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Identification of Wetting Agents for Water Conservation on Golf Course Fairways and Other Large Turf Areas in California

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Bermudagrass 'Tifway II' irrigated at 45% ET_o and treated with 11 different wetting agent treatments or untreated (U). Photo taken on 16 Aug. 2019.

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The Bottom Line

Eleven wetting agent treatments were tested against an untreated control to determine their ability to conserve water and enhance turf quality on 'Tifway II' hybrid bermudagrass irrigated at 65%, 55%, and 45% ET_o in Riverside, CA under fairway conditions from May through October in 2018 and 2019. All treatments had positive effects on turf quality in comparison to control during the hot summer months. Results showed that bermudagrass could sustain sufficient quality throughout the summer when irrigated as low as 55% ET_o if a wetting agent was applied. Identification of a 'best' treatment was inconclusive, as 10 wetting agent treatments were ranked in the top-performing group according to green cover using digital image analysis (DIA). Higher soil volumetric water content (VWC) seemed to result in greater green cover among wetting agent treatments. Results in 2019 showed that wetting agents also had positive effects on increasing soil water distribution uniformity. Furthermore, according to the amount of proline discovered in fresh tissue samples, the effects of alleviating drought stress vary among wetting agents. TriCure AD applied at one-half (1/2x) of the label rate (3 oz/1,000 ft2) produced similar results compared to the 1x rate and grouped in the highest rankings for all products tested with statistically significant measurements except VWC in which it was slightly lower. Overall, products including ACA001, TriCure AD (1x and 1/2x rates), Aquimax Turf Lateral, Passage, and Hydro90+Symphony showed comparable effects to Revolution on deficit irrigated 'Tifway II' bermudagrass.

Justification

Previous research by UCR identified three effective strategies that can sustain or improve turf quality under deficit irrigation or water use restrictions: 1) wetting agents; 2) the PGR Primo Maxx (trinexapac-ethyl); and 3) sufficient N fertilization. Among the aforementioned strategies, use of wetting agents appear to be the most important strategy. However, not all wetting agents are effective. Revolution (Aquatrols) was among the top-performing wetting agents in California based on our previous research. However, its high cost can hinder widespread use on golf course fairways and other large turf areas.

Objectives

To evaluate a select number of viable commercial products for fairways and other large areas of turf to achieve significant water savings on bermudagrass turf subjected to 45, 55, and 65% ET_o irrigation replacement.

Materials and Methods

The study was conducted at the UC Riverside turfgrass research facility in Riverside, CA on mature hybrid bermudagrass 'Tifway II' established in 2017. Climate data are provided in Table 1. Soil was a Hanford fine sandy loam. The 60' x 90' field was divided into twelve 20' x 20' plots. From May through October in 2018 and 2019, plots were hand-watered to maximize distribution

uniformity and received 45, 55, or 65% of previous week ET_o as determined by an on-site CIMIS station.

Treatments were arranged in a split-plot design with twelve wetting agent treatments including an untreated control (plot size 24 ft^2) randomized within 4 replicates of ET_o replacement plots. Treatments were applied according to company recommendations beginning in May 2018 and 2019 (Table 2). Revolution served as a standard based on previous results. The study received 5 lb N/M/year and was mowed three times weekly at 0.5 in. Treatments were applied using a CO_2-powered hand boom sprayer equipped with TeeJet 8004VS nozzles and output of 2 gal/M. All treatments were watered in with ca. 0.3-in of water following application.

Every two weeks, plots were evaluated for turf quality on a scale from 1 = worst to 9 = best, and Normalized Difference Vegetation Index (NDVI) data were collected using a GreenSeeker instrument. Volumetric soil water content (VWC) was measured using time domain reflectometry (TDR), 3 ratings per plot were recorded in 2018, and 10 ratings were recorded in 2019. The standard deviation of the mean was determined as a measurement of soil moisture uniformity in 2019. Dark green color index (DGCI), as well as percent green cover were determined using Digital Image Analysis (DIA). For clarity of presentation, data collected in the same month were averaged and are presented as monthly data. Leaf samples were collected monthly from May until October to determine the proline content in the tissue. Visual turf quality and % green cover using DIA were also taken to evaluate the effect of products on bermudagrass dormancy in late fall each year.

