Evaluation of Products to Alleviate Salinity Stress On Bermudagrass Turf

2013 Progress Report

Salinity alleviation study area at UC Riverside, CA. Hybrid bermudagrass 'Tifway II' sod was laid in August 2012 and, beginning November 2012, the turf was irrigated exclusively with saline water from adjacent storage tanks. Commercial and experimental products were applied from April to October 2013. Photo taken on 9 Oct 2012.

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The Bottom Line: Twenty 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. During 2013, EC_e (soil saturated paste extract) and EC_L (leachate) reached as high as 9 and 18 dS/M, respectively. The bermudagrass was stressed from irrigation with saline water, but no turf thinning or loss occurred. Only a few products showed results that were significantly different than the untreated control in 2013. The treatment containing DeSal (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. The study will be continued in 2014.

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 21 commercial and experimental products for alleviating soil salinity and stress on bermudagrass turf irrigated with saline water.

Materials and Methods:

The study was conducted at the UC Riverside turfgrass research facility in Riverside, CA. 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, verticut once in August 2013, and received 0.5 lbs N/M/month for a total of 4 lbs N/M in 2013 using a complete granular fertilizer.

Since November 2012, plots were irrigated at 75% reference evapotranspiration (ET_o) based on ET_o 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 1). Total salinity of the water was chosen to simulate an extreme, but realistic irrigation salinity for turf in California (personal communication, M. Huck). Toro 300 series pop-up stream sprinklers (Toro Company, Bloomington, MN) were spaced 30 ft apart. Environmental data for the site are provided in Table 2.

Treatments were applied either at one time only, bi-weekly, monthly, or bi-monthly between 4 Apr and 17 Oct 2013 (Tables 3 and 4). 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%), and volumetric soil water content (VWC) using time domain reflectometry (TDR). In addition, Digital Image Analysis (DIA) and leachate were 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. Soil samples were collected and analyzed for salinity and nutrients (Ag Source Labs, Lincoln, NE) before the start of the study, in August 2013 (bulk samples across replications from select treatments only), and on 16 Oct 2013 (from 3 reps of each treatment) prior to the first fall/winter rainfall event.

Results:

- Soil lab test results from the study area before saline irrigation and start of treatment applications are presented in Table 5. 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.

- 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, with the beginning of the 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 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 in irrigation water in comparison to control starting from August 29th (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 6). 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.

- The study will be repeated in 2014.

Acknowledgments:

Thanks to the Metropolitan Water District of Southern California, United States Golf Association, California Turfgrass & Landscape Foundation, and companies who provided product and financial support for this research.

Table 1. Properties of potable and saline (salts mixed with potable water) irrigation water used in the salinity alleviation study in Riverside, CA.

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 2. 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.

