FIELD EVALUATION OF EXPERIMENTAL SOIL SURFACTANT: 2005 SEASON

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Sponsor: Aquatrols Corporation

OBJECTIVE

The objective of this project was to determine efficacy of an experimental wetting agent on a variety of turfgrasses and under diverse climatic and edaphic conditions.

EXPERIMENTAL DESIGN / METHODS

The experiment was located on the alternative construction putting green at the GTI, which is a typical industry standard green of this type, with 30 cm of USGA specification rootzone mixture (80% sand, 20% peat v/v) on a graded subsoil with tile drains but no gravel drainage layer. Permanent turf cover on this green is 100% 'Cobra' creeping bentgrass *(Agrostis stolonifera)*. The green has a history of hydrophobic dry spots (Table 1). Standard cultural practices were maintained on the green (mowing at 4 mm, 5 g actual N m^{-2} $month^{-1}$, fungicide as needed to control disease, irrigation to
prevent stress) .

Test Design:

The test was a randomized complete block design with four replicates per treatment. Each plot measured 2.5 m x 1.5 m (3.75 m^2).

Treatments:

Treatments listed in Table 2 were applied via a calibrated CO_2 sprayer (Figure 1). All liquid applications were made in 80 ml of water per square meter (8 L $100m^{-2}$). Control plots were treated with water only. Treatments were watered following application.

Data collected:

1) Turf Quality, Color, Uniformity and Density - Visual Ratings of turf functional features based on a 1-9 scale (Best quality = 9).

2) Localized Dry Spot Formation- Percentage of plot exhibiting LDS symptoms. First Assessment was made prior to initial treatment application and weekly thereafter until the end of the experiment. LDS evaluation procedure was : 1) Determine if a 2.5 m X 1.5 m plot is exhibiting LDS symptoms; 2) If yes, place 10 cm x 10 cm grid box in plot; 3) Count the number of 10 cm X 10 cm blocks with LDS; 4) Record percentage.

3) Water Repellency/Hydrophobicity/Wettability- Plots were sampled prior to treatment application and every two weeks after initial treatment application. Five soil cores, approximately 15 cm each, were taken from each plot. Cores were be air dried for two weeks at room temperature. Dried cores were evaluated for hydrophobicity using the water droplet penetration test: 1) Core was placed horizontally on workbench. A 35 μl droplet of distilled water was dispensed via a pipette and placed at 1 cm intervals along the core starting at the thatch-air interface and ending at 6 cm. 2) Using a stopwatch, the length of time (in seconds) it took for the water droplet to completely penetrate the soil core was determined. 3) Droplets that did not penetrate the core after 10 minutes (600 seconds) were recorded as >600 seconds.

4) Soil Analysis - A standard soil physical properties analysis and interpretation is appended. Soil was sampled prior to initial treatment application.

5) Precipitation, Temperature, and Irrigation - Precipitation and temperature was recorded daily for the duration of the trial. Irrigation events were recorded.

6) % Volumetric Water - Percent volumetric water (twenty measurements per plot) was collected regularly from each plot using a moisture meter or TDR probe.

Table 2. Treatments and treatment schedule.

Treatment	Product	Rate / m^2	Application dates
1 Control	Water only	0	all
2 Primer 604	Primer 604	1.25 ml	June 8, July 7, August 10, September 12
3 ACA 1820_L	ACA 1820	1.9 ml	June 8, July 7, August 10, September 12
4 ACA 1820_G	ACA 1820	18 g	June 8, July 7, August 10, September 12
5 Cascade Plus	Cascade Plus	2.5 ml	June 8, June 17

Figure 1. Application of treatments with compressed air sprayer (4 flat-fan TeeJet 8001VS nozzles at 20 psi).

Data Analysis:

All data were analyzed using appropriate statistical methods (ANOVA, LSD).

RESULTS

Environmental data:

The environmental data for the project site for the period of the experiment are presented in Figures 2 and 3. Because of failures at the GTI weather station, the local data was not complete, and data are presented from the Waterloo-Wellington Airport weather station. The general pattern of precipitation and temperature is very similar to that experienced at GTI. The summer of 2005 was wet during the 4 months of interest: June, July, August and September. There was approximately 250 mm of rainfall in this period, spaced fairly evenly. Air temperatures were typical for summer in Guelph, with no extreme periods of high or low, but fairly warm.