Data were subjected to analysis of variance (ANOVA). When necessary, multiple comparisons of means were assessed using Fisher's protected least significant difference test at the $\alpha = 0.05$ probability level. For turf quality, NDVI, VWC, DIA, and DGCI, year by treatment interactions were not significant ($P = 0.05$), so data were pooled across years. For proline content, there was a significant ET by year effect, therefore, data were analyzed for each year. No wetting agent treatment effects were observed for proline content in 2018, and thus data are presented for 2019 only. For soil moisture uniformity, due to the limited data collected in 2018, only 2019 data are presented in this report.

Results

Wetting agent treatments affected turf quality, VWC, green cover, DGCI, soil moisture uniformity, and proline content. For turf quality, all treatments performed better than the untreated control and no differences were observed among the wetting agent treatments (Fig. 1). For VWC, besides the combination of Forte + CounterAct Retain, and Aquimax Turf Lateral, all treatments increased soil moisture levels in comparison to the control. Wetting agents also greatly increased soil moisture distribution uniformity, and only minor differences were exhibited as 10 out of 11

treatments were in the top statistical group. Results of percent green cover were comparable to turf quality, as plots treated with any of the wetting agents had greater green cover than the untreated control. Minor differences of green cover were observed among treatments. For DGCI, untreated plots had lower DGCI compared to most of the wetting agent treatments, except the combination of the product Forte and CounterAct Retain. Proline is an amino acid known to accumulate in plant cells as an adaptive response to abiotic stress such as drought. For proline content in fresh leaves, wetting agent treatment had a significant effect in 2019. Except for Forte + CounterAct Retain, Vivax, and Cascade Plus, the rest of wetting agent treatments significantly reduced proline accumulation compared to the untreated control, indicating their effects of alleviating drought stress in bermudagrass. No treatment effect was observed for NDVI and fall color retention in both years (data not shown). TriCure AD applied at one-half (1/2x) of the label rate (3 oz/1,000 ft^2) produced similar results compared to the 1x rate and grouped in the highest ranking for all statistically significant measurements except VWC in which it was slightly lower (Fig. 1).

The interaction of ET_o replacement and month also affected turf quality, VWC, green cover, DGCI, soil moisture uniformity, and proline content. Evaporation affected VWC from the first month of the study, earlier than all other parameters including turf quality, cover, DGCI, soil moisture uniformity, and proline content (Fig. 2). No differences were observed for NDVI. Although 65% ET_o plots performed the best, our data suggest that 55% ET_o replacement could be used to sustain acceptable bermudagrass quality through most of the summer when a wetting agent is applied to bermudagrass.

Acknowledgments

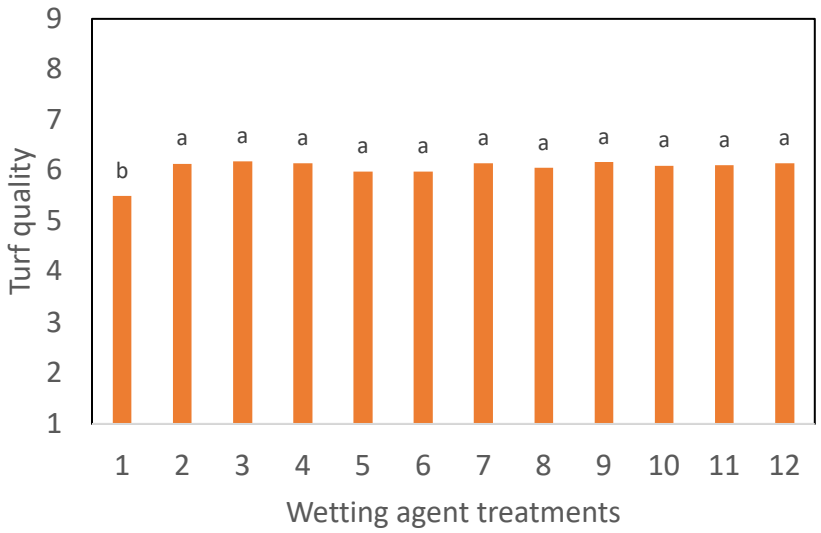
Thanks to the California Turfgrass & Landscape Foundation (CTLF) for financial support of this research and to companies for donating products.

Table 1. Climate data collected and reported by the California Irrigation Management System (CIMIS) for Station 44 (Riverside) during the study in Riverside, CA. Weather station located ≈ 100 ft away from study area.

