6	6.8	BDC	7.0	B	8.0	AB	6.3	A	6.6	B	8.0
7	6.9	B	7.5	AB	7.8	6.0	DC	7.0	B	7.8	B	6.1	BA	7.4	A	8.0
8	6.9	B	7.4	AB	7.9	6.4	BDC	7.3	B	7.6	B	6.3	A	7.5	A	7.9
9	6.6	B	7.4	AB	7.5	6.5	BDC	7.0	B	7.9	AB	6.4	A	7.5	A	7.9
10	7.1	AB	7.3	B	7.3	6.5	BDC	7.8	AB	7.6	B	6.8	A	7.3	AB	8.0
11	7.3	AB	7.3	B	7.5	8.0	A	8.6	A	8.5	A	6.5	A	7.4	A	8.0

* Means followed by the same letter in a column are not statistically different ($P < 0.05$).

Table 4. Soil volumetric water content of 'Tifway II' bermudagrass treated with various products and irrigated at 55%, 65%, and 75% ET_o. Riverside, CA.

	Volumetric water content														
	7/14/20				8/11/20					9/9/20					
Trt	55% ET_o	65%ET_o	75% ET_o		55% ET_o	65%ET_o		75% ET_o		55% ET_o	65%ET_o		75% ET_o		
1	30.9	34.9	43.7	ABC*	17.1	24.6	AB	35.6	ABC	13.2	18.2	B	41.1	AB	
2	26.6	33.7	49.6	AB	13.2	24.4	AB	41.1	AB	13.6	27.1	AB	47.4	A	
3	28.7	36.7	46.2	ABC	17.7	26.5	AB	39.4	ABC	13.6	19.6	AB	43.6	AB	
4	30.3	35.2	42.7	BC	18.0	26.0	AB	33.8	BC	15.2	25.0	AB	39.1	AB	
5	27.6	40.3	42.7	BC	19.0	33.3	A	33.3	BC	19.5	32.4	A	38.8	AB	
6	32.0	30.0	43.7	ABC	22.5	18.7	B	37.4	ABC	19.3	17.7	B	44.5	AB	
7	30.4	33.8	50.6	A	19.5	24.8	AB	42.3	A	20.5	25.4	AB	49.0	A	
8	28.7	32.7	48.6	ABC	16.5	25.5	AB	39.7	ABC	14.8	23.0	AB	43.5	AB	
9	27.2	35.0	50.2	AB	16.3	27.9	AB	42.1	A	15.2	30.9	AB	43.4	AB	
10	29.2	36.8	41.7	C	19.0	25.6	AB	32.3	C	15.5	23.6	AB	36.1	B	
11	30.3	31.5	50.9	A	16.2	24.5	AB	42.2	A	14.6	20.2	AB	43.9	AB	

* Means followed by the same letter are not statistically different ($P < 0.05$).

Figure 1. Plot area on September 15, 2020. Plots with arrows were treated with CIVITAS at 8.5 oz/M at the 3-week interval on the same date.

Video Stop #6a: Granular preemergence herbicides for 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 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 2 days/wk at 0.5 inch and fertilized with a total of 1.5 lbs N in 2020 season separated into 3 fertilization events (0.5 lb N each). Herbicide treatments were applied on April 2, 2020 and May 17, 2020 and are presented in Table 1. 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 5×6 ft with 1-ft alleys between rows and 6-inch alleys between plots within row. Starting from April 2, 2020 plots were evaluated biweekly for smooth crabgrass cover (0-100%) and other weeds present at the study initiation. Data from two consecutive evaluations were pooled together and presented for each month. The differences in weed cover were assessed using non-parametric Kruskal-Wallis test with Mann-Whitney U-test for pairwise comparisons at P = 0.05.

Results:

Results for smooth crabgrass cover are presented in Table 2. On April 2nd at the time of treatment initiation, crabgrass was already present in seedling stage. Despite late application, all products were able to at least partially control targeted weed at this time and only up to 6% cover was detected throughout first month in treated plots compared to 15% cover in untreated control. At the beginning of May, crabgrass cover started increasing rapidly in plots treated with Ronstar G and at this time the second application did not provide better control, although crabgrass pressure was reduced compared to untreated control until late July. For all other herbicides, the second application increased control compared to either the same (150 lbs/A) or higher rate (200 lbs/A) applied only once. This difference started to be evident in August for Specticle G and Freehand 1.75G and in September for Crew. Crew, a new herbicide introduced by Corteva, was the best performing herbicide in this trial with only 12% of smooth crabgrass cover on last rating on October 1st for treatment 4. California registration for this herbicide is expected in early 2021.

From tested herbicides, Specticle G and Freehand 1.75G can only be used on warm season grasses and in addition to crabgrass control, provided also marvelous control of mature annual bluegrass (Table 3). One month was needed for complete control, although injury started becoming visible within 1 week after application (data not shown). None of the herbicides provided good postemergence control of slender celery, which took over space left by crabgrass and annual bluegrass reaching 50-60% cover in treated plots. Eventually, higher temperatures in June and July provided unfavorable conditions for celery and good growing conditions for bermudagrass.

