Evaluation of Products to Alleviate Salinity Stress in Bermudagrass Turf

2013-14 Final Report

Salinity alleviation study area at UC Riverside, CA. Hybrid bermudagrass 'Tifway II' sod was installed in August 2012. Turf was irrigated with saline water from adjacent storage tanks and commercial and experimental products were applied from April to October in 2013 and 2014. Photo taken on 9 Oct 2012.

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The Bottom Line: Thirty commercial and experimental products were tested for their ability to alleviate salinity stress on bermudagrass turf irrigated with saline water (electrical conductivity = EC ≈ 4.4 dS/m). Product applications were made from April to October 2013 and 2014. Bermudagrass was stressed from irrigation with saline water, but no turf thinning or loss occurred in either year. During 2013, EC_e (soil saturated paste extract) and EC_L (leachate) reached as high as 8 and 18 dS/M, respectively. Only a few products showed results that were significantly different than the untreated control. The treatment containing DeSal and Stress Rx (Ocean Organics) increased turf quality at the end of the 2013 study period and decreased sodium absorption ratio (SAR) and sodium (Na) content in the soil. ACA 2994 (Aquatrols) decreased EC_L and lowered SAR and Na in soil, but results for turf quality were inconsistent. Biolink Cal Plus (Westbridge Agricultural Products) applied at a rate of 0.75 oz/M also decreased EC_L, but no other effects were detected. Products containing microbes showed no effects on either salinity alleviation or turf quality. During 2014, EC_e and EC_L reached as high as 12 and 20 dS/M, respectively. The treatment containing DeSal and Stress Rx not only increased turf quality and Dark Green Color Index (DGCI) but also decreased EC_e, SAR and Na content in the soil. ACA 2994 applied at 8 oz/M every 2 weeks and ACA 1849 (Aquatrols) + Gypsum decreased EC_L and lowered EC_e, SAR and Na in soil, but results for turf quality were inconsistent. Conversely, Biolink Cal Plus applied at both rates, Turfcare NPN (Gantec Inc.) and MST-1410 increased turf quality or DGCI, but did not ameliorate soil salinity in comparison to the control. Overall, the treatment containing DeSal and Stress Rx provided the best combination of salinity alleviation and turf quality in both years of the study.

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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. Modification of soil physicochemical properties that result from salinity is one means of alleviating plant salinity stress. Moreover, there is a growing movement toward use of "organic" and microbial products for purposes of improving plant health under salinity stress. Overall, turf managers are inundated with a plethora of salinity alleviation products, many of which have not been tested under non-biased, replicated experiments on turf. The objective of this study was to evaluate commercial and experimental products for alleviating soil salinity and stress on bermudagrass turf irrigated with saline water.

Materials and Methods:

The study was conducted in 2013 and 2014 at the UC Riverside turfgrass research facility in Riverside, CA. Environmental data for the site are provided in Table 1. The research area was sodded with hybrid bermudagrass 'Tifway II' on 6 August 2012 on a Hanford fine sandy loam. The turf was mowed three times per week at 0.75 inches during each growing season, verticut once in August 2013 and again in June 2014, and received 0.5 lbs N/M/month during each growing season for a total of 4 lbs N/M/yr using either ammonium sulfate or a complete granular fertilizer.

Turf was irrigated with Toro 300 series pop-up stream sprinklers (Toro Company, Bloomington, MN) on 30-ft spacing. Since November 2012, plots were irrigated at 75% reference evapotranspiration (ET_o) recorded from the previous week with saline water that was made by mixing salts in potable water within two 5000-gal storage tanks (Snyder Industries, Inc., Lincoln, NE) 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 not HCO_3^- and CO_3^{2-} (Table 2). Total salinity of the water was chosen to simulate an extreme, but realistic irrigation salinity for turf in California (personal communication, M. Huck). Saline irrigation was withheld during the winter months in 2013-14 and restored in the spring. Furthermore, natural precipitation helped leaching of salts present in the soil (Table 3).

The experimental design was a randomized complete block and treatments were replicated 6 times. Treatments were applied either at one time only, bi-weekly, monthly, or bi-monthly between 4 Apr and 17 Oct 2013 and 3 Apr and 15 Oct 2014 (Tables 4-6). Sprayable treatments were applied using a CO_2-powered hand boom sprayer equipped with TeeJet 8004VS nozzles and output of 2 gal/M. Turf irrigation scheduling included irrigation immediately after application of treatments and again later in the evening. Every two weeks and in between treatment applications, plots were evaluated for turf quality on a scale from 1 = worst to 9 = best, leaf firing (0-100%), volumetric soil water content (VWC) using time domain reflectometry (TDR), and dark green color index (DGCI) using Digital Image Analysis (DIA). Leachate (3 replicates/treatment) was also collected and analyzed for electrical conductivity (EC_L) on the same day (Fig. 1). During rating weeks, irrigation scheduling included the night before collection of leachate samples. Composite or replicate (6/treatment) soil samples were collected and analyzed

for salinity and nutrients (Ag Source Labs, Lincoln, NE) at the time of turf establishment in 2012 and before initial and after final treatment applications in 2013 and 2014.

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 when treatment effect (chemical) was significant during one or more rating dates.

General Results:

- Soil lab test results from the study area before and after saline irrigation and treatment applications are presented in Table 3. Note that the study area was fallow and without irrigation or significant rainfall for ca. 6 months prior to the first sampling date, hence the elevated soil salinity. In general, soil salinity was similar at the beginning of treatment applications in both years.

- Total precipitation and ET_o were 2.31 and 44.99 inches, respectively from April to October 2013, and 2.45 and 47.43 inches, respectively from April to October 2014 (Table 1).

2013 Results:

- There were no differences in VWC, leaf firing, or from DIA among treatments throughout the study (data not shown).

