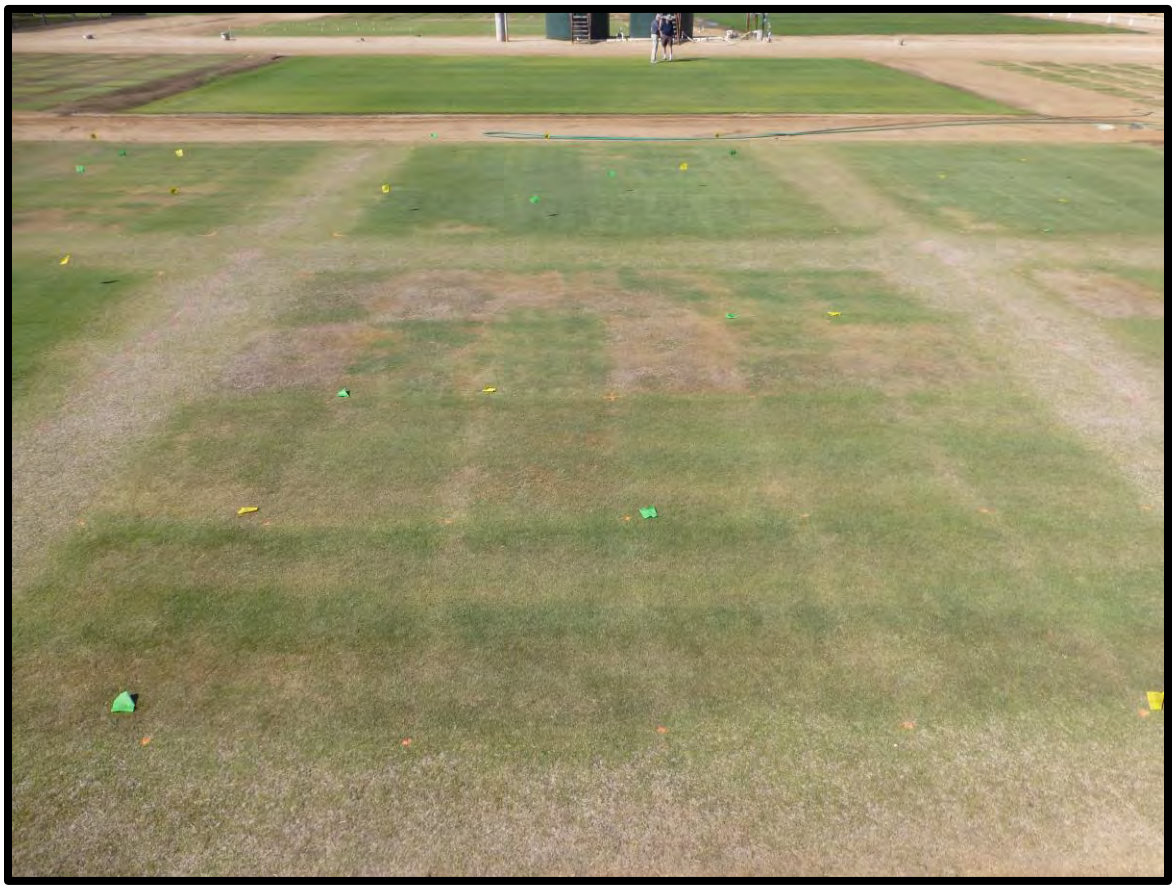
Best Management Practices for Bermudagrass under Deficit Irrigation



Bermudagrass 'Princess 77' irrigated at 70% ET_{os} (above) or 40% ET_{os} (below) replacement and treated with combinations of Revolution, Primo Maxx, and nitrogen (N) within sub-plots. Turf on borders of main plot areas received no chemical treatment or N during the study. Photo taken by Stan Kostka on 20 October 2016.

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Best Management Practices for Bermudagrass under Deficit Irrigation

2016 Progress Report

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The Bottom Line: Warm-season turfgrasses including bermudagrass use less water compared to cool-season species. This study sought to determine if PGRs (Primo Maxx), wetting agents (Revolution), and nitrogen (N) fertilization (6 different fertilizers compared at a rate of 5 lb/1,000 ft^2/year) could further reduce water use and enhance quality of bermudagrass 'Princess 77' irrigated at either 70% or 40% ET_{os} in Riverside, CA. Product and irrigation treatments were applied from May thru October 2016. Under less stressful 70% ET_{os} irrigation replacement, turf quality was highest in plots that received Primo Maxx and Revolution. Although no differences were found among fertilizer treatments, fertilizer alone was able to sustain bermudagrass quality at a minimum acceptable level. Revolution had the most positive effect on turf irrigated at 40% ET_{os}, whereas Primo Maxx did not improve quality under more severe deficit irrigation. Experimental products ACA 1935 and 5000 improved bermudagrass quality under severe deficit irrigation starting in September when ET_{os} lessened. Results from 2016 indicate that Revolution, sufficient N fertilization, Primo Maxx, and ACA experimental products can help sustain or improve turf quality with less water. The experiment will be repeated in 2017.