Date	Tot ETo (in)	Tot Precip (in)	Avg Sol Rad (Ly/Day)	Avg Vap Pres (mBars)	Avg Max Air Tmp (F)	Avg Min Air Tmp (F)	Avg Air Tmp (F)	Avg Max Rel Hum (%)	Avg Min Rel Hum (%)	Avg Rel Hum (%)	Avg Dew Point (F)	Avg Wind Speed (mph)	Avg Soil Temp (F)
Aug 2012	7.83	0.18	604	15.0	95.2	68.0 K	80.3	65	26	43	55.2	4.1 K	77.3
Sep 2012	6.44 K	0.01 K	522 K	12.7	93.6	63.8 K	78.2	63	22	39	50.2	3.9 K	75.3
Oct 2012	4.38	0.17	407 K	10.9	82.0 K	56.7 K	68.2 K	68 K	29 K	48	45.3	3.7 K	66.5
Nov 2012	2.72	0.38 K	296 K	8.9 K	73.7 K	49.6 K	60.2 K	71 K	31 K	51 K	39.7 K	3.3 K	58.7 K
Dec 2012	1.70	1.59 K	219	8.6 K	62.5	43.9 K	52.3	79	42	60 K	37.4 K	3.2	54.3 K
Jan 2013	2.72	0.60 K	289	5.2 K	65.2 K	40.9 K	52.5	58	23	39 K	24.9 K	4.1 K	48.8 K
Feb 2013	3.18	0.84	372 K	6.2 K	65.7	41.3	53.2	68	28	47 K	30.5 K	4.0 K	52.2
Mar 2013	4.80	0.66	476 K	9.1	74.1 K	48.6	60.0	76	31	53	41.5	3.8	59.6
Apr 2013	5.71	0.00	544 K	9.6 K	75.5	51.2	61.9	73	31	51 K	41.9 K	4.6 K	63.2
May 2013	7.01 K	0.25	626 K	11.4 K	81.2 K	56.6 K	67.6	75	31	52 K	48.2 K	4.5 K	68.3
Jun 2013	7.36	0.00	684	14.1	86.3	59.8 K	71.3	78	32	55	53.7	4.4	72.1
Jul 2013	7.13	0.35	594	15.3 K	89.5 K	64.1 K	75.4	74	31	51 K	55.6 K	4.0 K	74.6
Aug 2013	7.37 K	1.20	600	14.2	91.9	62.9 K	75.9	74	25	47	53.5	3.9	72.7
Sep 2013	6.14	0.00	523 K	12.6 K	89.4	62.2 K	74.5	66	24	44 K	49.6 K	3.8 K	71.9
Oct 2013	4.27 K	0.51	407 K	9.1 K	78.1 K	51.6	63.9 K	71 K	26 K	47 K	40.7 K	3.7 K	62.8
Nov 2013	2.76	1.20	270	7.7	72.1 K	49.7	60.0	66	31	46	36.6	3.7	57.9
Dec 2013	2.80	0.39	261	5.1	67.9 K	43.7 K	55.3	55	22	36	26.0	3.9	51.1
Totals	84.32	8.33	453	10.3	79.1	53.8	65.3	69	29	48	43.0	3.9	64.0

Flag Legend

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

Conversion Table

W/sq.m = Ly/day / 2.065	inches * 25.4 = mm
C = 5/9 * (F - 32)	m/s = mph * 0.447
kPa = mBars * 0.1	

Table 3. Commercial and experimental products and their frequency of application in the salinity alleviation study. Riverside, CA.

No.	Treatment	Company	Rate	Frequency (wks)
1	Untreated Control	--	--	--
2	ACA 3086	Aquatrols	8 oz/M	2
3	ACA 2994	Aquatrols	8 oz/M	2
4	ACA 1849	Aquatrols	3 oz/M	2
5 5	ACA 1849 Gypsum	Aquatrols	3 oz/M 5 lbs/M	2 2
6	ACA 2786	Aquatrols	4.5 oz/M	2
7	MC TP	Mitchell Products	2 oz/M	2
8	MC TP3	Mitchell Products	2 oz/M	2
9	Crossover	Numerator Technologies	5 lb/M	4
10	Revert	Numerator Technologies	6 oz/M	4
11	SST 8%CA	Numerator Technologies	8 oz/M	2
12	pHAcid Sprayable	Numerator Technologies	1.5 oz/M	2
13	Cal Plus	Westbridge Agricultural Products	0.75 oz/M	2
14	Cal Plus	Westbridge Agricultural Products	1.5 oz/M	2
15 15 15	DeSal EXP 2 EXP 5-0-1	Ocean Organics Ocean Organics Ocean Organics	0.75 oz/M 6 oz/M 6 oz/M	2 2 2
16 16	Displace Carboplex	Grigg Brothers Grigg Brothers	12 oz/M 6 oz/M	2 2
17 17	Elicitor Kelplex	Grigg Brothers Grigg Brothers	2 oz/M 2 oz/M	2 2
18 18	SumaGrow SumaGrow	Agribiotic Products Agribiotic Products	5 oz/M 3 oz/M	Initial 2
19	Soil System 1	LH Organics	50 g/18 gal	2 (twice every other month)
20	UCR001	UCR		Once
21	Turfcare NPN Turfcare NPN Turfcare 6-1-2	Gantec Gantec Gantec	0.1 oz/M 0.1 oz/M 2.3 lb/M	2 (Apr-May) 4 (Jun-Dec) Apr/May/Jul/Sep