- Quality ratings were inconsistent during the first year of the study. Plots treated with ACA 2994 developed initial symptoms of phytotoxicity within 2 weeks after application developing orange color, but one month after initial treatment exhibited the highest quality. Nevertheless, at the beginning of summer, those plots were the most prone to scalping, and their quality decreased significantly.

- Lowest turf quality during the study corresponded to the verticutting practice in August. No other treatments increased turf quality in comparison to control, with the exception of the treatment containing DeSal and Stress Rx toward the end of the study. Generally, plots treated with ACA 3086 exhibited lower quality in comparison to control (Figure 2).

- Salinity in leachate increased steadily from April until August, was stable from August until October, and started decreasing in October, when frequent precipitation events started occurring. Leachate analysis revealed that only two treatments, ACA 2994 and Cal Plus applied at a rate of 0.75 oz/M, decreased EC from irrigation water in comparison to control starting from August 29 (Figure 3).

- Soil lab test results from replicate samples taken in October 2013 showed no differences at the end of the study for EC_e or pH (Table 7). However treatment differences were detected for SAR, with DeSal and ACA 2994 showing the lowest means but not different than the control. DeSal was the only treatment to decrease sodium content in comparison to control. Sodium contents following MC TP and ACA 2994 applications were next lowest, but not different than the control.

2014 Results:

- The combination of natural rainfall (Table 1) and cessation of saline irrigation during the winter of 2013-14 lowered soil salinity in the study area (Table 3). Furthermore, no differences were detected among treatment plots in March 2014 (data not shown); therefore, there was no carryover from treatments applied in 2013 and the 2014 experiment was initiated when salinity levels were similar in all plots.

- Higher ET_o rates, and temperatures coupled with lower precipitation at the beginning of the study period (April to August; Table 1) led to a faster accumulation of salts in 2014 in comparison to 2013 (Figure 3 and 6).

- There were no differences in VWC or leaf firing among treatments throughout the study (data not shown).

- Turf quality was enhanced by several treatments on different rating dates (Figure 4). However, the treatment containing DeSal and Stress Rx was consistently best among all others throughout 2014. Cal Plus (both rates), Turfcare NPN, and MST-1410 after its first application on June 12 also improved turf visual quality in comparison to the control.

- Dark Green Color Index (DGCI) was higher in comparison to the control among the same treatments that also showed higher turf quality. Improved DGCIs were also collected in plots treated with ACA 3217 (Figure 5). Conversely, ACA 2994 caused bermudagrass discoloration, especially during the early stages of the 2014 experiment, and lower DGCI in comparison to control (data not shown).

- Lower leachate salinity (EC_L) in comparison to the control were recorded only in plots treated with Cal Plus at 1.5 oz/M, DeSal, and particularly ACA 2994 that was the most effective treatment (Figure 6). In fact, EC_L of ACA 2994 plots matched that of control plots only at the beginning of the study, and at three other rating dates that were always preceded by abundant rainfall events.

- Soil samples collected at the end of the year showed that only three treatments were able to lower salinity level (Table 8). ACA 1849 + Gypsum, ACA 2994, and DeSal plots showed lower EC_E, SAR and Na content in comparison to control. However, out of these three treatments, DeSal was the only one that also had a positive effect on turf quality. ACA 1849 and gypsum were effective only in combination; whereas, neither had a positive effect when applied alone.

- The DeSal and Stress Rx treatment provided the best overall turf quality and salinity alleviation in 2014 in addition to 2013. Some treatments either enhanced turf quality without having a clear effect on soil salinity (ACA 3217, Cal Plus, MST-1410, Turfcare NPN) or had a positive effect on alleviating soil salinity, but with detrimental (ACA 2994) or no effect (ACA 1849 + Gypsum) on visual turf quality. The remainder of treatments neither improved turf quality nor reduced soil salinity in comparison to the untreated control.

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

Month Year	Total ETo (in)	Total Precip (in)	Avg Sol Rad (Ly/day)	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 Dew Point (F)	Avg Wind Speed (mph)	Avg Soil Temp (F)
Aug-12	7.83	0.18	604	15.0	95.2	68.0	80.3	65	26	43	55.2	4.1	77.3
Sep-12	6.44	0.01	522	12.7	93.6	63.8	78.2	63	22	39	50.2	3.9	75.3
Oct-12	4.38	0.17	407	10.9	82.0	56.7	68.2	68	29	48	45.3	3.7	66.5
Nov-12	2.72	0.38	296	8.9	73.7	49.6	60.2	71	31	51	39.7	3.3	58.7
Dec-12	1.70	1.59	219	8.6	62.5	43.9	52.3	79	42	60	37.4	3.2	54.3
Jan-13	2.72	0.6	289	5.2	65.2	40.9	52.5	58	23	39	24.9	4.1	48.8
Feb-13	3.18	0.84	372	6.2	65.7	41.3	53.2	68	28	47	30.5	4.0	52.2
Mar-13	4.80	0.66	476	9.1	74.1	48.6	60.0	76	31	53	41.5	3.8	59.6
Apr-13	5.71	0.00	544	9.6	75.5	51.2	61.9	73	31	51	41.9	4.6	63.2
May-13	7.01	0.25	626	11.4	81.2	56.6	67.6	75	31	52	48.2	4.5	68.3
Jun-13	7.36	0.00	684	14.1	86.3	59.8	71.3	78	32	55	53.7	4.4	72.1
Jul-13	7.13	0.35	594	15.3	89.5	64.1	75.4	74	31	51	55.6	4.0	74.6
Aug-13	7.37	1.20	600	14.2	91.9	62.9	75.9	74	25	47	53.5	3.9	72.7
Sep-13	6.14	0.00	523	12.6	89.4	62.2	74.5	66	24	44	49.6	3.8	71.9
Oct-13	4.27	0.51	407	9.1	78.1	51.6	63.9	71	26	47	40.7	3.7	62.8
Nov-13	2.76	1.20	270	7.7	72.1	49.7	60.0	66	31	46	36.6	3.7	57.9
Dec-13	2.80	0.39	261	5.1	67.9	43.7	55.3	55	22	36	26.0	3.9	51.1
Jan-14	3.27	0.00	280	5.2	73.8	47.3	59.7	49	18	32	25.7	3.8	51.5
Feb-14	3.03	1.15	345	8.1	70.4	47.3	57.7	72	31	51	38.4	3.4	55.7
Mar-14	4.95	0.50	469	8.8	73.3	50	60.9	74	30	50	40.1	4.2	59.1
Apr-14	6.52	0.72	595	8.5	77.3	51.3	63.6	69	26	45	39.3	4.9	62.3
May-14	7.65	0.00	656	9.7	82.9	56.9	69.4	65	26	48	45.6	4.8	66
Jun-14	7.62	0.00	716	13.3	85.9	58.4	70.9	78	29	51	51.6	4.4	71
Jul-14	7.76	0.00	630	14.8	91.2	65.5	77.8	71	28	47	54.8	4.3	74.6
Aug-14	7.29	0.28	605	14.9	91	63.6	76.1	75	27	49	54.9	4.1	73.4
Sep-14	6.19	1.45	538	14.7	91.6	64.6	76.7	72	27	48	54.6	3.8	73.4
Oct-14	4.40	0.00	419	11.6	84.9	57.7	69.8	71	27	49	47.5	3.3	67.4