Introduction:

Drought and resultant water use restrictions call for implementation of best management practices to conserve water. Warm-season turfgrasses like bermudagrass use at least 20% less water compared to their cool-season counterparts. Previous research conducted by UCR and other turfgrass researchers have identified that products including the wetting agent Revolution (Aquatrols), PGR Primo Maxx (Syngenta) and sufficient N fertilization help to maintain turf quality under drought or deficit irrigation. The objectives of this study were to identify the best combinations of these products for water conservation and to further pinpoint fertilizer products that may be more effective than others for enhancing turf quality with less water.

Methods:

The study was conducted in 2016 at the UCR Turfgrass Research Facility in Riverside on mature 'Princess 77' bermudagrass turf grown on Hanford fine sandy loam. Turf was mowed three times per week at 0.5 inches during the growing season. Environmental

data for the site are provided in Table 1. The 60' x 90' field was divided into six 30' x 30' plots. From May 19 to October 31, the plots were hand watered three times per week to replace either 40% or 70% of previous week reference short crop evapotranspiration (ET_{os}) as determined by an on-site CIMIS weather station. Treatments were arranged in a split-plot design with 3 different factors randomized within ET_{os} replacement plots and 3 replicates. The plant growth regulator (PGR) Primo Maxx (trinexapac-ethyl; Syngenta) served as split plot; wetting agent Revolution (Aquatrols) as split-split-plot; and fertilizer products (Table 2) were randomized inside the wetting agent plots (plot size 24 ft^2) and applied monthly beginning in May. Each treatment received an equivalent of 1 lb N/1,000 ft^2/month, for a total of 5 lb N/1,000 ft^2/year. Granular treatments were applied with shaker jars, while spray treatments were applied using a CO_2-powered hand boom sprayer equipped with TeeJet 8004VS nozzles and output of 2 gal/1,000 ft^2. Revolution and granular fertilizers were irrigated with ca. 1/8 inches of water following application. Every two weeks, plots were evaluated for turf quality on a scale from 1 = worst to 9 = best, Naturalized Difference Vegetation Index (NDVI), volumetric soil water content (VWC) using time domain reflectometry (TDR), and dark green color index (DGCI) as well as percent green cover using Digital Image Analysis (DIA). Root samples were collected to a 6-inch depth using a soil probe on November 2, washed free of soil, and analyzed using WinRhizo software. Visual turf quality ratings were taken in late November and early December to measure the effect of fertilizer and chemical treatments on bermudagrass winter color retention.

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 0.05 probability level. Each graphical output is presented and discussed only if treatment effect, ET_{os} replacement effect, or their interaction was significant during one or more rating dates.

Results:

- ET_{os} had a huge impact on bermudagrass performance. Although some treatments had some positive effect on severely drought stressed turf plots, no plots irrigated at 40% ET_{os} showed quality, NDVI, or percent green cover comparable to those irrigated at 70% ET_{os}. Therefore all results will be discussed separately for ET_{os} replacement.
- At 70% ET_{os}, the combination of Primo Maxx and Revolution had the most positive effect on turf quality (Fig. 1). NDVI and DIA confirmed these findings, although no differences were found between the combination of the two chemicals, or one of the two chemicals sprayed alone. Regardless, all plots irrigated at 70% ET_{os} showed sufficient quality throughout the study.
- No differences were detected for fertilizer treatments at 70% ET_{os} (data not shown). Our results suggest that, under this level of irrigation replacement, choice of N source doesn't appear to affect bermudagrass performance. However, surrounding turf that received no N showed drastically lower turf quality

than any plot that received N fertilization, stressing the importance of sufficient N fertilization to overall turf health.

- At 40% ET_{os}, Revolution had the greatest impact on bermudagrass performance. Quality, NDVI, and green cover were improved in plots that received Revolution (Fig. 2). Even though plots treated with Revolution did not achieve an acceptable level of 6 from mid-July until September when irrigated at 40% ET_{os}, Revolution provided the most help in alleviating symptoms of drought, and its use is strongly recommended prior to and during drought and water use restrictions.
- Toward the end of the study, when ET_{os} lessened, differences among fertilizer treatments were detected in plots irrigated at 40% ET_{os} that did not receive Revolution. ACA 1935 and 5000 showed improved quality, NDVI and cover, followed by SeaBlend + Stress Rx + XP Micro and Gro-Power (Fig. 3). Conversely, Yara Liva showed the lowest turf quality. More research is needed to determine the effect of ACA 1935 and 5000 under drought conditions and combined with different sources of N.
- VWC was affected by fertilizer treatments. Plots treated with ACA 5000 and SeaBlend + Stress Rx + XP Micro had the highest VWC starting in July, and were matched by ACA 1935 in August (Fig. 4). Revolution also had a positive impact on VWC on 6 rating dates in comparison to untreated plots (Fig. 5).
- Root length was affected by the interaction of Primo Maxx, Revolution and fertilizers. The longest roots were found in plots that received Primo Maxx, Revolution and SeaBlend + Stress Rx+ XP Micro (Table 3.). Moreover, root length of plots fertilized with Gro-Power, SeaBlend + Stress Rx + XP Micro, ACA 1935 and 5000 was positively affected by the application of Primo Maxx and Revolution. Shortest roots were found in plots that received fertilizer only with the exception of Yara Liva. Is it possible that, since plots fertilized with Yara Liva looked the most stressed during the highest ETos weeks, bermudagrass tried to avoid drought by extending root length.
- Plots that retained color longer in the fall were those that received Primo Maxx and Revolution regardless of irrigation replacement, plots that received only Revolution irrigated at 40% ET_{os}, and those that received only Primo Maxx at 70% ET_{os} replacement (Fig. 6). Fertilizer treatments also had an effect on fall color retention with plots that received SeaBlend + Stress Rx + XP Micro and Yara Liva showing lighter color in December (Fig. 7).