Turf functional features

Visual ratings. There was little environmental stress during the experiment, and the only observation was a decline in visual ratings for all treatments in late July and early August, which was towards the end of one of the drier periods in the summer (Table 3). There were no significant differences among the treatments at any time except for a slight phytotoxicity detected in the Cascade Plus plots on June 14 (following the first application), which had disappeared by June 28.

Full spectrum color and chlorophyll index. Two other measures of turf quality or health were also recorded, namely full spectrum color as measured by the Minolta CR310 colorimeter and the chlorophyll content index as measured by the Spectrum CM1000. Both of these sets of measurements allow detection of stress (phytotoxicity, drought stress) in addition to turf quality assessment. The observed data agree well with the visual ratings, in that there were very few differences among the treatments. Of the full spectrum color parameters, lightness and hue angle are the most significant for turf evaluation. There were some statistical differences on some dates (Table 4), particularly for hue angle, but the patterns were not consistent. All values for hue angle and lightness are well within the range for healthy high quality bentgrass turf.

The chlorophyll index (Table 5) showed significant treatment effects on a number of dates, but the patterns were not consistent. Generally the wetting agent treated plots (especially ACA 1820 granular) had higher indices than the control, though the absolute differences among the plots in chlorophyll index were not large enough to be

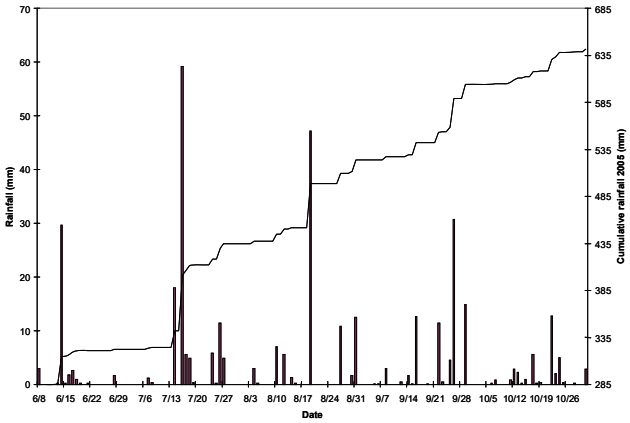

Figure 2. Daily maximum and minimum air temperatures – summer 2005. Data are from the Waterloo-Wellington airport weather station because of failures at the GTI weather station.

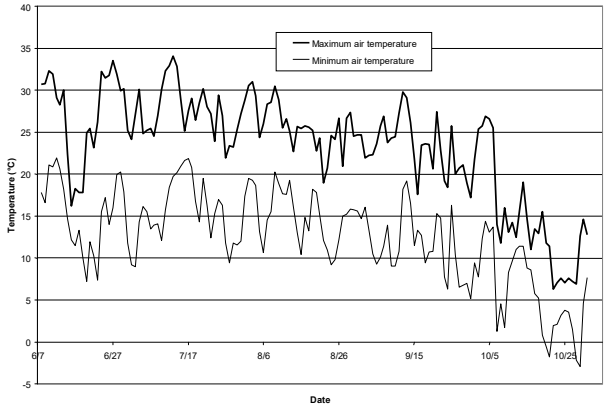

Figure 3. Daily and cumulative precipitation – summer 2005. Data are from the Waterloo-Wellington airport weather station because of failures at the GTI weather station.

biologically or functionally significant (all plots were green and healthy throughout the experiment – the index values were well within the range of healthy active bentgrass turf.)

Localized dry spot and volumetric water content. Because of the weather conditions in the summer of 2005, we never observed localized dry spot development on the alternative sand green where the plots were located, despite a history of relatively severe LDS in previous years. The volumetric water content readings (Table 6) indicated a similar lack of LDS, since apart from the pre-treatment readings there were never readings below ~25%. There were statistically significant differences among treatments on many dates; but the patterns were not consistent, and all observations indicated water status well into adequate range.