Table 2. Properties of potable and saline (salts mixed with potable water) irrigation water used in the salinity alleviation study in Riverside, CA. 2012-2014.

Properties	**Potable**	**Saline**
pH	7.8	7.6
EC, dS m^{-1}	0.6	4.4
TSS, mg L^{-1}	390	2835
SAR, meq L^{-1}	3.2	18.3
Na^{+}, mg L^{-1}	53	524
K^{+}, mg L^{-1}	4	130
Ca^{2+}, mg L^{-1}	66	126
Mg^{2+}, mg L^{-1}	12	152
Cl^{-}, mg L^{-1}	31	996
NO_3^{-}-N, mg L^{-1}	5.2	5.1
HCO_3^{-}, mg L^{-1}	215	210
CO_3^{2-}, mg L^{-1}	0.01	0.01
SO_4^{2-}, mg L^{-1}	78	708
B, mg L^{-1}	0.08	0.11

Table 3. Soil test results for study area before and after application of saline irrigation in the salinity alleviation study. 2012-14. Riverside, CA. Composite samples were collected from control plots only after initial application of chemical treatments.

Date	pH	EC_e (dS/m)	SAR	Olsen P ppm	K ppm	Ca ppm	Mg ppm	Na ppm	CEC	Soluble Salts (dS/m)
November 2012	6.6	6.5	0.81	NA	261	1904	202	79	12.2	2.45
April 2013	7.7	2.13	4.79	29.6	159	1653	351	283	12.8	0.64
October 2013	7.3	7.9	8.4	NA	390	1175	395	830	NA	NA
March 2014	7.7	2.32	6.1	21.8	253	957	326	267	9.3	0.53
October 2014	7.6	11.9	13.8	19.0	392	1201	424	879	14.4	1.5

pH = acidity; EC_e = electrical conductivity of soil saturated paste extract; SAR = sodium absorption ratio; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; Na = sodium; CEC = cation exchange capacity; ppm = parts per million; NA = not analyzed.

Table 4. Commercial and experimental products and their year and frequency of application in the salinity alleviation study. 2013-14. Riverside, CA.

Treatment	Company	Year	Rate	Frequency (wks)
Control	--	2013; 2014	--	--
ACA 2786	Aquatrols	2013	4.5 oz/M	2
ACA 3086	Aquatrols	2013	8 oz/M	2
ACA 3217	Aquatrols	2014	6 oz/M	2
ACA 2994	Aquatrols	2013; 2014	8 oz/M	2
ACA 2994	Aquatrols	2014	4 oz/M	6
ACA 2994	Aquatrols	2014	8 oz/M	6
ACA 1849	Aquatrols	2013; 2014	3 oz/M	2
ACA 1849 Gypsum	Aquatrols	2013; 2014 2013; 2014	3 oz/M 5 lbs/M	2 2
Cal-Vantage Kick Proactin TriCure AD	EarthWorks Earthworks Mitchell Products Mitchell Prod	2014 2014 2014 2014	5 oz/M 10 oz/M 1.5 oz/M 4 oz/M	Cal-Vantage and Kick rotated every 2 wks with Proactin and TriCure
MC TP	Mitchell Products	2013; 2014	2 oz/M	2
MC TP3	Mitchell Products	2013; 2014	2 oz/M	2
Crossover	Numerator Tech.	2013; 2014	5 lb/M	4
Revert	Numerator Tech.	2013; 2014	6 oz/M	4
SST 8%CA	Numerator Tech.	2013; 2014	8 oz/M	2
pHAcid Sprayable	Numerator Tech.	2013	1.5 oz/M	2
pHAcid Sprayable Crossover	Numerator Tech. Numerator Tech.	2014 2014	2 oz/M 5 lb/M	2 4
Cal Plus 1	Westbridge Agric.	2013; 2014	0.75 oz/M	2
Cal Plus 2	Westbridge Agric.	2013; 2014	1.5 oz/M	2
DeSal Stress Rx XP 5-0-1	Ocean Organics Ocean Organics Ocean Organics	2013; 2014 2013; 2014 2013; 2014	0.75 oz/M 6 oz/M 6 oz/M	2 2 2
Displace Carboplex	Grigg Brothers Grigg Brothers	2013 2013	12 oz/M 6 oz/M	2 2
Elicitor Kelplex	Grigg Brothers Grigg Brothers	2013 2013	2 oz/M 2 oz/M	2 2
SumaGrow SumaGrow	Agribiotic Products	2013 2013	5 oz/M 3 oz/M	Initial 2
Soil System 1	LH Organics	2013	50 g/18 gal	2 (alternate months)
UCR001	UC Riverside	2013		
Gypsum		2014	5 lb/M	2
Gypsum		2014	10 lb/M	2
MST-1410		2014*	3 oz/M	2
MST-1410		2014*	5 oz/M	2
Turfcare NPN Turfcare NPN Turfcare 6-1-2	Gantec Gantec Gantec	2013; 2014 2013; 2014 2013; 2014	0.1 oz/M 0.1 oz/M 2.3 lb/M	2 (Apr-May) 4 (Jun-Oct) Apr/May/Jul/Sep

*Treatments applied initially on 12 June 2014.