Acknowlegments:

Thanks to California Turfgrass & Landscape Foundation, Aquatrols Corp. of America, Gro-Power Inc., Ocean Organics, Syngenta, and Yara International for financial support.

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

Month Year	Total ETos (in)	Total Precip (in)	Avg Vap Pres (mBars)	Avg Max Air Temp (F)	Avg Min Air Temp (F)	Avg Air Temp (F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Wind Speed (mph)	Avg Soil Temp (F)
May-16	6.21	0.02	12	71.2	55.5	62.6	80	40	62	4	67.8
June-16	7.21	0	13.6	89.4	61.5	74.5	74	30	49	4.4	73
July-16	7.74	0	14.3	93.5	64.2	77.5	73	25	45	4.2	75.9
Aug-16	6.88	0	14.4	92.6	63.6	76.5	74	25	47	4	75.4
Sep-16	5.3	0	12.6	87.9	60.8	72.9	71	27	47	4	71.5
Oct-16	3.87	0.87	11.2	80.7	56.6	67.7	70	31	51	3.5	66.4

Table 2. PGR, wetting agent, and fertilization study treatment list 2016.

Plot	Treatment	Company	Rate	Frequency (wks)
Whole Plot	ET_{os} replacement	---	40%-70%	M-W-F
Split	Primo Maxx	Syngenta	0.25 oz/M	2
Split-split-plot	Revolution	Aquatrols	6 oz/M	4
Split-split-split-plot	Gro-Power (5-3-1)	Gro-Power	1 lb N/M	4
Split-split-split-plot	SeaBlend (12-4-5) + StressRX + XP Micro	Ocean Organics	1 lb N/M + 6 oz/M + 6 oz/M	4 2 2
Split-split-split-plot	Turf Royale (21-7-14)	Yara	1 lb N/M	4
Split-split-split-plot	Yara Liva (15.5-0-0)	Yara	1 lb N/M	4
Split-split-split-plot	Turf Royale (21-7-14) + ACA 1935	Yara Aquatrols	1 lb N/M + 4 oz/M	4 4
Split-split-split-plot	Turf Royale (21-7-14) + ACA 5000	Yara Aquatrols	1 lb N/M + 4 oz/M	4 2

PGR Wetting Agent and Fertilization Study Treatment List and Plot Plan

Rep 1	70% ET_{os}	19	20	12	9		13	18	4	3	40% ET_{os}
		21	22	11	7		15	16	1	2	
		23	24	8	10		17	14	6	5	
		14	18	5	2		9	8	19	21	
		13	17	1	6		11	7	22	24	
		16	15	3	4		10	12	23	20	

Rep 2	70% ET_{os}	5	6	15	16		5	3	13	17	40% ET_{os}
		2	3	17	14		6	2	14	16	
		1	4	18	13		1	4	18	15	
		23	19	10	12		9	11	22	19	
		21	22	8	9		10	12	20	21	
		24	20	7	11		8	7	23	24	

Rep 3	40% ET_{os}	13	16	2	5		23	19	7	11	70% ET_{os}
		15	17	1	3		22	21	10	12	
		14	18	6	4		20	24	9	8	
		11	8	20	19		2	3	18	14	
		10	7	24	23		1	6	13	17	
		9	12	22	21		4	5	16	15	

Trt #	Fertilizer	Primo Maxx	Revolution
1	Gro-Power		
2	SeaBlend + StressRx + XP Micro		
3	Yara Turf Royale		
4	Yara Liva		
5	Yara Turf Royale + ACA 1935		
6	Yara Turf Royale + ACA 5000		
7	Gro-Power	x	
8	SeaBlend + StressRx + XP Micro	x	
9	Yara Turf Royale	x	
10	Yara Liva	x	
11	Yara Turf Royale + ACA 1935	x	
12	Yara Turf Royale + ACA 5000	x	
13	Gro-Power		x
14	SeaBlend + StressRx + XP Micro		x
15	Yara Turf Royale		x
16	Yara Liva		x
17	Yara Turf Royale + ACA 1935		x
18	Yara Turf Royale + ACA 5000		x
19	Gro-Power	x	x
20	SeaBlend + StressRx + XP Micro	x	x
21	Yara Turf Royale	x	x
22	Yara Liva	x	x
23	Yara Turf Royale + ACA 1935	x	x
24	Yara Turf Royale + ACA 5000	x	x

Table 3. Root length (cm/mm^3) of plots untreated or treated with either Primo Maxx, Revolution, or a combination of the two. All plots received 5 lb/1,000 ft^2/year using six different fertilizers.