Hydrophobicity (water drop penetration tests). Despite the lack of LDS development in the plots, as in the previous season's results there was evidence of significant treatment effects in the reduction on hydrophobicity in the soil cores (Table 7), particularly at 0, 1 and 2 cm depths. Since this is the third year of this trial, some differences were present pre-treatment (i.e. lower hydrophobicity in Cascade plots). By the end of the season the two ACA 1820 treatments had the lowest hydrophobicity, followed by Primer 604 and Cascade. The gradient in hydrophobicity in the cores from 0 to 6 cm depth at the beginning of the trial is indicative of the history of LDS on the green, with penetration times >300 seconds at the 0 and 1 cm levels. While the control plots stayed hydrophobic at the top two levels through to the end of the trial, all treatments produced a significant reduction in hydrophobicity at the thatch (0) and 1 cm level by the end of the trial, and all but Primer 604 produced a significant reduction at the 2 cm depth. The single application treatment (Cascade Plus) showed a tendency to lose effectiveness over the course of the experiment.

CONCLUSIONS

Because of the lack of stress and development of LDS, it was not possible to assess the effectiveness of the treatments on reducing LDS. All treated plots had turf which was as good as the control for the observed characteristics of quality, color, uniformity and density. There was some evidence of phytotoxicity in the Cascade Plus treatment, but it disappeared after 2 weeks; there were no adverse effects of any of the other treatments.

All wetting agent treatments had some effect by the end of the experiment in reducing the hydrophobicity of the rootzone profile at the top levels, where hydrophobicity was at its maximum. ACA 1820 granular and ACA 1820 liquid treatments had the best effect at all levels where a treatment effect was noted, with the granular being slightly but not significantly more effective than the liquid. The rank order of the treatments was ACA 1820 granular=ACA 1820 liquid > Primer 604 = Cascade Plus > control (though not all differences were statistically significant).

Table 3. Visual turf ratings[1] for treated plots.

Treatment	14-Jun	28-Jun	6-Jul	8-Jul	13-Jul	29-Jul	5-Aug	18-Aug	25-Aug	1-Sep	15-Sep
						color[1]					
ACA 1820 granular	9.0 a	9.0	8.9	9.0	9.0	6.8	7.8	8.0	8.5	9.0	8.5
ACA 1820 liquid	8.8 a	9.0	8.9	8.9	9.0	6.9	8.0	8.0	9.0	9.0	8.5
Cascade Plus	8.1 b	8.9	8.9	8.9	9.0	6.8	8.0	7.8	9.0	9.0	8.5
Control (Water only)	9.0 a	8.8	8.9	8.9	9.0	6.8	8.0	8.0	8.3	9.0	8.5
Primer 604	9.0 a	9.0	8.9	8.8	9.0	6.5	8.0	8.0	8.8	9.0	8.5
lsd p=0.05	0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
						quality[1]					
ACA 1820 granular	9.0 a	9.0	9.0	9.0	9.0	6.8	7.0	7.3	7.3		
ACA 1820 liquid	8.8 a	9.0	9.0	9.0	9.0	6.9	7.0	7.3	7.5		
Cascade Plus	8.1 b	9.0	9.0	9.0	9.0	6.8	7.0	7.3	7.8		
Control (Water only)	9.0 a	8.9	9.0	9.0	9.0	6.8	7.0	7.3	7.3		
Primer 604	9.0 a	9.0	9.0	9.0	9.0	6.5	7.0	7.5	7.3		
lsd p=0.05	0.4	NS	NS	NS	NS	NS	NS	NS	NS		
						uniformity[1]					
ACA 1820 granular	9.0	9.0	9.0	9.0	9.0	6.8	7.0	7.3	7.3		9.0
ACA 1820 liquid	9.0	9.0	9.0	9.0	9.0	6.9	7.0	7.3	7.5		9.0
Cascade Plus	9.0	8.9	9.0	9.0	9.0	6.8	7.0	7.3	7.8		9.0
Control (Water only)	9.0	9.0	9.0	9.0	9.0	6.8	7.0	7.3	7.3		9.0
Primer 604	9.0	9.0	9.0	9.0	9.0	6.5	7.0	7.5	7.3		9.0
lsd p=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS		NS
						density[1]					
ACA 1820 granular	9.0	9.0	9.0	9.0	9.0	6.9	7.6	7.8	9.0	9.0	9.0
ACA 1820 liquid	9.0	9.0	9.0	9.0	9.0	7.0	7.8	7.8	9.0	9.0	9.0
Cascade Plus	9.0	9.0	9.0	9.0	9.0	6.9	7.9	7.5	9.0	9.0	9.0
Control (Water only)	9.0	9.0	9.0	9.0	9.0	6.9	7.6	7.8	9.0	9.0	9.0
Primer 604	9.0	9.0	9.0	9.0	9.0	6.8	7.6	7.8	9.0	9.0	9.0
lsd p=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Visual ratings from 0-9, 9=best, 6=acceptable.