Table 5. Application record for commercial and experimental products in the salinity alleviation study. 2013. Riverside, CA.

Timing (wks)	Initial	1	2
Date	4 April 2013	10 April 2013	18 April 2013
Time	11:20am-12:45pm	9:40am-9:50am	6:25am-7:45am
Temperature	64F	74F	56F
Wind	5 mph	11 mph	3 mph
Conditions	Overcast→Sunny	Sunny, Windy	Clear, Windy

Timing	4	6	8
Date	2 May 2013	16 May 2013	30 May 2013
Time	6:48am-7:50am	6:40am-7:50am	7:15am-8:10am
Temperature	63F	58F	63F
Wind	3 mph	3 mph	3 mph
Conditions	Slight Wind→Calm	Cloudy, Calm	Sunny

Timing	10	12	14
Date	13 June 2013	27 June 2013	11 July 2013
Time	7:10am-7:57am	7:20am-8:30am	6:30am-7:15am
Temperature	61F	80F	70F
Wind	2.5 mph	2 mph	2 mph
Conditions	Cloudy	Really Hot	Cloudy

Timing	16	18	20
Date	25 July 2013	8 August 2013	22 August 2013
Time	6:30am-7:20am	7:35am-8:45am	7:22am-8:20am
Temperature	64F	64F	70F
Wind	1.5 mph	2 mph	2 mph
Conditions	Clear	Clear	Clear

Timing	22	24	26
Date	5 September 2013	19 September 2013	3 October 2013
Time	7:00am-8:10am	7:30am-8:30am	7:58am-8:50am
Temperature	77F	60F	63F
Wind	1.5 mph	1.5 mph	3.5 mph
Conditions	Clear, Hot	Clear	Cloudy, Slight Wind

Timing	28
Date	17 October 2013
Time	7:20am-8:17am
Temperature	55F
Wind	2 mph
Conditions	Clear

Table 6. Application record for commercial and experimental products in the salinity alleviation study. 2014. Riverside, CA.

Timing (wks)	Initial	2	4
Date	4 April 2014	17 April 2014	1 May 2014
Time	2:00pm-3:00pm	9:55am-10:50am	7:07am-7:51am
Temperature	63F	59F	72F
Wind	6 mph	4 mph	4 mph
Conditions	Overcast→Windy	Sunny, Slight Wind	Sunny

Timing	6	8	10
Date	15 May 2014	29 May 2014	12 June 2014
Time	7:00am-8:00am	6:40am-7:50am	8:30am-9:10am
Temperature	73F	60F	66F
Wind	2 mph	2 mph	3 mph
Conditions	Sunny, Calm	Sunny, Calm	Sunny

Timing	12	14	16
Date	26 June 2014	10 July 2014	23 July 2014
Time	7:10am-7:57am	7:20am-8:30am	8:30am-9:15am
Temperature	63F	67F	75F
Wind	3 mph	3 mph	2 mph
Conditions	Cloudy	Sunny	Hot

Timing	18	20	22
Date	6 August 2014	20 August 2014	4 September 2014
Time	7:00am-7:52am	7:35am-8:45am	7:22am-8:20am
Temperature	61F	63F	65F
Wind	1 mph	2 mph	2 mph
Conditions	Cloudy, Calm	Clear	Clear

Timing	24	26	28
Date	18 September 2014	31 September 2014	15 October 2014
Time	7:20am-8:15am	7:11am-8:06am	7:45am-8:43am
Temperature	67F	60F	64F
Wind	2 mph	2 mph	3 mph
Conditions	Clear	Overcast, Calm	Cloudy, Slight Wind

Table 7. Soil EC_e (dS/m), sodium absorption ratio (SAR), acidity (pH), and sodium (Na) content (meq/L) in October 2013 following application of treatments since April 2013. Riverside, CA.

Treatment	EC_e (dS/m)	SAR	pH	Na (Meq/L)
Control	7.94	8.41 A-F	7.3	36.11 A-E
ACA 3086	7.29	8.28 A-F	7.4	33.97 A-F
ACA 2994	6.41	7.45 EF	7.4	28.64 D-F
ACA 1849	6.86	8.50 AE	7.4	33.78 A-F
ACA 1849 Gypsum	6.69	7.51 D-F	7.3	29.95 B-F
ACA 2786	7.16	8.07 B-F	7.4	32.95 B-F
MC TP	5.79	7.82 C-F	7.5	27.99 EF
MC TP3	8.90	9.30 A	7.3	42.87 A
Crossover	7.09	8.36 A-F	7.4	33.45 A-F
Revert	8.18	8.79 A-C	7.4	38.35 A-C
SST 8%CA	6.63	7.64 D-F	7.3	29.14 C-F
pHAcid Sprayable	8.07	9.05 AB	7.4	39.26 AB
Cal Plus 1	6.86	8.01 B-F	7.3	31.82 B-F
Cal Plus 2	6.34	7.97 B-F	7.4	29.27 C-F
DeSal Stress Rx EXP 5-0-1	5.57	7.28 F	7.3	25.65 F
Displace Carboplex	7.95	8.83 A-C	7.4	37.94 A-D
Elicitor Kelplex	7.54	8.33 A-F	7.3	34.80 A-F
SumaGrow	8.11	8.64 A-D	7.3	37.43 A-E
Soil System 1	6.12	7.93 B-F	7.5	28.54 D-F
UCR001	6.80	7.75 C-F	7.4	30.10 B-F
Turfcare NPN Turfcare NPN Turfcare 6-1-2	7.06	8.53 A-E	7.4	34.69 A-F

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

Table 8. Soil EC_e (dS/m), sodium absorption ratio (SAR), acidity (pH), and sodium (Na) content (meq/L) in October 2014 following application of treatments since April 2014. Riverside, CA.