Acknowledgments

Thanks to BASF, Bayer, Corteva and the California Turfgrass & Landscape Foundation (CTLF) for providing products and supporting this research.

Table 1. Herbicide treatments tested in preemergence smooth crabgrass (*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.) control trial. Riverside, CA. 2020.

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	Specticle G	indaziflam	Bayer	150	A
6	Specticle G	indaziflam	Bayer	200	A
7	Specticle G	indaziflam	Bayer	150	AB
8	FreeHand 1.75G	dimethenamid-P, pendimethalin	BASF	150	A
9	FreeHand 1.75G	dimethenamid-P, pendimethalin	BASF	200	A
10	FreeHand 1.75G	dimethenamid-P, pendimethalin	BASF	150	AB
11	Ronstar G	oxadiazon	Bayer	150	A
12	Ronstar G	oxadiazon	Bayer	200	A
13	Ronstar G	oxadiazon	Bayer	150	AB

Application timings:
A – 4/2/2020
B – 5/17/2020

Table 2. Effect of herbicides on smooth crabgrass (*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.) cover (%). Riverside, CA. 2020.

Treatment	April	May	June	July	August	September	10/1/2020
01 Untreated Control	15 a	41 a	82 a	99 a	100 a	100 a	100 a
02 Crew (150 lbs/A)	4 bcd	0 de	5 cde	9 de	30 cd	41 e	45 cd
03 Crew (200 lbs/A)	2 bcd	0 e	0 ef	0 g	4 e	18 f	42 d
04 Crew (2 x 150 lbs/A)	1 d	0 de	0 ef	1 gf	6 e	8 g	12 e
05 Specticle G (150 lbs/A)	4 bcd	11 bc	14 c	33 c	71 b	81 bc	84 abcd
06 Specticle G (200 lbs/A)	3 bcd	4 cde	8 cde	15 cd	47 b	73 cd	71 bc
07 Specticle G (2 x 150 lbs/A)	3 cd	4 cd	6 cd	8 de	26 d	44 def	59 bcd
08 FreeHand 1.75G (150 lbs/A)	3 bcd	1 cde	4 c	14 cd	57 bc	72 cd	71 abcd
09 FreeHand 1.75G (200 lbs/A)	2 cd	0 e	1 def	10 de	56 bc	82 bc	88 ab
10 FreeHand 1.75G (2 x 150 lbs/A)	3 bcd	0 cde	0 f	4 ef	22 d	47 def	59 abcd
11 Ronstar G (150 lbs/A)	6 b	38 a	55 b	86 b	99 a	100 a	100 a
12 Ronstar G (200 lbs/A)	5 bc	18 ab	48 b	77 b	94 a	97 ab	98 a
13 Ronstar G (2 x 150 lbs/A)	4 bcd	28 ab	45 b	85 ab	99 a	98 a	100 a
p-value	**0.003**	**0**	**0**	**0**	**0**	**0**	**0.0002**

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

Table 3. Effect of herbicides on annual bluegrass (*Poa annua* L.) cover (%) and slender celery (*Cyclospermum leptophyllum* (Pers.) Sprague ex Britton & P. Wils.) cover (%). Riverside, CA. 2020.

	Annual bluegrass			**Slender celery**		
Treatment	**Initial**	**April**	**May**	**April**	**May**	**June**
01 Untreated Control	82	51	11 abc	16	16 e	10 d
02 Crew (150 lbs/A)	86	51	10 bc	19	42 ab	45 b
03 Crew (200 lbs/A)	82	44	16 ab	13	44 abc	53 ab
04 Crew (2 x 150 lbs/A)	94	46	14 abc	17	44 ab	46 b
05 Specticle G (150 lbs/A)	84	44	1 d	16	44 ab	49 ab
06 Specticle G (200 lbs/A)	92	32	1 d	16	46 a	61 ab
07 Specticle G (2 x 150 lbs/A)	94	36	1 d	19	54 a	59 ab
08 FreeHand 1.75G (150 lbs/A)	89	30	0 d	16	46 ab	60 ab
09 FreeHand 1.75G (200 lbs/A)	92	28	0 d	13	56 a	61 a
10 FreeHand 1.75G (2 x 150 lbs/A)	90	34	1 d	15	46 a	59 ab
11 Ronstar G (150 lbs/A)	91	56	16 a	18	19 de	25 c
12 Ronstar G (200 lbs/A)	92	39	8 c	16	32 bcd	22 c
13 Ronstar G (2 x 150 lbs/A)	89	41	13 abc	20	28 cd	21 c
p-value	**0.188**	**0.33**	**0**	**0.942**	**0**	**0**

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

Video Stop #6b: Postemergence broadleaf 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 stricta*) 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 2 days/wk at 0.5 inch and fertilized with a total of 1.5 lbs N in 2020 season separated into 3 fertilization events (0.5 lb N each). Herbicide treatments were applied on 6-wk intervals beginning on July 7, 2020 for a total of 2 applications with exception of treatments 6, 7, 8 and 10 which were applied only once. All treatments are presented in Table 1. 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 4 replications. Plot size was 4×6 ft with 1-ft alleys. Plots were evaluated weekly for yellow woodsorrel cover (0-100%), slender celery cover (0-100%) and spotted spurge cover (0-100%) beginning at the time of initial herbicide application. The differences in weed cover were assessed using non-parametric Kruskal-Wallis test with Mann-Whitney U-test for pairwise comparisons at $P = 0.05$.