	Primo Maxx			
	Yes		No	
	Revolution		Revolution	
	Yes	No	Yes	No
Gro-Power	608 AB	501 ABCD	464 ABCD	382 CD
SeaBlend + StressRx +XPMicro	660 A	441 BCD	442 BCD	323 D
Turf Royale	385 CD	459 ABCD	444 BCD	325 D
Yara Liva	551 ABC	382 CD	565 ABC	516 ABCD
Turf Royale + ACA1935	625 AB	359 CD	466 ABCD	332 D
Turf Royale + ACA5000	569 ABC	394 CD	50 ABCD	314 D

Figure 1. Quality, Naturalized Difference Vegetation Index (NDVI), and % green cover of plots irrigated at 70% ET_{os} untreated or treated with Primo Maxx, Revolution, or a combination of the two. All plots were fertilized with 5 lb N/M/year. 2016. Riverside, CA.

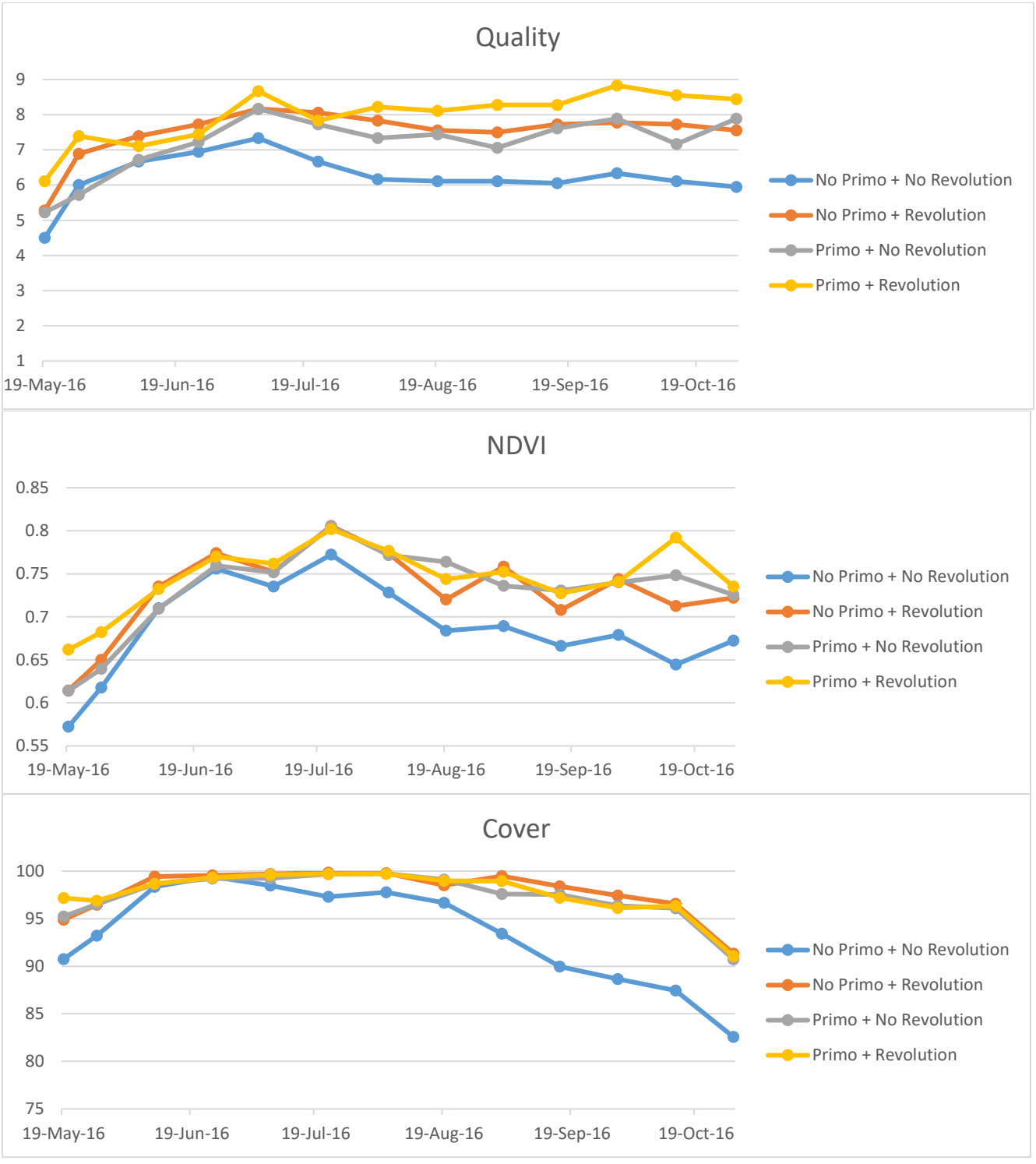


Figure 2. Quality, Naturalized Difference Vegetation Index (NDVI), and % green cover of plots irrigated at 40% ET_{os} and treated with either Revolution or untreated. All plots were fertilized with 5 lb N/M/year. 2016. Riverside, CA.