Treatment	EC_e (dS/m)	SAR	pH	Na (Meq/L)
Untreated Control	11.9 A-F	13.79 A-F	7.6	71.33 A-E
ACA 2994	9.39 D-G	12.26 B-G	7.6	54.4 C-F
ACA 2994	7.9 G	10.08 G	7.7	43.97 F
ACA 1849	13.89 AB	15.2 AB	7.6	86.02 A
ACA 1849 Gypsum	7.9 G	10.67 G	7.7	42.71 F
ACA 2994	11.45 A-G	14.18 A-D	7.6	69.76 A-F
Cal-Vantage Kick Proactin TriCure AD	11.7 A-G	13.81 A-F	7.6	68.53 A-F
MC TP	8.7 E-G	11.13 E-G	7.9	48.39 C-F
MC TP3	12.29 A-E	14.1 A-E	7.6	74.53 A-D
Crossover	9.21 D-G	11.71 C-G	7.9	51.69 C-F
Revert	10.68 B-G	13.03 A-G	7.6	62.83 A-F
SST 8%CA	13.63 A-C	15.17 AB	7.6	82.59 AB
pHAcid Sprayable Crossover	13.01 A-D	15.45 A	7.7	82.36 AB
Cal Plus 1	8.58 E-G	10.88 FG	7.6	47.46 D-F
Cal Plus 2	8.26 FG	11.28 D-G	7.8	45.61 EF
DeSal Stress Rx XP 5-0-1	7.79 G	10.66 G	7.6	42.83 F
Gypsum	11.43 A-G	12.95 A-G	7.6	67.47 A-F
Gypsum	15.03 A	14.46 A-C	7.3	87.49 A
ACA 3217	9.45 D-G	12.22 B-G	7.7	53.84 C-F
MST-1410*	12.32 A-E	14.29 A-D	7.7	74.8 A-C
MST-1410*	9.79 C-G	12.88 A-G	7.7	58.58 B-F
Turfcare NPN Turfcare NPN Turfcare NPN	10.66 B-G	13.07 A-G	7.7	63.02 A-F

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

*Treatments first applied on 12 June 2014

Figure 1. Suction lysimeters (Irrometer, Riverside, CA) used to capture leachate for analysis of EC_L. Lysimeters were buried 4 inches below the turf surface in 3 out of 6 replicate plots for each treatment.