Results:

Results for yellow woodsorrel cover are presented in Table 2. GameOn, a new herbicide introduced by Corteva, provided best control of yellow woodsorrel. The lower rate (3.5 pt/A) applied only once was enough to provide complete control of this weed from the 3rd week after initial treatment (WAIT) until the end of the study. Complete control was also obtained by Celsius WG (treatment 4) and SP37938* but in latter case, higher initial application was needed (10 oz/A) followed by a second application of 5 oz/A.

Although some oxalis plants were present on plots by 12 WAIT; Monument, Tribute Total and SP37938 (applied twice at 7.5 oz/A) provided significant control up until 10 WAIT and only up to 2% weed cover was observed on the last rating day on September 29th for those treatments. Despite a short period of injury, SpeedZone Southern did not provide long lasting control of yellow woodsorrel.

Other weeds present within the study area when the experiment began included slender celery (*Cyclospermum leptophyllum*) and spotted spurge (*Euphorbia maculata*). All of the treatments employed in the trial accelerated the natural dieback of slender celery plants (Table 3). As for spotted spurge, new germination occurred throughout the study and natural variation in population was observed. Regardless, significant difference from control was observed for SpeedZone Southern (treatment 5), GameOn (treatment 7) and SP37938 (treatment 9) on 6th WAIT and only for SpeedZone Southern and SP37938 (10 oz/A + 5 oz/A) on 9th WAIT (Table 4).

* - Bayer is currently awaiting tradename approval

Acknowledgments

Thanks to Bayer, Corteva, Helena, PBI Gordon, Syngenta and the California Turfgrass & Landscape Foundation (CTLF) for providing products and supporting this research.

Table 1. Herbicide treatments tested in post emergence broadleaf weed control trial. Riverside, CA. 2020.

No	Treatment	Active ingredient(s)	Company	Rate	Timing
1	Untreated Control	-	-	-	-
2	Monument	trifloxysulfuron-sodium	Syngenta	15 g/A	AB
	Induce	non-ionic surfactant	Helena	0.25% v/v	AB
3	Tribute Total	thiencarbazone-methyl, foramsulfuron, halosulfuron-methyl	Bayer	3.2 oz/A	AB
	Induce	non-ionic surfactant	Helena	0.25% v/v	AB
4	Celsius	thiencarbazone-methyl, iodosulfuron-methyl-sodium, dicamba	Bayer	3.7 oz/A	AB
	Induce	non-ionic surfactant	Helena	0.25% v/v	AB
5	SpeedZone Southern	2,4-D, mecoprop-p, dicamba, carfentrazone-ethyl	PBI-Gordon	4 pt/A	AB
6	GameOn	2,4-D choline, fluroxypyr, halauxifen	Corteva	3.5 pt/A	A
7	GameOn	2,4-D choline, fluroxypyr, halauxifen	Corteva	4 pt/A	A
8	SP37938	-	Bayer	10 oz/A	A
	Induce	non-ionic surfactant	Helena	0.25% v/v	A
9	SP37938	-	Bayer	10 oz/A	A
	Induce	non-ionic surfactant	Helena	0.25% v/v	A
	SP37938	-	Bayer	5 oz/A	B
	Induce	non-ionic surfactant	Helena	0.25% v/v	B
10	SP37938	-	Bayer	7.5 oz/A	A
	Induce	non-ionic surfactant	Helena	0.25% v/v	A
11	SP37938	-	Bayer	7.5 oz/A	AB
	Induce	non-ionic surfactant	Helena	0.25% v/v	AB

Application timings: A – 7/8/2020; B – 8/19/2020

Table 2. Effect of herbicides on yellow woodsorrel (*Oxalis stricta* L.) cover (%). Riverside, CA. 2020.