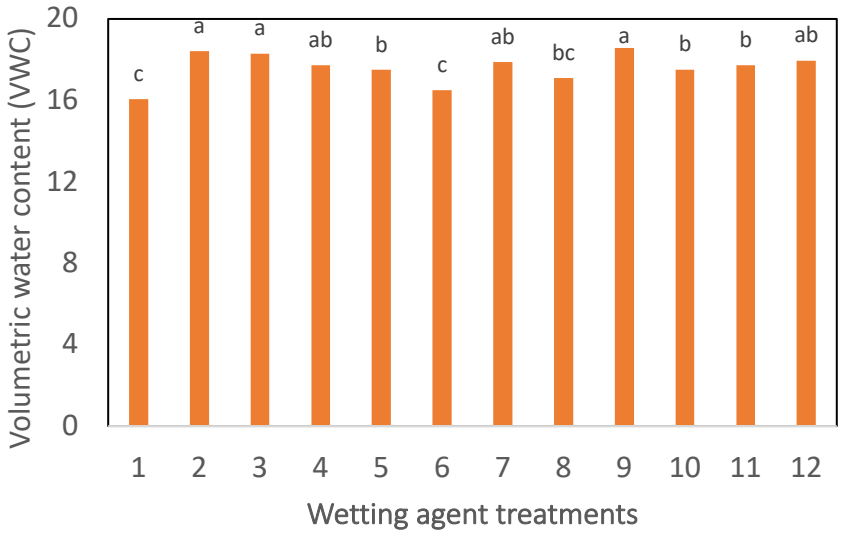
Year	Month	Total ET_o (in)	Total Precipitation (in)	Avg Max Air Temperature (ºF)	Avg Min Air Temperature (ºF)	Avg Air Temperature (ºF)	Avg Soil Temperature (ºF)
2018	May	5.57	0.27	75.4	54.7	63.7	68.6
	June	7.61	0	86.3	58.9	71	73.9
	July	8.04	0.04	95.8	67.7	80.8	78.8
	Aug.	7.35	0	92.8	66.3	78.2	77.8
	Sep.	5.86	0	90.1	60.8	73.5	73.8
	Oct.	4.3	0.96	80.3	56.7	67.5	68.2
2019	May	4.95	0.97	71.2	52.6	60.8	66.9
	June	6.49	0.02	83.1	60	69.7	73.4
	July	8.03	0.01	91.2	62.7	75.8	74.9
	Aug.	7.68	0	93.3	62.5	76.6	74.3
	Sep.	5.76	0.01	87.6	62	73.8	74.4
	Oct.	5.11	0	82.9	52.8	67	64

Table 2. Treatment list for the wetting agent trial (2018-2019) in Riverside, CA.

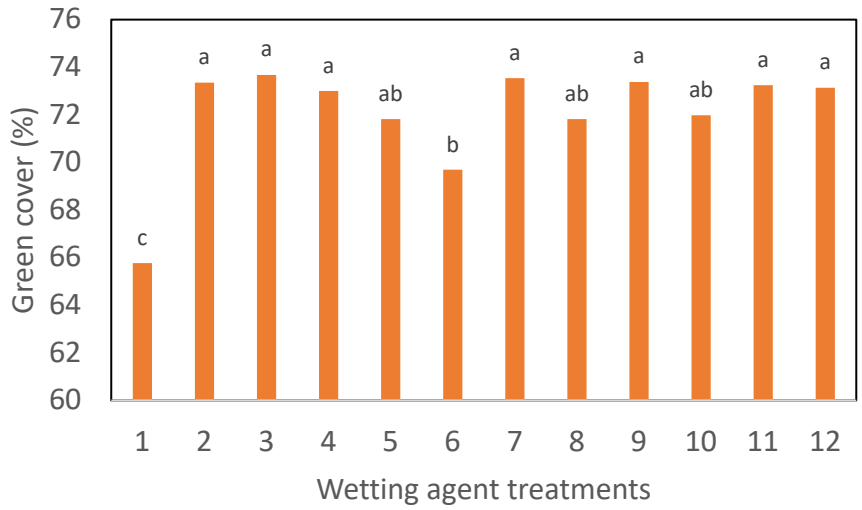
Treatment #	Treatment	Rate (oz/1,000 ft^2)	Company	Frequency (weeks)
1	Untreated control	--	--	
2	Revolution	6	Aquatrols	4
3	ACA001	4	Aquatrols	4
4	TriCure AD	6	Mitchell Products	4
5	TriCure AD	3	Mitchell Products	4
6	Forte + CounterAct Retain	0.37 + 3	Simplot	4
7	Forte + Brilliance	0.37 + 3	Simplot	4
8	Aquimax Turf Lateral	8 (initial)/4 (subsequent)	Exacto	4
9	Passage	6	Numerator Tech	4
10	Vivax	5	Precision Laboratories	4
11	Cascade Plus	8 (initial)/4 (subsequent)	Precision Laboratories	4
12	Hydro90+Symphony	3 + 3	Harrell's	4