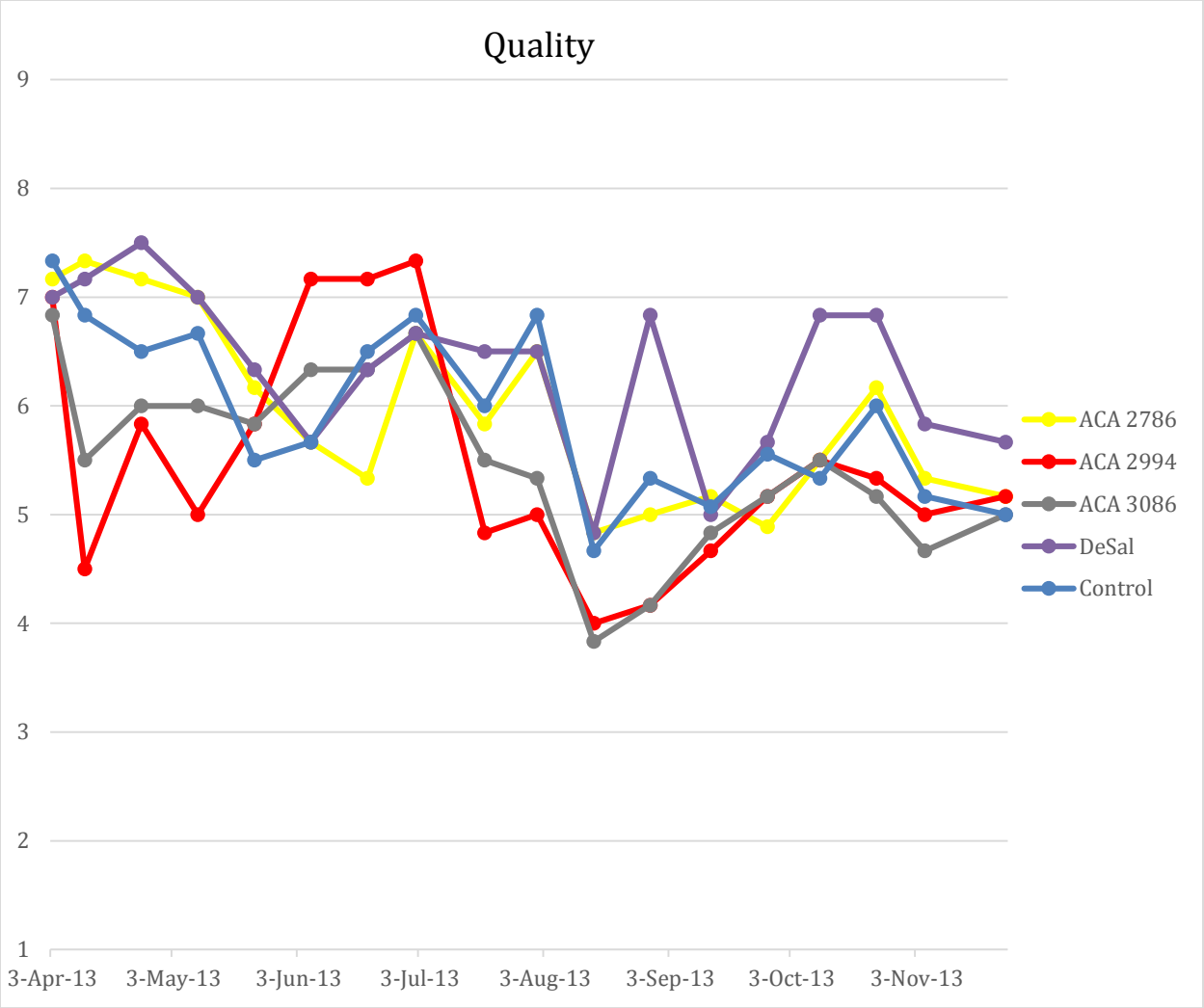

Figure 2. Turf quality (1 to 9 scale, 9 = best) in response to treatments in the salinity alleviation study in 2013. Riverside, CA. Treatments not shown were not significantly different from the control during the rating period.

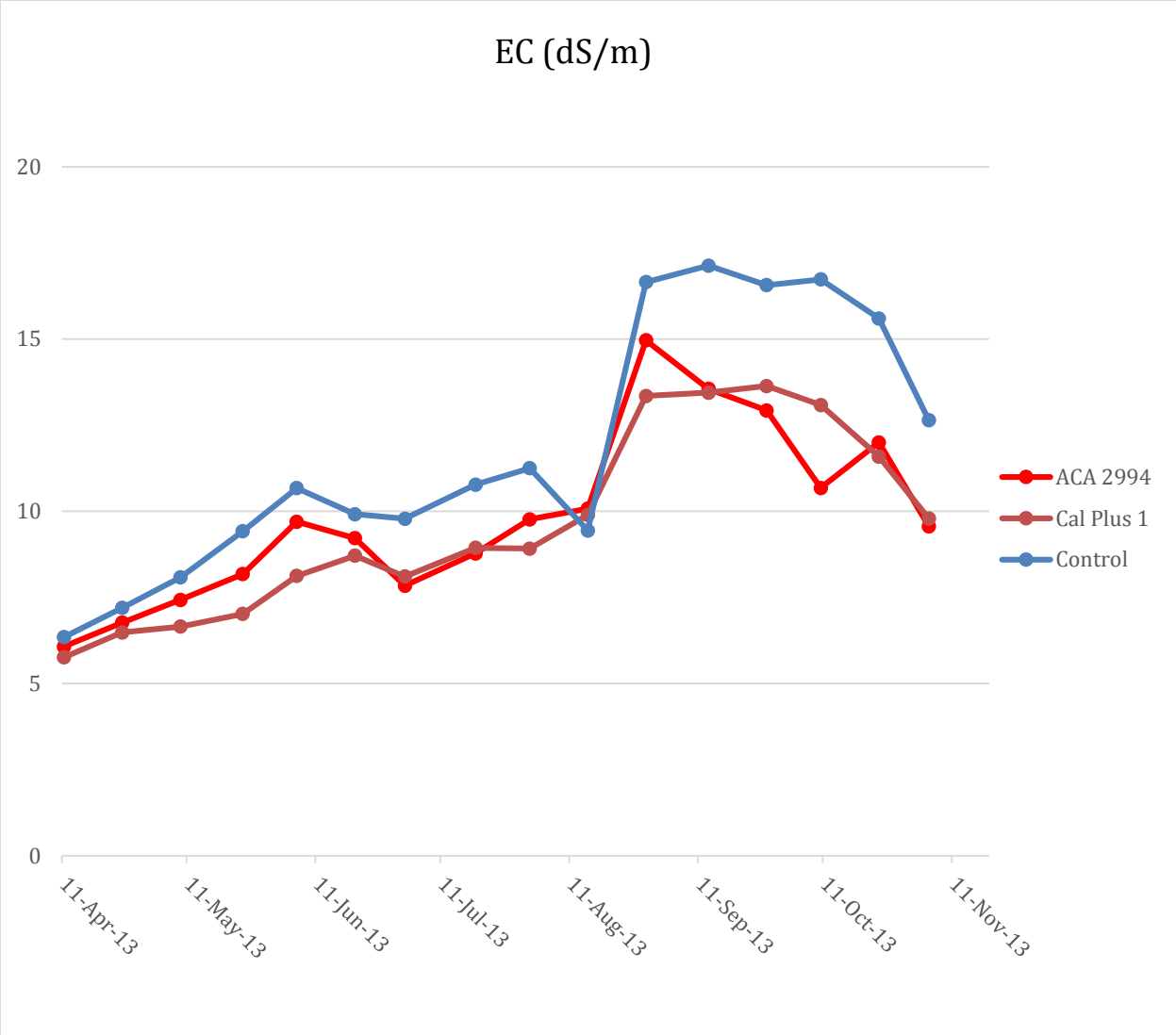

Figure 3. Electrical conductivity (EC_L; dS/m) of leachate collected from the plots during the salinity alleviation study in 2013. Riverside, CA. Treatments not shown were not significantly different from the control during the rating period.