No	Treatment	Initial	1 WAIT	2 WAIT	3 WAIT	4 WAIT	5 WAIT	6 WAIT	7 WAIT	8 WAIT	9 WAIT	10 WAIT	11 WAIT	12 WAIT
1	Untreated Control	20	24	14 a	18 a	16 ab	16 a	29 a	18 a	16 a	19 ab	16 a	11 ab	11 ab
2	Monument (15 g/A)	24	14	6 abc	0 b	1 bc	0 c	5 bc	4 abc	0 b	0 c	0 c	0 bc	2 bc
3	Tribute Total (3.2 oz/A)	26	13	3 bc	0 b	1 bc	0 c	2 bcd	2 abc	0 b	0 c	0 c	1 bc	0 bc
4	Celsius WG (3.7 oz/A)	16	11	4 abc	0 b	0 c	0 c	5 abcd	2 abc	1 b	0 c	0 c	0 c	0 c
5	SpeedZone Southern (4 pt/A)	22	6	4 abcd	16 a	21 a	13 ab	21 a	5 abc	4 ab	10 a	9 a	12 a	10 a
6	GameOn (3.5 pt/A)	24	6	0 d	0 b	0 c	0 c	0 d	0 c	0 b	0 c	0 c	0 c	0 c
7	GameOn (4 pt/A)	20	5	0 d	0 b	0 c	0 c	0 d	0 c	0 b	0 c	0 c	0 c	0 c
8	SP37938 (10 oz/A)	11	12	3 abc	0 b	0 c	0 c	3 bc	1 bc	1 b	1 bc	1 bc	1 bc	1 bc
9	SP37938 (10 oz/A + 5 oz/A)	18	12	1 cd	0 b	0 c	0 c	1 cd	0 c	0 b	0 c	0 c	0 c	0 c
10	SP37938 (7.5 oz/A)	18	10	8 ab	0 b	0 c	1 bc	8 ab	8 ab	5 ab	9 a	8 ab	8 abc	2 abc
11	SP37938 (2x 7.5 oz/A)	14	12	5 abc	0 b	4 bc	8 abc	10 abcd	10 ab	2 b	0 c	1 bc	3 abc	2 abc
	p-value	**0.908**	**0.663**	**0.003**	**0.000**	**0.001**	**0.001**	**0.001**	**0.003**	**0.013**	**0.000**	**0.000**	**0.001**	**0.004**

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

Table 3. Effect of herbicides on slender celery (*Cyclospermum leptophyllum* (Pers.) Sprague ex Britton & P. Wils.) cover (%). Riverside, CA. 2020.

No	Treatment	Initial	1 WAIT	2 WAIT	3 WAIT
1	Untreated Control	54	49	34 a	23 a
2	Monument (15 g/A)	59	32	6 abc	0 b
3	Tribute Total (3.2 oz/A)	55	22	3 abc	0 b
4	Celsius WG (3.7 oz/A)	56	12	1 bc	0 b
5	SpeedZone Southern (4 pt/A)	61	24	1 bc	2 ab
6	GameOn (3.5 pt/A)	55	19	4 abc	0 b
7	GameOn (4 pt/A)	59	29	3 b	0 b
8	SP37938 (10 oz/A)	45	40	2 abc	0 b
9	SP37938 (10 oz/A + 5 oz/A)	35	20	1 bc	0 b
10	SP37938 (7.5 oz/A)	60	44	4 abc	0 b
11	SP37938 (2x 7.5 oz/A)	65	55	0 c	1 ab
	p-value	**0.876**	**0.109**	**0.044**	**0.013**

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

Table 4. Effect of herbicides on spotted spurge (*Euphorbia maculata* L.) cover (%). Riverside, CA. 2020.

No	Treatment	Initial	1 WAIT	2 WAIT	3 WAIT	4 WAIT	5 WAIT	6 WAIT	7 WAIT	8 WAIT	9 WAIT	10 WAIT	11 WAIT	12 WAIT
1	Untreated Control	5	6	6 a	8	8	9	15 ab	14	11	16 abc	17	15 ab	14
2	Monument (15 g/A)	5	1	3 a	4	4	5	6 abc	2	1	8 abc	5	6 ab	6
3	Tribute Total (3.2 oz/A)	5	1	0 a	0	2	1	4 ab	2	0	1 bcd	1	1 ab	2
4	Celsius WG (3.7 oz/A)	4	1	2 a	5	2	3	4 abc	4	3	4 abcd	2	2 ab	3
5	SpeedZone Southern (4 pt/A)	4	0	0 a	0	0	2	0 c	0	0	0 d	0	0 b	0
6	GameOn (3.5 pt/A)	10	1	0 a	1	0	1	1 bc	0	0	1 bcd	0	1 ab	0
7	GameOn (4 pt/A)	6	0	0 a	0	0	0	0 c	0	0	0 cd	0	0 b	0
8	SP37938 (10 oz/A)	1	0	0 a	1	0	0	1 bc	1	1	1 bcd	1	1 ab	1
9	SP37938 (10 oz/A + 5 oz/A)	0	0	0 a	0	1	0	0 c	0	0	0 d	0	0 b	0
10	SP37938 (7.5 oz/A)	3	0	0 a	2	2	4	5 a	2	2	7 a	4	4 a	3
11	SP37938 (2x 7.5 oz/A)	1	1	1 a	1	3	0	3 abc	0	2	5 ab	1	3 ab	2
	p-value	**0.255**	**0.211**	**0.008**	**0.185**	**0.262**	**0.160**	**0.004**	**0.086**	**0.088**	**0.001**	**0.053**	**0.021**	**0.077**

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

Video Stop #7: Evaluation of Fungicides for Control of Anthracnose Disease on Annual Bluegrass Putting Greens

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Objectives:

This study was conducted to evaluate 33 different fungicide treatments to control foliar and basal rot anthracnose (*Colletotrichum cereale*) disease preventatively on an annual bluegrass (*Poa annua*) 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 were originally inoculated with anthracnose spores grown in the laboratory. In later years, inoculation was achieved through core aeration and dragging to spread the existing inoculum.