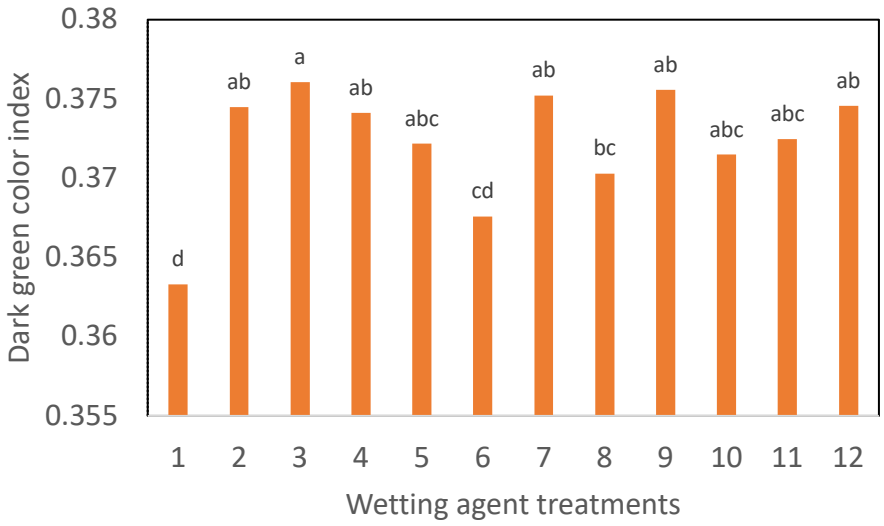
1	Untreated control
2	Revolution
3	ACA001
4	TriCure AD
5	TriCure AD (1/2x)
6	Forte + CounterAct Retain
7	Forte + Brilliance
8	Aquimax Turf Lateral
9	Passage
10	Vivax
11	Cascade Plus
12	Hydro90+Symphony



1	Untreated control
2	Revolution
3	ACA001
4	TriCure AD
5	TriCure AD (1/2x)
6	Forte + CounterAct Retain
7	Forte + Brilliance
8	Aquimax Turf Lateral
9	Passage
10	Vivax
11	Cascade Plus
12	Hydro90+Symphony



1	Untreated control
2	Revolution
3	ACA001
4	TriCure AD
5	TriCure AD (1/2x)
6	Forte + CounterAct Retain
7	Forte + Brilliance
8	Aquimax Turf Lateral
9	Passage
10	Vivax
11	Cascade Plus
12	Hydro90+Symphony



1	Untreated control
2	Revolution
3	ACA001
4	TriCure AD
5	TriCure AD (1/2x)
6	Forte + CounterAct Retain
7	Forte + Brilliance
8	Aquimax Turf Lateral
9	Passage
10	Vivax
11	Cascade Plus
12	Hydro90+Symphony