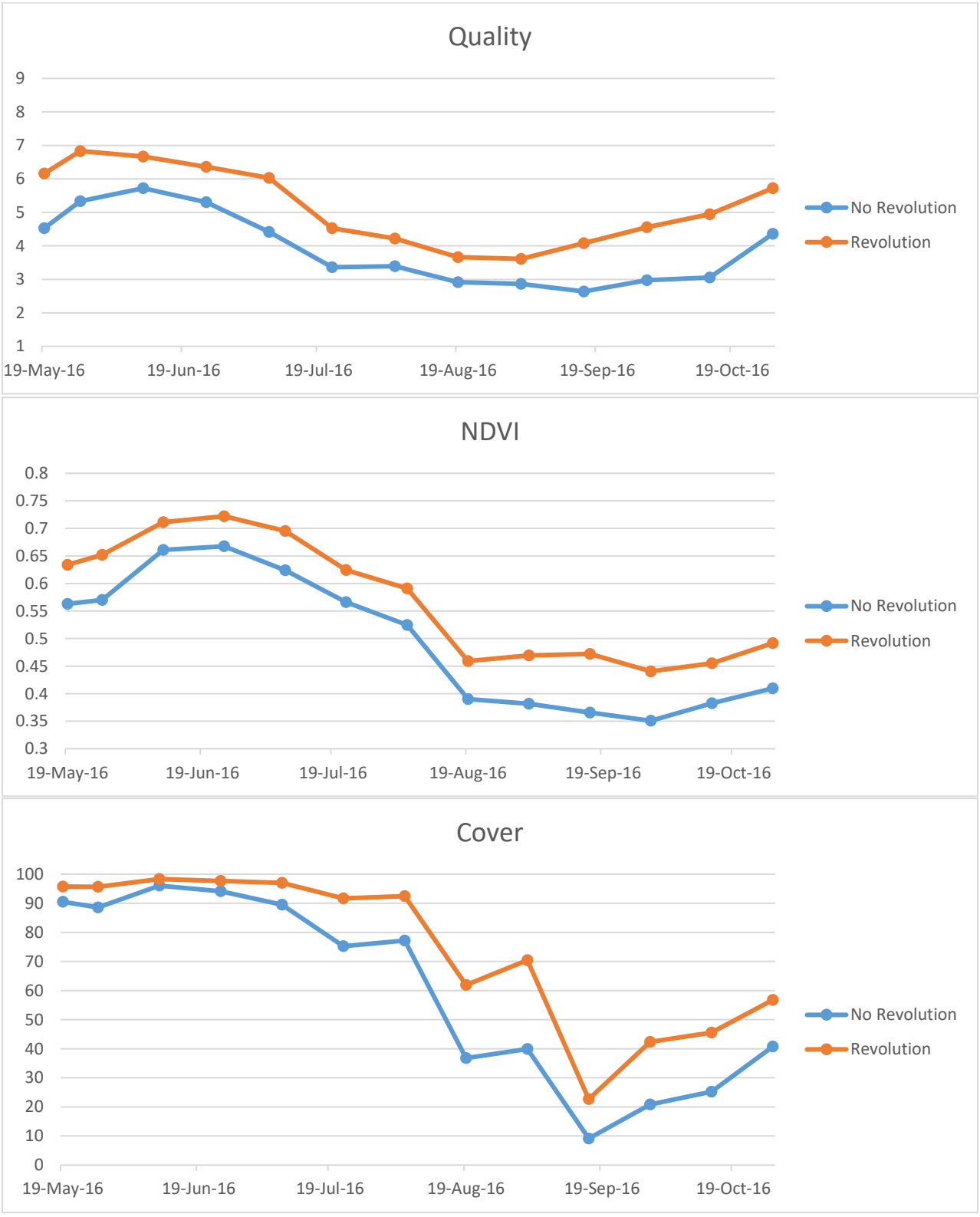
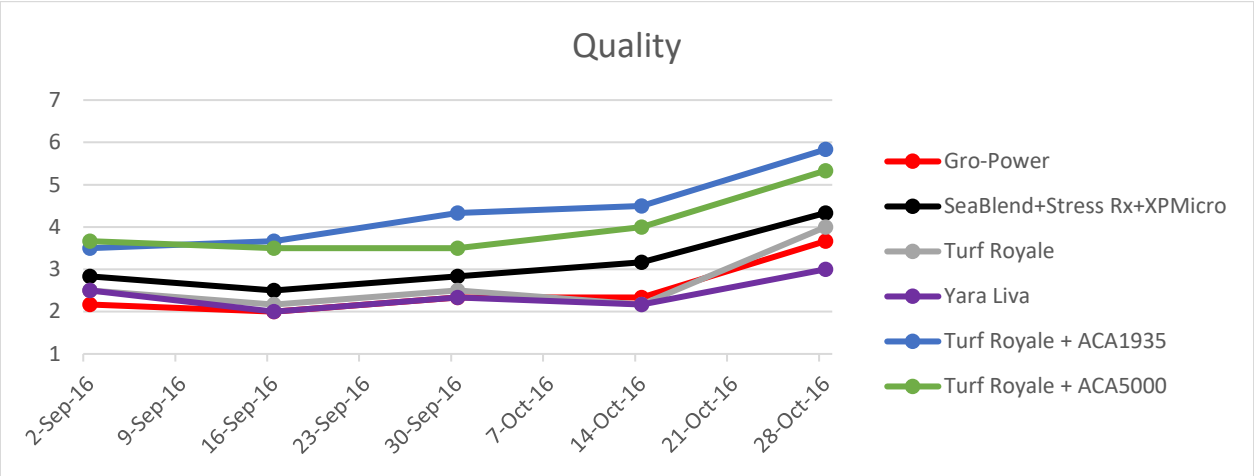
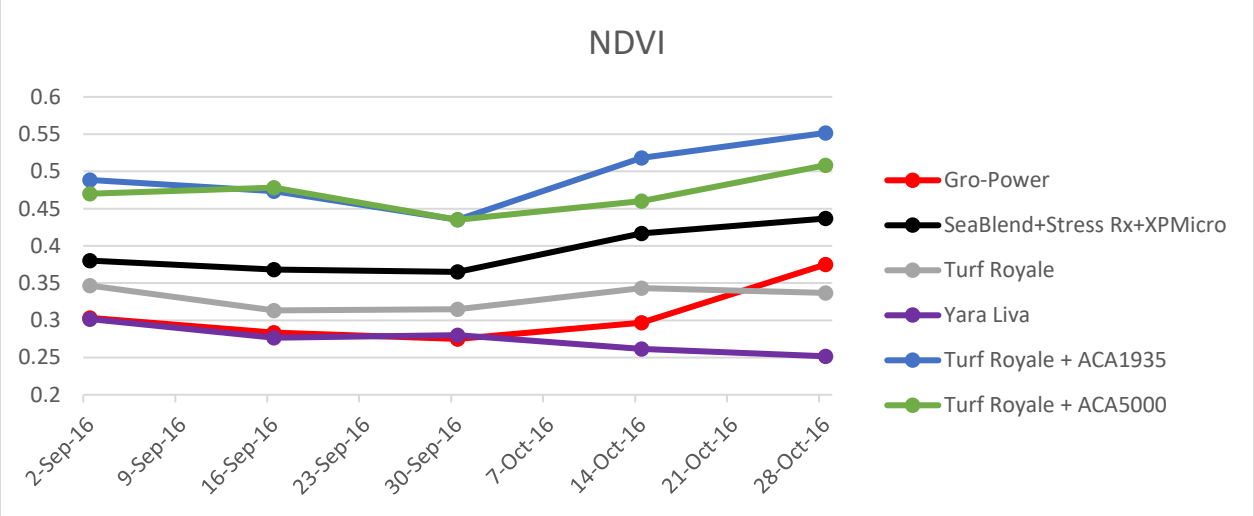