Turf was mowed 5 days/wk at 0.125 inches. Until July 5, 2020 the study area was irrigated at 100% of previous day's ET_O replacement and received 0.125 lb N/1000 ft^2 in liquid form every 7 days as well as 0.5 lb N/1000 ft^2 in granular form every 4 wks. Starting from July 6, 2020 irrigation rate was gradually decreased to 80% of previous day's ET_O replacement, granular fertilizer applications were suspended and time interval for liquid formulation applications was extended to 14 days. Throughout the entire trial, hand syringing was performed in the afternoon to prevent turf decline or death due to excessive heat stress. Fungicide treatments were applied every 14 days beginning on May 22, 2020 (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 5 replications. Plot size was 4×6 ft with 1-ft alleys.

Starting from May 21, plots were evaluated every two weeks visually for turf quality (1-9; 9=highest), injury caused by treatments (phytotoxicity only, 0-10; 10=highest), loss of turfgrass stand cover expressed as the percentage of ratio between initial cover and cover at the time of each evaluation (0-100%), and anthracnose disease cover (0-100%).

Results:

Acervuli (Fig. 1) of *Colletotrichum cereale* were first noted by the end of June; however, disease symptoms in the untreated control (Fig. 2) became noticeable in the middle of July with about 20% of disease cover. Throughout July and August, disease cover increased, resulting in 70% cover within untreated plots on August 25 and average cover of 20% across the study (data not shown). Two weeks later on September 9, disease cover in the untreated control dropped by 13%, but the total loss of turf cover in untreated plots reached almost 50% and the average disease pressure across the study increased further, reaching almost 24% cover. Furthermore, turfgrass visual quality in untreated plots was the lowest on both dates. New growth and turf recovery within untreated plots was observed following treatment application performed on September 10 (Table 2).

On August 25, significant injury (i.e., phytotoxicity) was noted on plots subjected to some programmatic treatments following the application of tebuconazole (AMVAC Program, Bayer Programs No. 1-3). However, only in Bayer Programs No. 1 and 2 (Fig. 3) the injury level crossed the threshold of acceptability (above 3 on 0-10 scale, Table 2). Nevertheless, the occurrence of this injury coincided with an extreme heat wave with temperatures surpassing 100 F and persisting for 8 days in a row starting from August 14. Furthermore, the injury was only temporary, and it almost fully recovered by the next data collection event (data not shown).

Considering data from September 9 when the average disease pressure across the study was at its highest, all treatments employed in the study, except for Primo Maxx at 0.1 oz/M, Autilus at 6.0 oz/M + PAR SG at 0.37 oz/M tank-mix and UCR 003, significantly decreased anthracnose cover in comparison to control. The best performing treatment on this date was Bayer Program No. 1, with the disease cover below 5% (Fig. 2). Disease cover equal or below 10% was provided by Briskway at 1.2 oz/M, BASF Program No. 1, Bayer Program No. 2 and UCR 005 (treatment 29). Disease cover exceeding 10% on September 9 was not considered satisfactory (Table 2).

Apart from the anthracnose disease cover, the loss of turfgrass cover as a result of the impact of suboptimal environmental conditions and disease was also evaluated. The only treatments preventing the increase of green cover loss above 5% on September 9 were Ascernity at 1.0 oz/M, BASF Program No. 1, Bayer Program No. 1, UCR 001, UCR 005 (treatment 29), and UCR 007. At the same time, turfgrass cover loss did not exceed 10% in plots treated with Briskway at 1.2 oz/M, Daconil Action at 3.5 oz/M + Appear II at 6.0 oz/M + Primo Maxx at 0.1 oz/M tank-mix, BASF Program No. 2, Bayer Program No. 2, UCR 004 (treatment 28), and UCR 006 (treatment 31; Table 2).

Finally, average turfgrass quality across the study was the lowest on September 9, mainly as a result of anthracnose-caused damage. However, acceptable quality (equal or above 6 on 1-9 scale) was provided on this date with Briskway at 1.2 oz/M, Daconil Action at 3.5 oz/M + Appear II at 6.0 oz/M + Primo Maxx at 0.1 oz/M tank-mix, Syngenta Rotation, AMVAC Program, both BASF Programs, all Bayer Programs, UCR 001, UCR 002 (treatment 21), UCR 004 (treatment 28), UCR 005 (treatment 29), UCR 006 and UCR 007. Although no significant differences were shown among those treatments, the highest turfgrass visual quality (score of 8.2) was provided with Bayer Program No. 1 (Table 2).

Acknowledgments

Thanks to CTLF, AMVAC, BASF, Bayer, FMC, Nufarm, Corteva, and Syngenta for supporting this research and/or for providing products.

Table 1. Fungicide treatments tested in the preventive anthracnose disease control study in Riverside, CA. 2020.