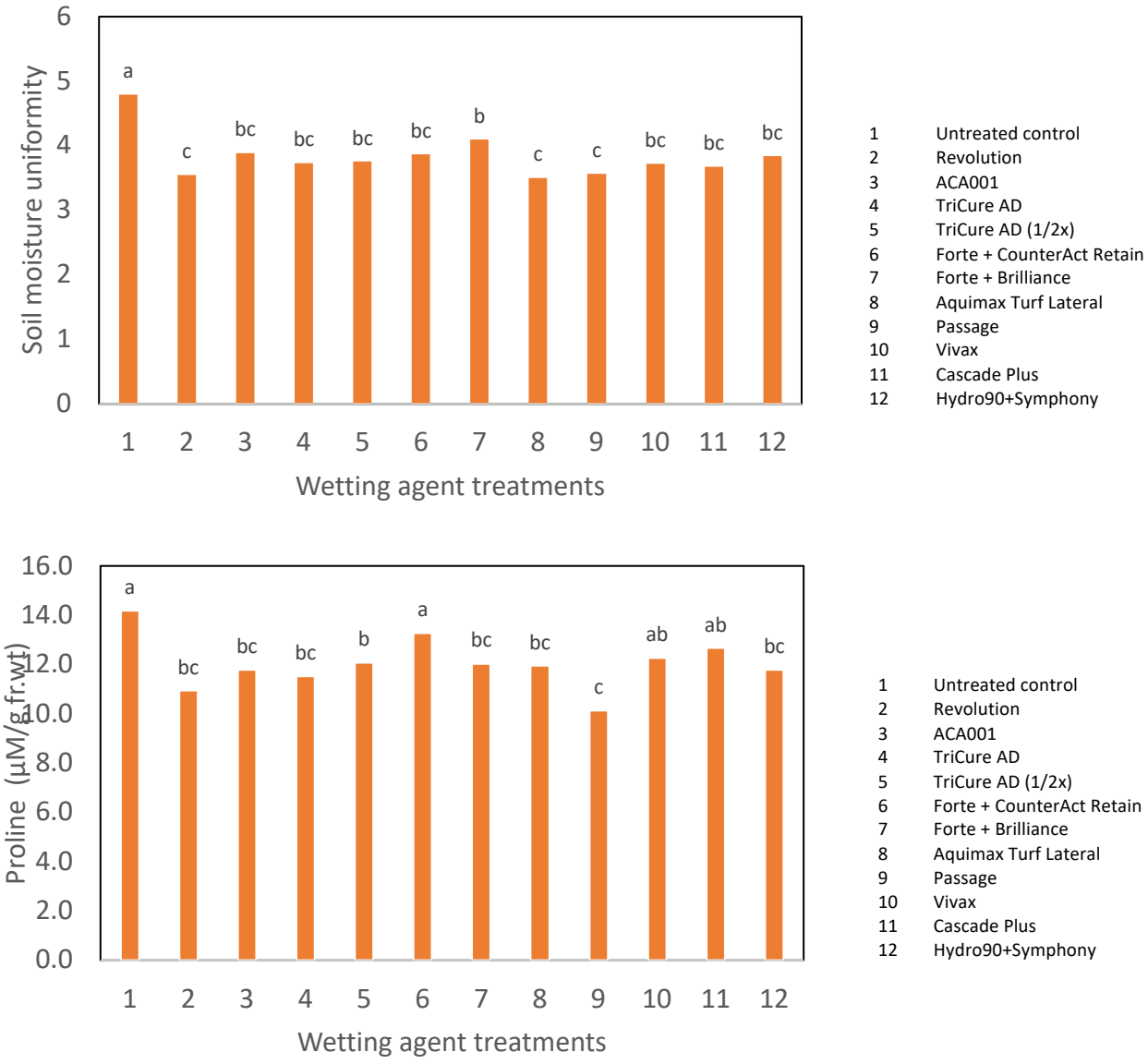
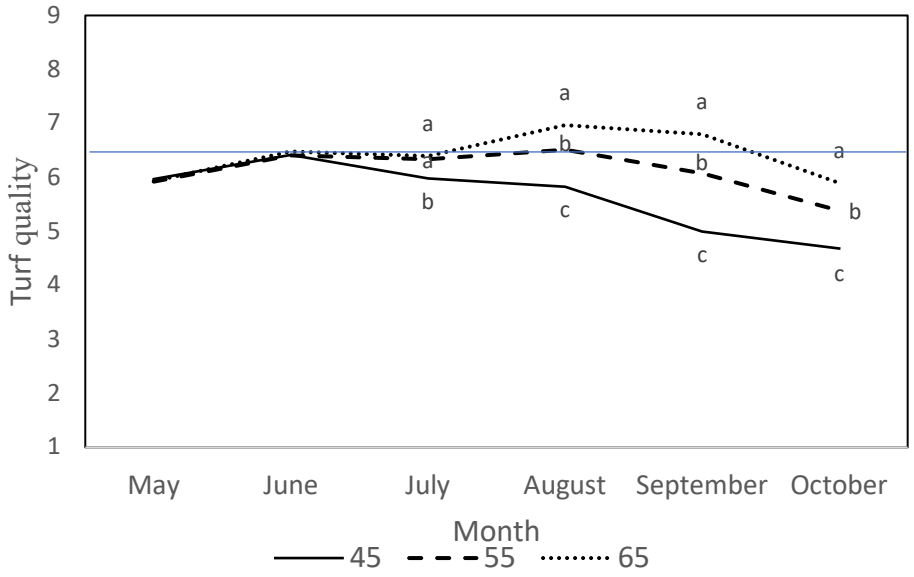
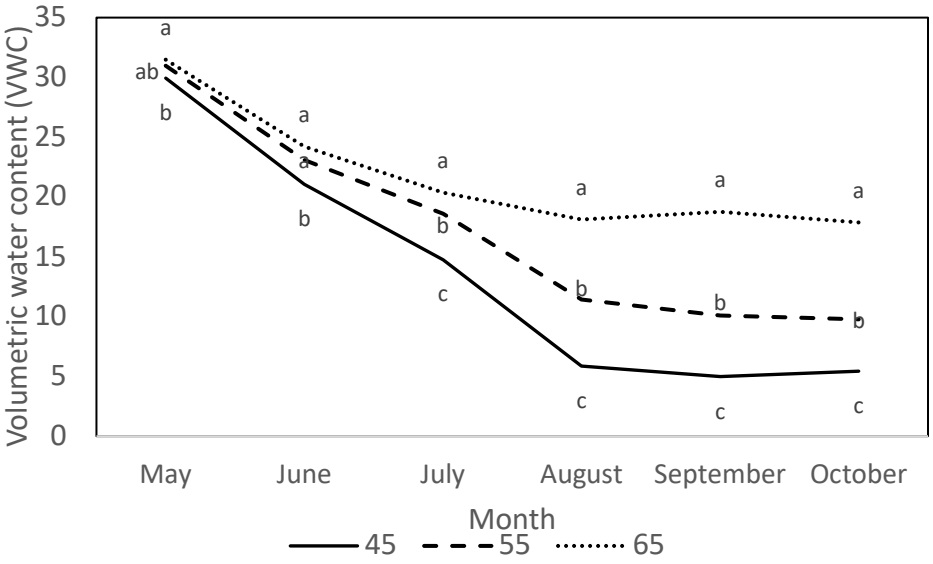