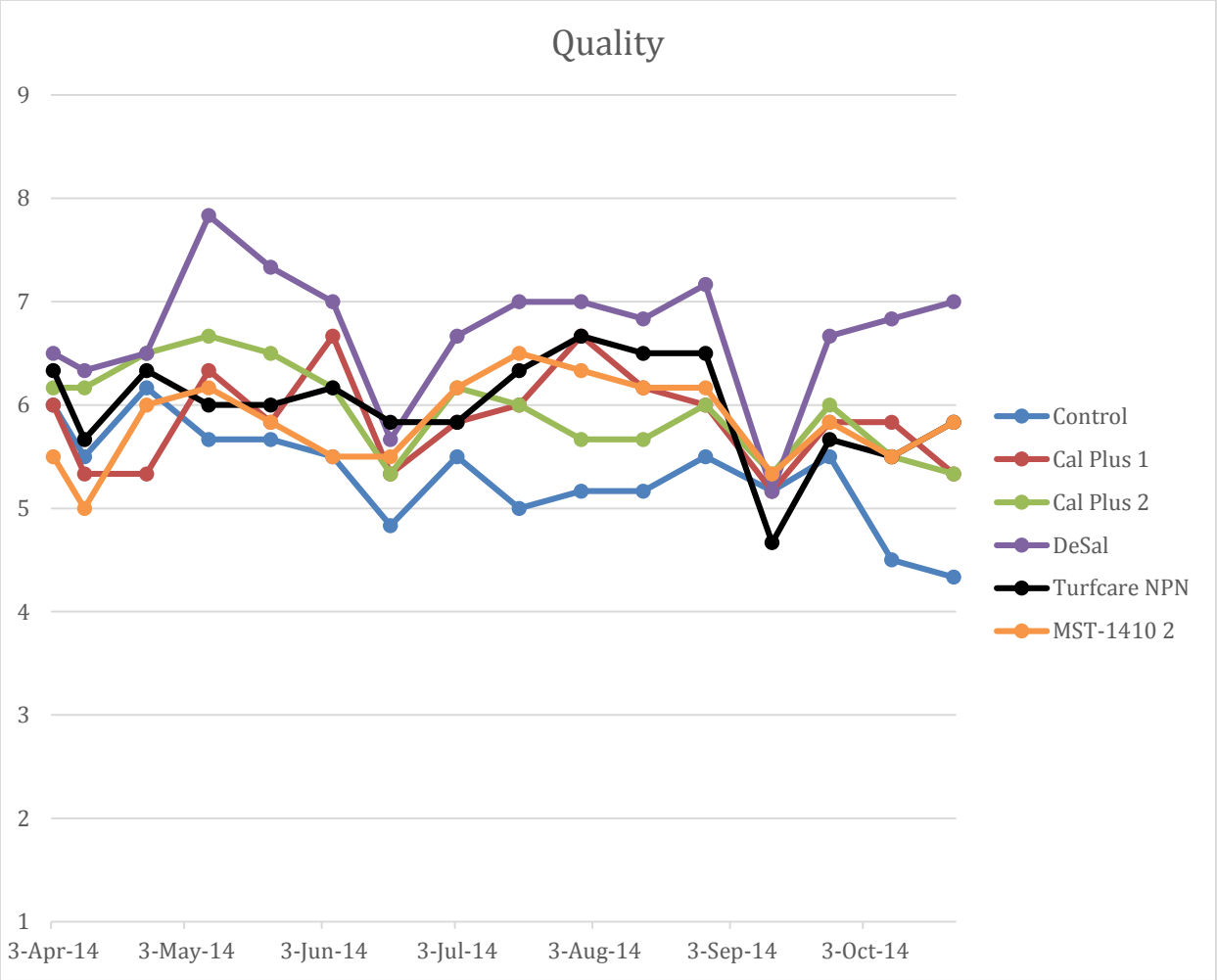

Figure 4. Turf quality (1 to 9 scale, 9 = best) in response to treatments in the salinity alleviation study in 2014. Riverside, CA. Treatments not shown were not significantly different from the control during the rating period.