No.	Treatment	Active ingredient	FRAC Class or *Product Type*	FRAC Code	Company	Rate (oz/M)	Timing
1	Untreated Control	-	-	-	-	-	-
2	Primo Maxx	*trinexapac-ethyl*	*PGR*	-	Syngenta	0.1	A-H
3	Eagle 20EW	myclobutanil	DMI	3	Corteva	1.2	A-H
4	Ascernity	benzovindiflupyr	SDHI	7	Syngenta	1.0	A-H
		difenoconazole	DMI	3			
5	Daconil Weatherstik	chlorothalonil	chloronitrile	M 05	Syngenta	3.6	A-H
6	Daconil Action	chlorothalonil	chloronitrile	M 05	Syngenta	3.5	A-H
		acibenzolar-S-methyl	BTH	P 01			
7	Premion	PCNB	AH	14	AMVAC	6.00	A-H
		tebuconazole	DMI	3			
	PAR SG	-	*pigment*	-	Harrell's	0.37	
8	Autilus	PCNB	AH	14	AMVAC	6.00	A-H
	PAR SG	-	*pigment*	-	Harrell's	0.37	
9	Briskway	azoxystrobin	QoI	11	Syngenta	0.72	A-H
		difenoconazole	DMI	3			
10	Briskway	azoxystrobin	QoI	11	Syngenta	0.9	A-H
		difenoconazole	DMI	3			
11	Briskway	azoxystrobin	QoI	11	Syngenta	1.2	A-H
		difenoconazole	DMI	3			
12	Daconil Action	chlorothalonil	chloronitrile	M 05	Syngenta	3.5	A-H
		acibenzolar-S-methyl	BTH	P 01			
	Appear II	potassium phosphite	phosphonate	P 07	Syngenta	0.6	
	Primo Maxx	*trinexapac-ethyl*	*PGR*	-	Syngenta	0.1	
13	*Syngenta Rotation*						
	Primo Maxx	*trinexapac-ethyl*	*PGR*	-	Syngenta	0.1	A-H
	Heritage Action	azoxystrobin	QoI	11	Syngenta	0.4	ADG
		acibenzolar-S-methyl	BTH	P 01			
	Daconil Action	chlorothalonil	chloronitrile	M 05	Syngenta	3.5	BEH
		acibenzolar-S-methyl	BTH	P 01			
	Velista	penthiopyrad	SDHI	7	Syngenta	0.5	CF

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14	*AMVAC Program*						
	Premion	PCNB	AH	14	AMVAC	8.00	AG
		tebuconazole	DMI	3			
	PAR SG	-	*pigment*	-	Harrell's	0.37	
	Signature XTRA Stressgard	aluminum tris	phosphonate	P 07	Bayer	4.00	BEH
	Previa	chlorothalonil	chloronitrile	M 05	AMVAC	3.60	
	Velista	penthiopyrad	SDHI	7	Syngenta	0.30	CF
	Affirm WDG	polyoxin D zinc salt	polyoxin	19	Nufarm	0.88	
	Oximus	azoxystrobin	QoI	11	AMVAC	1.00	D
		tebuconazole	DMI	3			
	Medallion SC	fludioxonil	PP	12	Syngenta	1.50	
15	*BASF Program No. 1*						
	Maxtima	mefentrifuconazole	DMI	3	BASF	0.6	A-H
	Insignia SC Intrinsic	pyraclostrobin	QoI	11	BASF	0.7	BDFH
	Encartis	boscalid	SDHI	7	BASF	4	
		chlorothalonil	chloronitrile	M 05			
	CIVITAS TURF DEFENSE Pre-M1xed	mineral oil	diverse	NC	Intelligro	12	CEG
	Affirm WDG	polyoxin D zinc salt	polyoxin	19	Nufarm	1	
16	*BASF Program No. 2*						
	Primo Maxx	*trinexapac-ethyl*	*PGR*	-	Syngenta	0.1	A-H
	Navicon Intrinsic	mefentrifuconazole	DMI	3	BASF	0.85	ACEG
		pyraclostrobin	QoI	11			
	Lexicon Intrinsic	fluxapyroxad	SDHI	7	BASF	0.47	BDFH
		pyraclostrobin	QoI	11			
	Signature XTRA Stressgard	aluminum tris	phosphonate	P 07	Bayer	5.3	
	Affirm WDG	polyoxin D zinc salt	polyoxin	19	Nufarm	1	
17	*Bayer Program No. 1*						
	Primo Maxx	*trinexapac-ethyl*	*PGR*	-	Syngenta	0.10	A-H
	Mirage Stressgard	tebuconazole	DMI	3	Bayer	1.00	ACEG
	Daconil Weatherstik	chlorothalonil	chloronitrile	M 05	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminum tris	phosphonate	P 07	Bayer	4.00	
	Insignia SC Intrinsic	pyraclostrobin	QoI	11	BASF	0.70	CE
18	*Bayer Program No. 2*						
	Primo Maxx	*trinexapac-ethyl*	*PGR*	-	Syngenta	0.10	A-H
	Mirage Stressgard	tebuconazole	DMI	3	Bayer	1.00	ACEG
	Daconil Weatherstik	chlorothalonil	chloronitrile	M 05	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminum tris	phosphonate	P 07	Bayer	4.00	
	Tartan Stressgard	trifloxystrobin	QoI	11	Bayer	1.00	
		triadimefon	DMI	3			