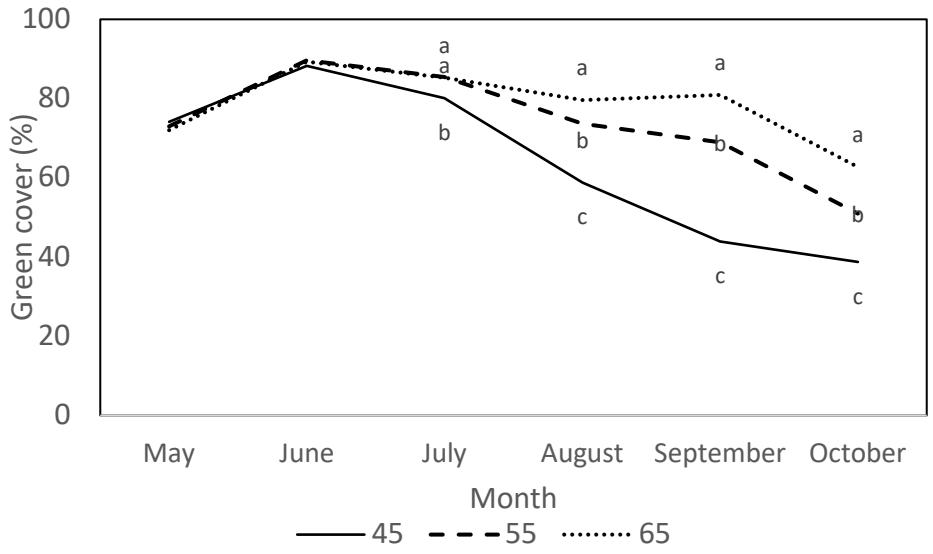
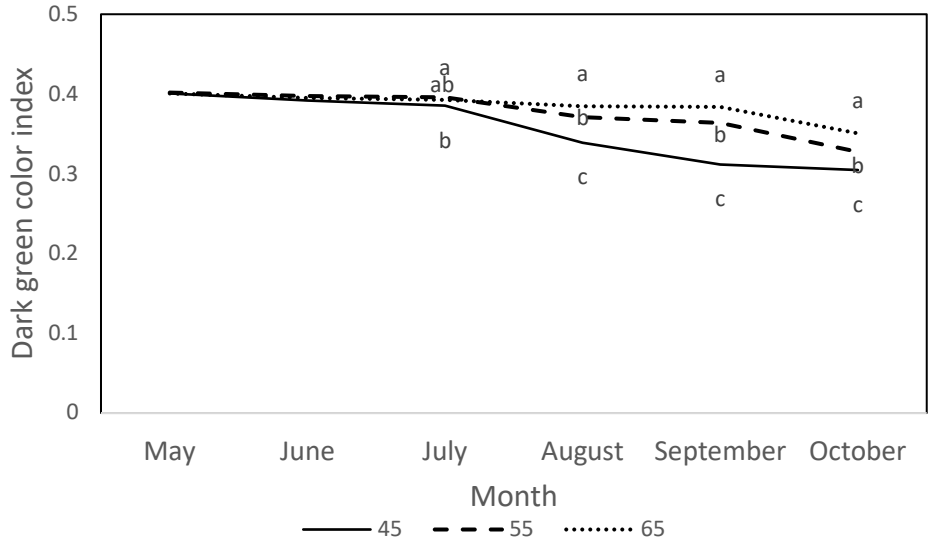