Figure 3. Quality, Naturalized Difference Vegetation Index (NDVI), and % green cover of plots irrigated at 40% ET_{os} that did not receive Revolution and fertilized with 6 different N sources. All plots were fertilized with 5 lb N/M/year. 2016. Riverside, CA.





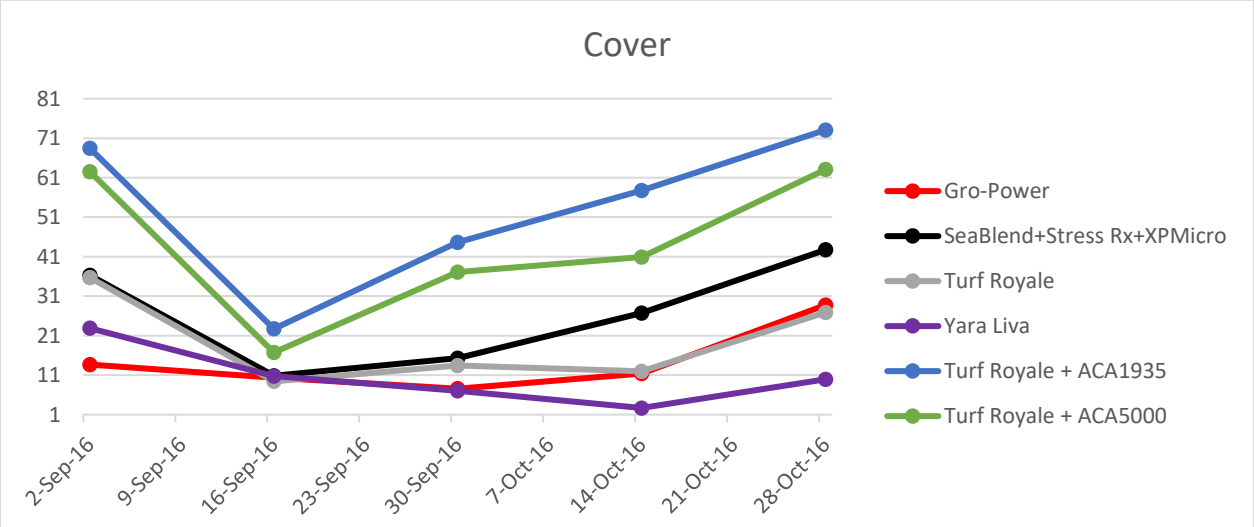


Figure 4. Volumetric Water Content (VWC) of plots irrigated fertilized with 6 different N sources. All plots were fertilized with 5 lb N/M/year. 2016. Riverside, CA.