Table 4. Application record for commercial and experimental products in the salinity alleviation study. 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 5. Bulk soil test results for study area before and after application of saline irrigation and select product treatments applied in the salinity alleviation study. Riverside, CA. Soil analyses were conducted on a composite sample from the entire plot area or from all six replicates of treatments which does not allow for statistical analysis among treatments.

Date	Treatment	pH	EC_e (dS/m)	SAR	Olsen P ppm	K ppm	Ca ppm	Mg ppm	Na ppm	CEC	Soluble Salts (dS/m)
Nov. 2012	Before Saline Irrigation	6.6	6.5	0.81	--	261	1904	202	79	12.2	2.45
Apr. 2013	Before Product Applications	7.7	2.13	4.79	29.6	159	1653	351	283	12.8	0.64
Aug. 2013	Control	7.8	7.33	8.67	19.1	215	1534	425	487	13.9	0.85
Aug. 2013	3	7.7	5.69	7.99	20.8	189	1346	375	450	12.3	0.79
Aug. 2013	9	7.7	4.24	6.98	21.7	253	1428	384	386	12.7	0.72

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.

Table 6. 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.

No.	Treatment	EC_e (dS/m)	SAR	pH	Na (Meq/L)
1	Control	7.94	8.41 ABCDEF	7.3	36.11 ABCDE
2	ACA 3086	7.29	8.28 ABCDEF	7.4	33.97 ABCDEF
3	ACA 2994	6.41	7.45 EF	7.4	28.64 DEF
4	ACA 1849	6.86	8.50 ABCDE	7.4	33.78 ABCDEF
5 5	ACA 1849 Gypsum	6.69	7.51 DEF	7.3	29.95 BCDEF
6	ACA 2786	7.16	8.07 BCDEF	7.4	32.95 BCDEF
7	MC TP	5.79	7.82 CDEF	7.5	27.99 EF
8	MC TP3	8.90	9.30 A	7.3	42.87 A
9	Crossover	7.09	8.36 ABCDEF	7.4	33.45 ABCDEF
10	Revert	8.18	8.79 ABC	7.4	38.35 ABC
11	SST 8%CA	6.63	7.64 DEF	7.3	29.14 CDEF
12	pHAcid Sprayable	8.07	9.05 AB	7.4	39.26 AB
13	Cal Plus 1	6.86	8.01 BCDEF	7.3	31.82 BCDEF
14	Cal Plus 2	6.34	7.97 BCDEF	7.4	29.27 CDEF
15 15 15	DeSal EXP 2 EXP 5-0-1	5.57	7.28 F	7.3	25.65 F
16 16	Displace Carboplex	7.95	8.83 ABC	7.4	37.94 ABCD
17 17	Elicitor Kelplex	7.54	8.33 ABCDEF	7.3	34.80 ABCDEF
18	SumaGrow	8.11	8.64 ABCD	7.3	37.43 ABCDE
19	Soil System 1	6.12	7.93 BCDEF	7.5	28.54 DEF
20	UCR001	6.80	7.75 CDEF	7.4	30.10 BCDEF
21	Turfcare NPN Turfcare NPN Turfcare 6-1-2	7.06	8.53 ABCDE	7.4	34.69 ABCDEF

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

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.