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19	*Bayer Program No. 3*						
	Primo Maxx	*trinexapac-ethyl*	*PGR*	*-*	Syngenta	0.10	A-H
	Mirage Stressgard	tebuconazole	DMI	3	Bayer	1.00	ACEG
	Daconil Weatherstik	chlorothalonil	chloronitrile	M 05	Syngenta	3.50	BDFH
	Signature XTRA Stressgard	aluminum tris	phosphonate	P 07	Bayer	4.00	
	Exteris Stressgard	fluopyram	SDHI	7	Bayer	4.00	
		trifloxystrobin	QoI	11			
20	UCR 001		*classified*				A-H
21	UCR 002		*classified*				A-H
22	UCR 002		*classified*				A-H
23	UCR 003		*classified*				A-H
24	UCR 003		*classified*				A-H
25	UCR 003		*classified*				A-H
26	UCR 004		*classified*				A-H
27	UCR 005		*classified*				A-H
28	UCR 004		*classified*				ABGH
29	UCR 005		*classified*				ABGH
30	UCR 006		*classified*				A-H
31	UCR 006		*classified*				A-H
32	UCR 007		*classified*				A-H
33	UCR 008		*classified*				A-H

Application codes (timing):

A	22 May 2020
B	3 June 2020
C	17 June 2020
D	1 July 2020
E	16 July 2020
F	30 July 2020
G	12 Aug. 2020
H	26 Aug. 2020

Abbreviations:

PCNB	pentachloronitrobenzene
DMI	demethylation inhibitor
AH	aromatic hydrocarbon
QoI	quinone outside inhibitor
BTH	benzo-thiadiazole
SDHI	succinate dehydrogenase inhibitor
PP	phenylpyrole
PGR	plant growth regulator

Table 2. Effect of fungicide treatments on anthracnose disease cover (0-100%), turfgrass cover loss (0-100%), turfgrass visual quality (1-9; 9 = best) on September 9 and on turfgrass injury (phytotoxicity, 0-10, 10 = dead turf) on August 25 evaluated on annual bluegrass turf. Riverside, CA, 2020.

No.	Treatment	Anthracnose Cover	Turfgrass Cover Loss	Visual Quality	Turfgrass Injury
		Sept. 9	Sept. 9	Sept. 9	Aug. 25
1	Untreated Control	57 AB*	47 AB*	2.6 F*	0.0 D*
2	Primo Maxx**	50 A-D	41 A-C	3.4 EF	0.2 D
3	Eagle 20EW	27 E-H	22 D-F	5.4 B-E	0.2 D
4	Ascernity	11 G-I	4 H	5.4 B-E	0.0 D
5	Daconil Weatherstik	32 C-F	22 D-F	5.4 B-E	0.0 D
6	Daconil Action	21 F-I	17 E-H	5.8 B-D	0.0 D
7	Premion + PAR SG	18 F-I	12 E-H	5.4 B-E	0.6 CD
8	Autilus + PAR SG	67 A	55 A	2.4 F	0.0 D
9	Briskway	30 D-G	26 C-E	5.2 C-E	0.0 D
10	Briskway	20 F-I	16 E-H	5.2 C-E	0.0 D
11	Briskway	8 HI	6 F-H	7.0 A-C	0.0 D
12	Daconil Action + Appear II + Primo Maxx	18 F-I	9 F-H	6.8 A-C	0.0 D
13	Syngenta Rotation	22 F-I	11 E-H	6.4 A-C	0.0 D
14	AMVAC Program	14 F-I	11 E-H	7.0 A-C	1.2 C
15	BASF Program No. 1	9 HI	5 GH	7.2 A-C	0.0 D
16	BASF Program No. 2	11 G-I	9 F-H	7.2 A-C	0.0 D
17	Bayer Program No. 1	4 I	3 H	8.2 A	3.2 B
18	Bayer Program No. 2	10 G-I	7 F-H	7.4 AB	4.2 A
19	Bayer Program No. 3	16 F-I	13 E-H	5.8 B-D	2.6 B
20	UCR 001	11 G-I	4 H	6.4 A-C	0.4 CD
21	UCR 002	14 F-I	8 F-H	6.6 A-C	0.4 CD
22	UCR 002	26 E-H	15 E-H	5.4 B-E	0.8 CD
23	UCR 003	59 AB	51 AB	2.8 F	0.4 CD
24	UCR 003	52 A-C	43 AB	2.8 F	0.6 CD
25	UCR 003	44 B-E	37 B-D	3.8 D-F	0.0 D
26	UCR 004	30 D-G	21 D-G	5.2 C-E	0.0 D
27	UCR 005	19 F-I	11 E-H	5.8 B-D	0.0 D
28	UCR 004	14 F-I	9 F-H	6.6 A-C	0.0 D
29	UCR 005	10 G-I	5 GH	6.8 A-C	0.0 D
30	UCR 006	18 F-I	11 E-H	6.2 A-C	0.0 D
31	UCR 006	11 G-I	6 F-H	6.2 A-C	0.0 D
32	UCR 007	10 G-I	2 H	7.0 A-C	0.0 D
33	UCR 008	21 F-I	13 E-H	5.4 B-E	0.0 D

* Means followed by the same letter or not followed by any letter in a column are not significantly different (P=0.05).
** Treatments rates listed in table 1.