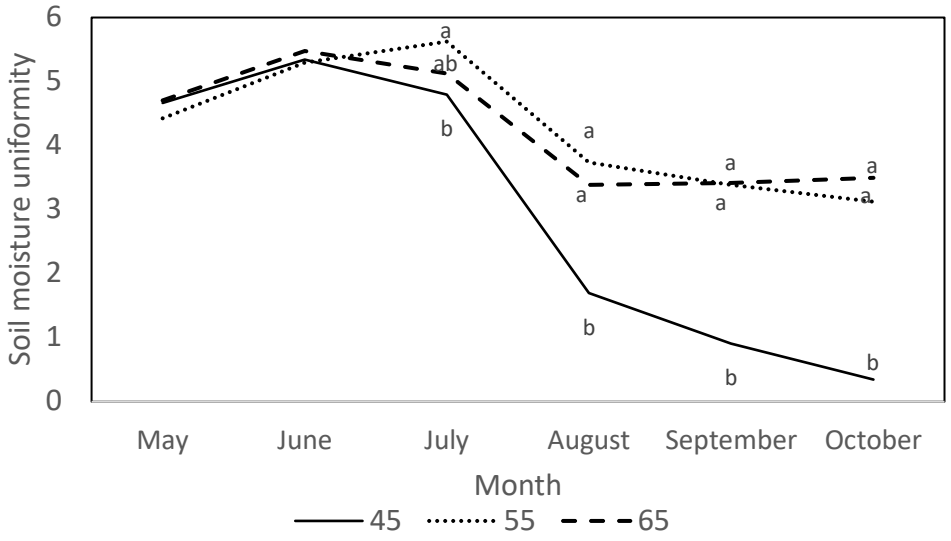
Fig 1. Turf quality, volumetric water content (VWC), soil moisture uniformity, percent green cover (DIA), dark green color index (DGCI), and proline content in fresh leaves of 'Tifway II' bermudagrass treated with 11 wetting agents and an untreated control. Results are pooled across three ET_o (reference evapotranspiration, 45, 55, and 65%), six months, four replicates, and two years (2018 and 2019) for all parameters besides soil moisture uniformity and the proline content. Soil moisture uniformity and proline content are presented for 2019 only.