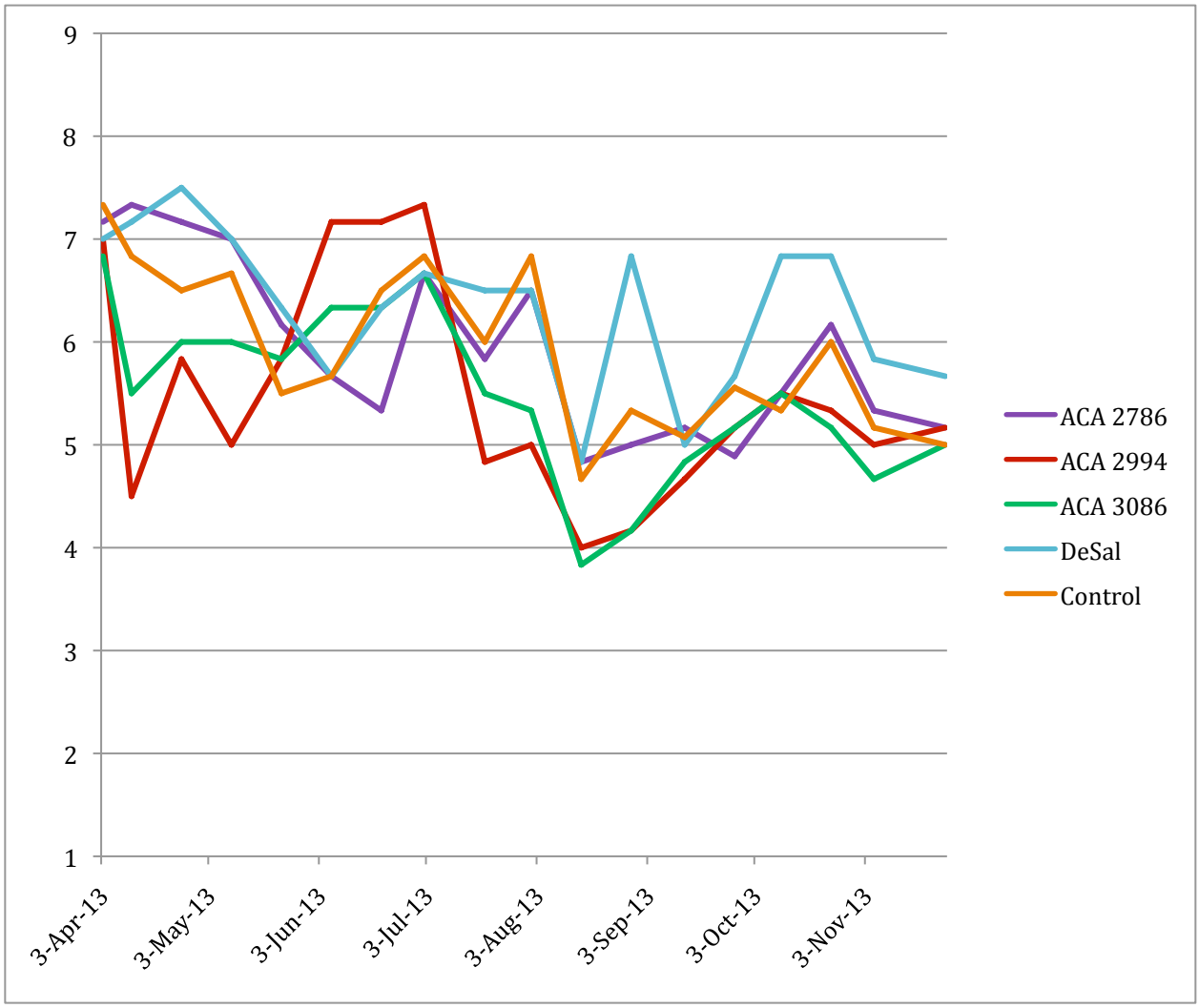

Figure 2. Turf quality (1 to 9 scale, 9 = best) in response to treatments in the salinity alleviation study in 2013. Riverside, CA. Treatments not shown were not significantly different from the control during the rating period.

Figure 3. Electrical conductivity (EC_L; dS/m) of leachate collected from the plots during the salinity alleviation study in 2013. Riverside, CA. Only treatments significantly different from control are shown in the graph.