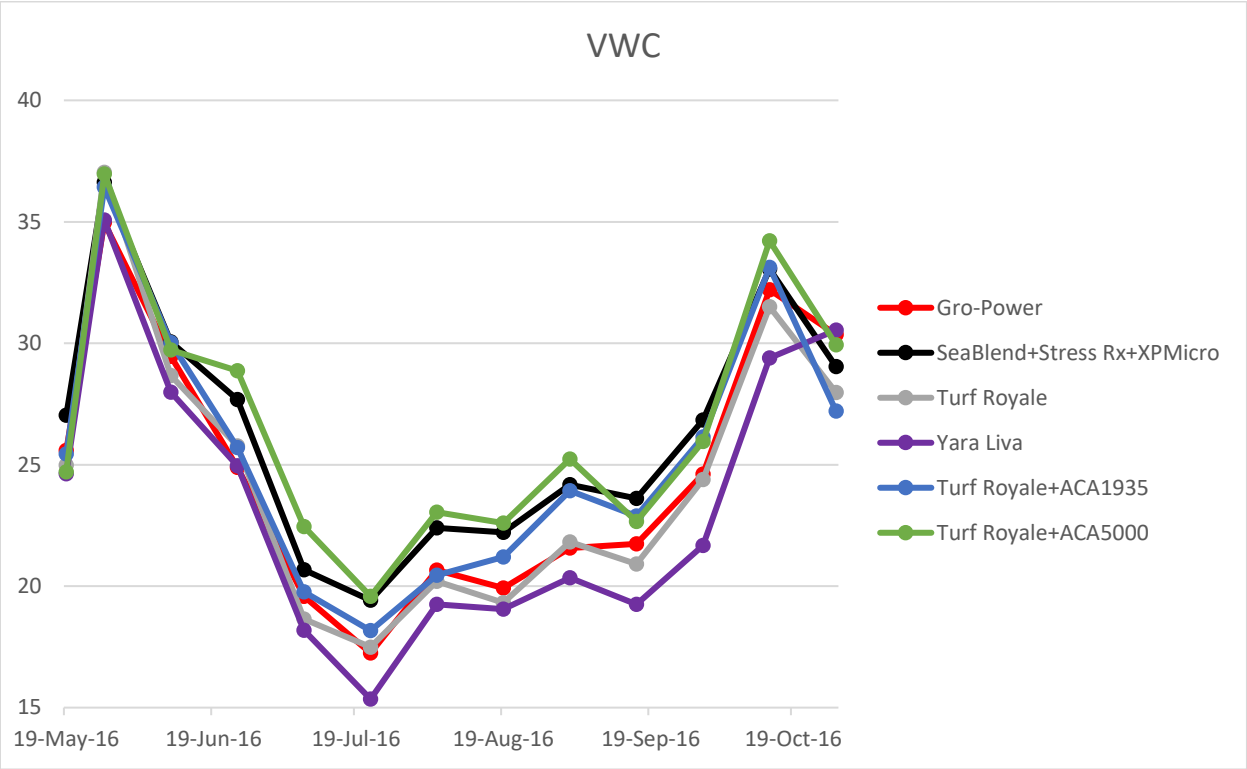


Figure 5. Volumetric Water Content (VWC) of plots treated with either Revolution or untreated. 2016. Riverside, CA.