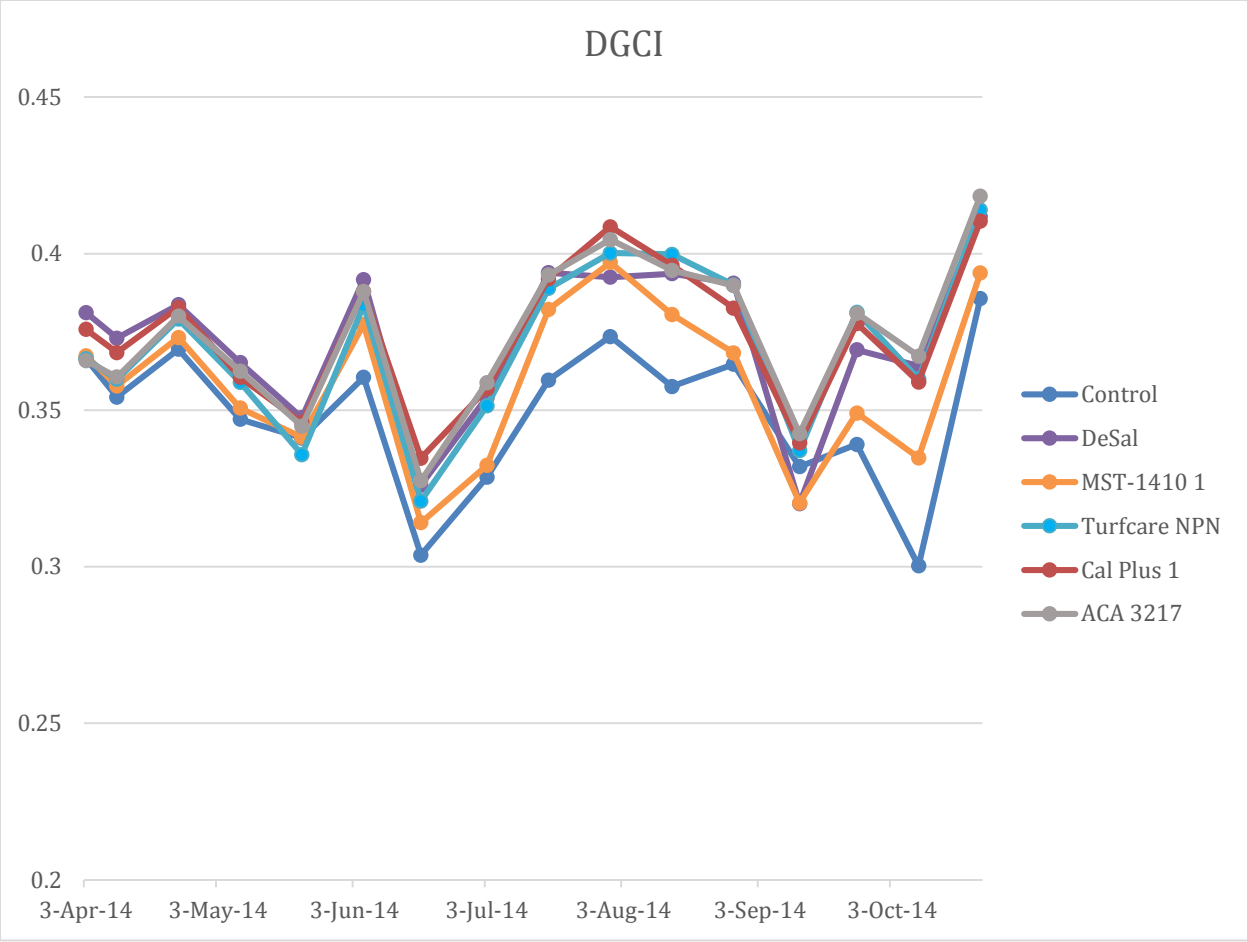

Figure 5. Dark Green Color Index (DGCI) in response to treatments in the salinity alleviation study in 2014. Riverside, CA. Treatments not shown were not significantly different from the control during the rating period.

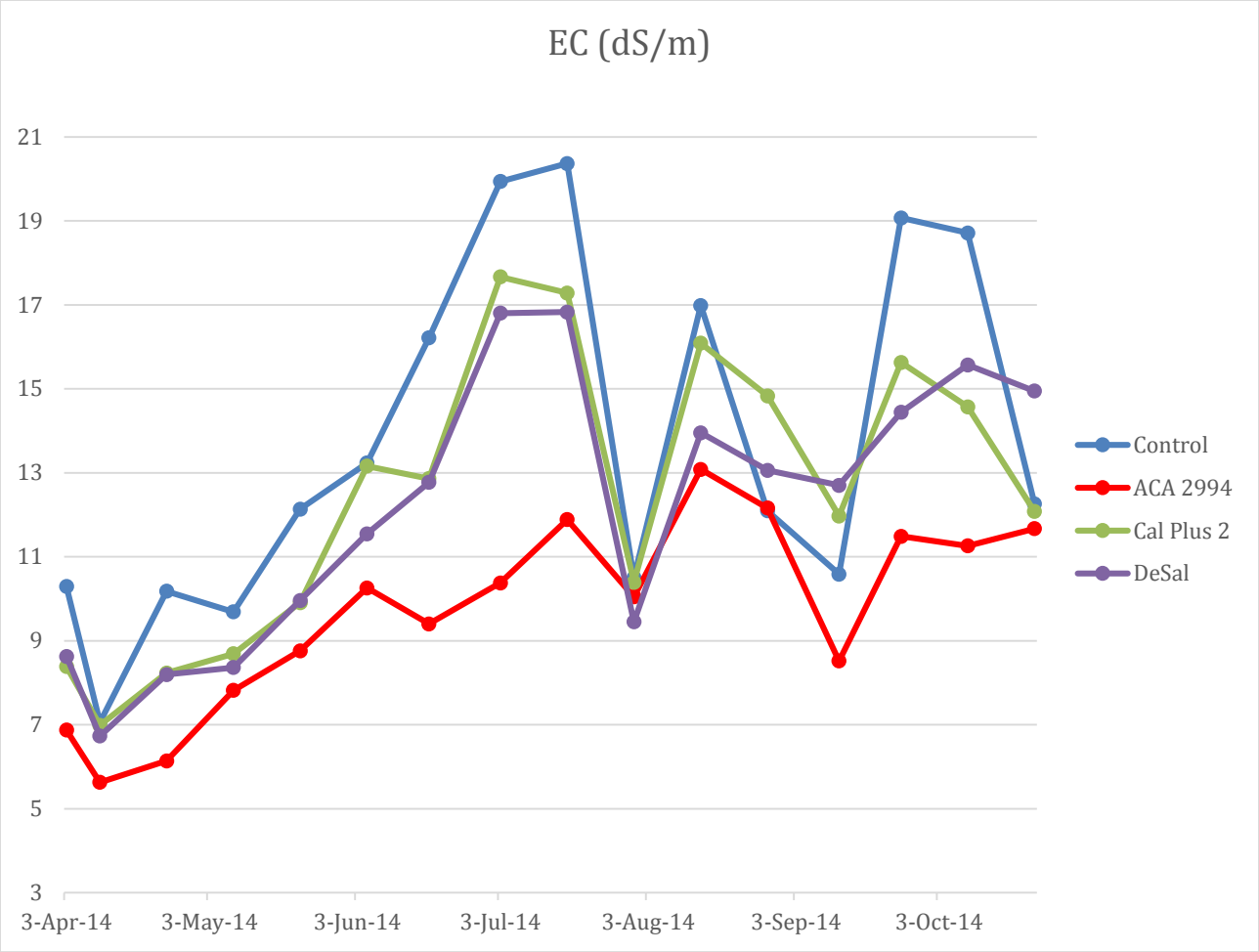

Figure 6. Electrical conductivity (EC_L; dS/m) of leachate collected from the plots during the salinity alleviation study in 2014. Riverside, CA. Treatments not shown were not significantly different from the control during the rating period.