Turf quality
9
8
7
6
5
4
3
2
1
May
June
July
August
September
October
Month
45
55
65

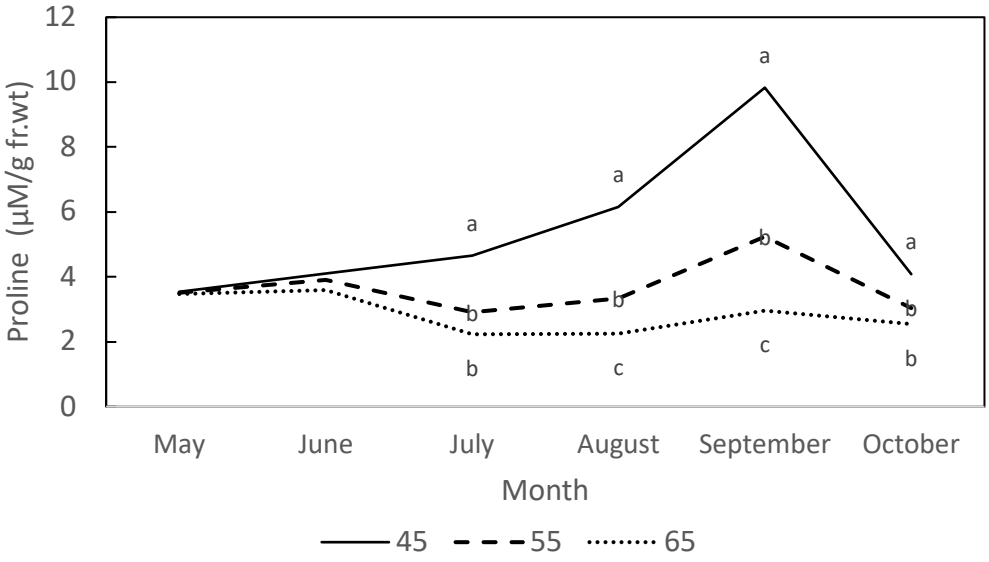

Volumetric water content (VWC)
35
30
25
20
15
10
5
0
May
June
July
August
September
October
Month
45
55
65


100
80
60
40
20
0
Green cover (%)
May
June
July
August
September
October
Month
45
55
65


0.5
0.4
0.3
0.2
0.1
0
Dark green color index
May
June
July
August
September
October
Month
45
55
65


Soil moisture uniformity
6
5
4
3
2
1
0
May
June
July
August
September
October
Month
45
55
65

2018


Proline (µM/g fr.wt)
12
10
8
6
4
2
0
May
June
July
August
September
October
Month
45
55
65

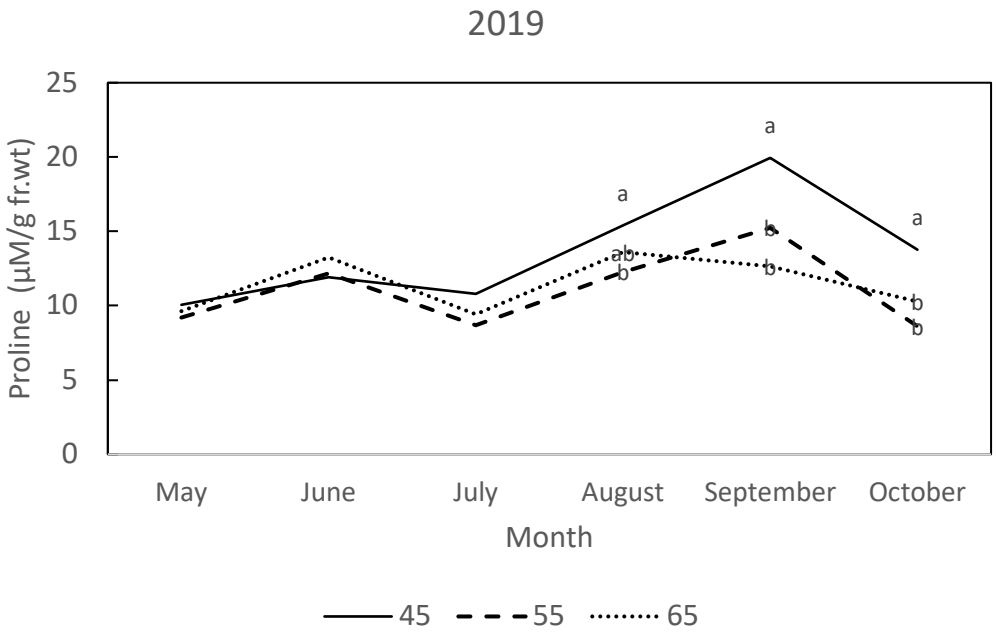


Fig 2. Turf quality, volumetric water content (VWC), soil moisture uniformity, percent green cover (DIA), dark green color index (DGCI), soil moisture uniformity, and the proline content in fresh leaves of 'Tifway II' bermudagrass under three ET_o replacements from May to October. For turf quality, volumetric water content (VWC), soil moisture uniformity, percent green cover (DIA), and dark green color index (DGCI), results are pooled across two years, 11 wetting agent treatments plus an untreated control, and four replicates. For soil moisture uniformity, results were present for 2019 only. For proline content in fresh leaves, data were presented for 2018 and 2019, separately.