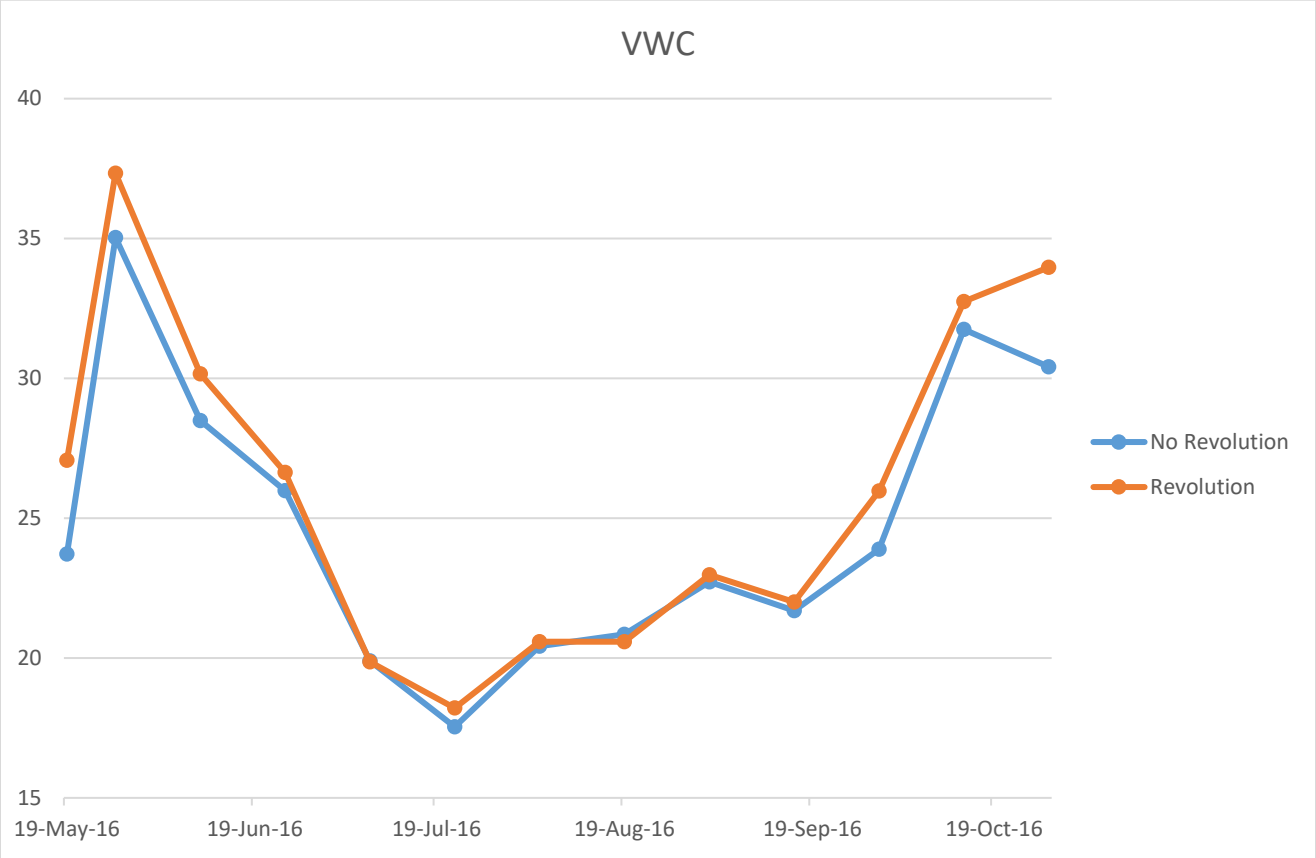


Figure 6. Fall Color Retention of plots untreated or treated with either Primo Maxx, Revolution, or a combination of the two. All plots were fertilized with 5 lb N/M/year. 2016. Riverside, CA.

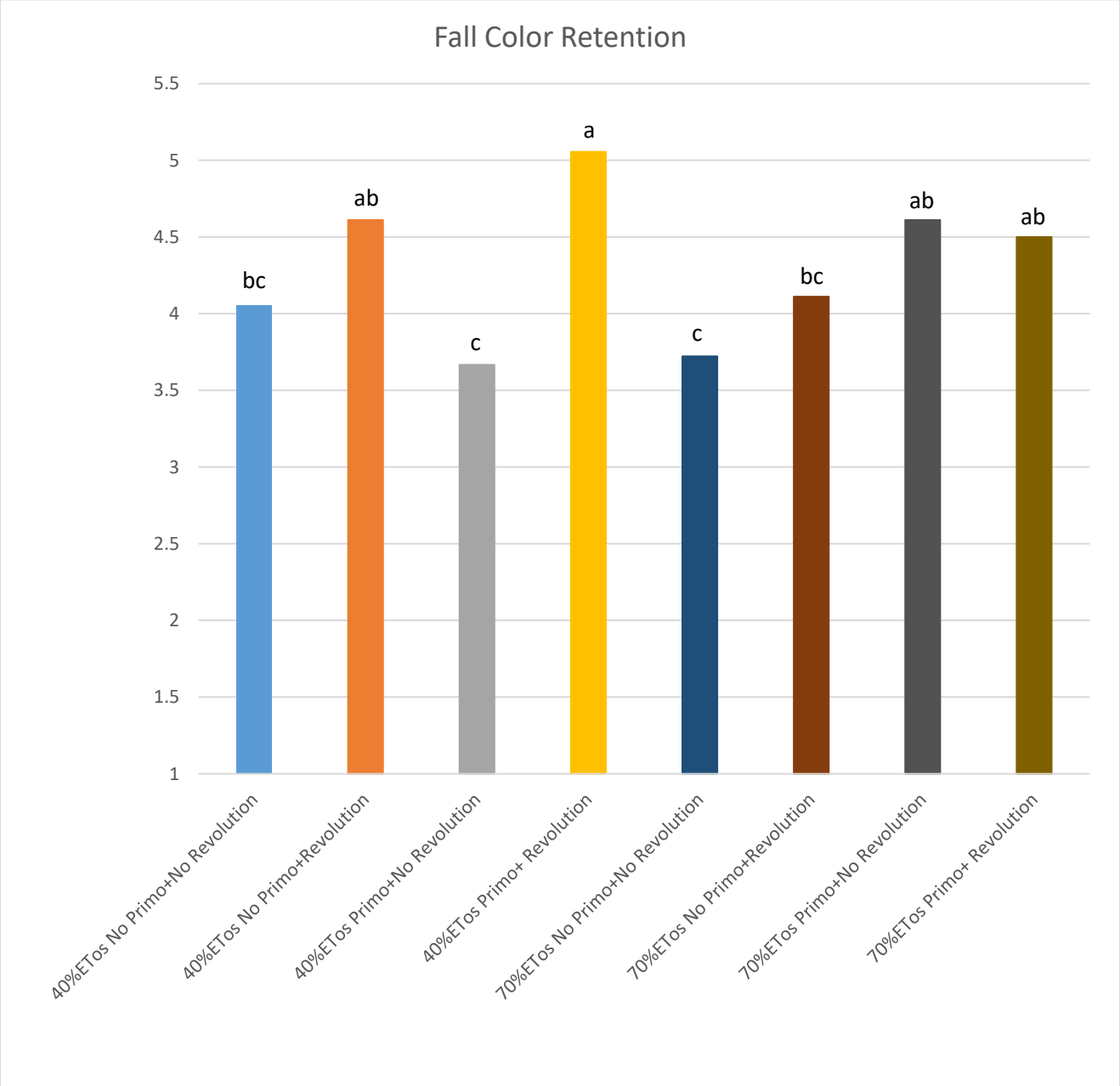


Figure 7. Fall color retention of plots irrigated fertilized with 6 different N sources. All plots were fertilized with 5 lb N/M/year. 2016. Riverside, CA.