Figure 1. Close-up of anthracnose (*Colletotrichum cereale*) acervuli occurring on dead annual bluegrass (*Poa annua*) foliage. Photo taken by P. Petelewicz on September 1, 2020. Riverside, CA.

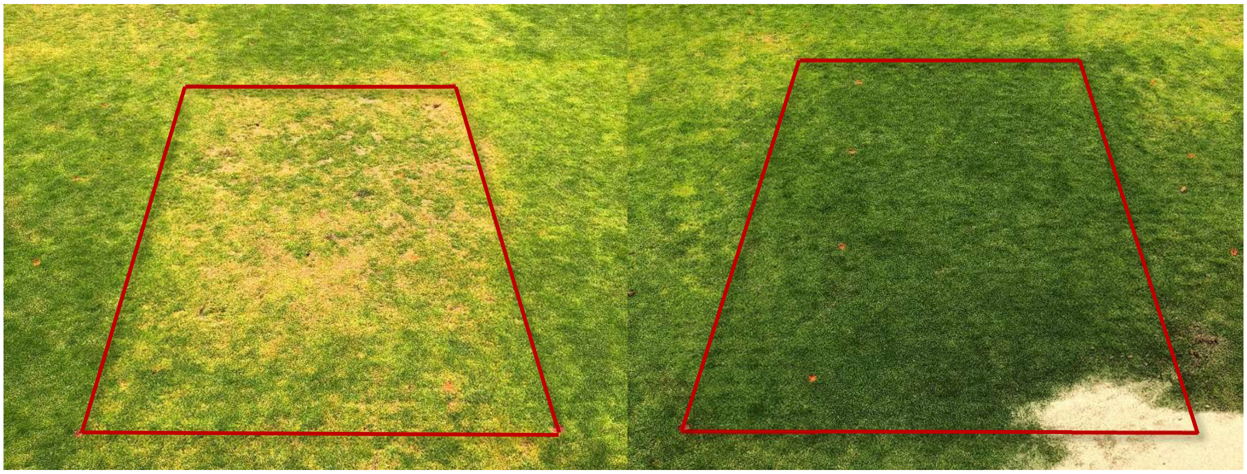

Figure 2. Comparison of untreated plot (left) to plot treated with Bayer Program No. 1 (right), with repaired coyote-caused damage in right bottom corner. Photos taken by P. Petelewicz on September 9, 2020. Riverside, CA.

Figure 3. Comparison of Bayer Program No. 1 (left) with Bayer Program No. 2 (right). Photo taken by P. Petelewicz on August 25, 2020. Riverside, CA.


Figure 4. General view of the study. Photo taken by P. Petelewicz on August 25, 2020. Riverside, CA.

CIMIS data Oct. 2019 – Aug. 2020

Los Angeles Basin – U.C. Riverside #44

Month Year	Total ETo	Total Precip	Avg Sol Rad	Avg Vap Pres	Avg Max Air Temp	Avg Min Air Temp	Avg Air Temp	Avg Max Rel Hum	Avg Min Rel Hum	Avg Rel Hum	Avg Dew Point	Avg Wind Speed	Avg Soil Temp
	(in)	(in)	(Ly/day)	(mBars)	(°F)	(°F)	(°F)	(%)	(%)	(%)	(°F)	(mph)	(°F)
Oct 2019	5.11K	0	467K	7.8K	82.9	52.8K	67K	61K	17K	35K	35.2K	4K	64
Nov 2019	3.05K	1.71	314K	7.6K	74.9K	48.3	60.4K	71	24	45K	35.7K	3.5	58.2
Dec 2019	1.81	3.02	217	8.6K	63.2	44.1	52.6	81	40	63K	38.8K	3.2	53.7
Jan 2020	2.65	0.09	294K	7.8	67.1	43.6	54.5	79	34	56	37.1	3.6K	52.3
Feb 2020	3.71K	0.09K	391K	6.6K	70.2	44.8K	57.1K	71K	23K	42K	31.7K	4.5K	53.7K
Mar 2020	3.66	3.92	398K	9.5	65.4	46.8	55.3	88	43	65	42.7	4K	59.2
Apr 2020	4.83	3.1	493K	11.6K	72.5K	52.5	61.7K	85	45	63K	48K	4	63.9
May 2020	7.25K	0K	667K	13.3K	82.2	56.6K	68.4K	84K	35K	57K	51.9K	4.3K	72.2K
Jun 2020	6.42	0.02	574K	13.7K	84.2	59.4K	70.5K	80	36	61L	54.8L	4.6K	73.1
Jul 2020	8.17	0	701K	14.4K	91.6	61.6	75.5	79	26	49K	54.1K	3.9	77.1K
Aug 2020	7.74	0	625K	16.4K	95.9K	66.4K	79.8K	75	27	48K	57.5K	3.9K	77.2
Sep 2020	6.33K	0	514	13.2K	95.1K	62.8K	77.7K	71	21	43L	51.2L	3.5K	73
Tots/Avgs	60.7	12.0	471.3	10.9	78.8	53.3	65.0	77.1	30.9	52.3	44.9	3.9	64.8

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/m2 = 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 16, 2021

See you then!

UC RIVERSIDE
UNIVERSITY OF CALIFORNIA
Turfgrass Science