Table 4. Full spectrum color readings from treated plots.

Treatment	10-Jun	20-Jun	29-Jun	7-Jul	15-Jul	28-Jul	5-Aug	25-Aug
					Lightness[1]			
ACA 1820 granular	37.4	33.2 ab	39.0	40.0	36.3 bc	32.0	39.0 a	35.9
ACA 1820 liquid	38.8	34.7 a	39.9	39.9	38.0 a	32.7	39.0 a	35.5
Cascade Plus	39.3	32.6 b	40.7	40.4	35.9 c	31.3	37.1 b	35.4
Control (Water only)	37.8	35.0 a	39.4	40.2	37.6 ab	31.5	39.1 a	36.0
Primer 604	38.4	32.3 b	39.0	40.3	36.8 abc	33.1	39.3 a	35.4
lsd p=0.05	NS	2.0	NS	NS	1.5	NS	1.2	NS
					Chroma[2]			
ACA 1820 granular	13.3	9.0	15.3	14.9	11.2	11.4	13.8 a	12.6
ACA 1820 liquid	14.2	11.0	15.8	14.9	12.0	11.2	13.8 a	12.3
Cascade Plus	13.8	9.2	16.0	14.9	11.6	9.3	12.9 b	12.0
Control (Water only)	12.7	10.6	15.2	14.5	12.1	10.0	13.8 a	12.7
Primer 604	13.6	9.3	15.6	14.8	11.2	11.3	14.2 a	12.0
lsd p=0.05	NS	NS	NS	NS	NS	NS	0.8	NS
					Hue angle[3]			
ACA 1820 granular	126.6 a	119.1 c	125.9 a	126.8 a	126.8	129.7	127.7 b	130.1
ACA 1820 liquid	123.7 bc	121.4 abc	125.4 a	125.5 bc	127.8	128.6	127.7 b	129.9
Cascade Plus	121.7 c	122.7 abc	123.2 b	126.2 ab	129.1	139.1	130.0 a	130.8
Control (Water only)	125.1 ab	120.1 bc	123.9 b	126.7 a	127.1	129.6	126.5 b	129.0
Primer 604	125.0 ab	122.0 abc	126.0 a	125.3 c	127.2	127.6	127.8 b	131.3
lsd p=0.05	2.3	2.4	1.4	0.9	NS	NS	2.1	NS

1 Lightness 0 (black) to 100 (white).

2 Chroma (vividness or color saturation) 0 (grey) to 60 (fully saturated)

3 Hue angle 0 to 360 degrees; in the range observed, lower values are yellower, higher are greener.

Table 5. Chlorophyll index of treated plots

Treatment	7-Jun	28-Jun	6-Jul	13-Jul	18-Jul	28-Jul	25-Aug	1-Sep	9-Sep	15-Sep	30-Sep
ACA 1820 granular	282.0 a[1]	290.0 a	260.9 a	300.4 a	311.4	275.3	292.3 ab	301.8	248.0 b	271.9	263.7 a
ACA 1820 liquid	269.3 b	278.8 b	253.7 b	278.3 d	305.4	272.9	298.3 a	302.3	254.8 a	268.0	260.5 ab
Cascade Plus	262.1 b	265.5 c	249.8 b	290.7 b	306.8	276.3	296.9 a	298.1	251.5 ab	268.6	254.3 bc
Control (Water only)	268.1 b	277.2 b	251.6 b	287.8 bc	309.5	279.3	286.4 bc	299.1	246.0 b	269.3	247.8 c
Primer 604	265.5 b	280.3 b	249.1 b	281.2 cd	302.4	272.6	280.8 c	303.0	245.1 b	265.3	251.7 c
lsd p=0.05	10.86	9.41	6.98	7.35	NS	NS	9.30	NS	6.50	NS	7.05

[1] Index 0-1000, higher value representing higher chlorophyll content; values are means of 10 readings x 4 replicates. Means within columns followed by the same letter are not significantly different (Fisher's protected lsd, p=0.05).

Table 6. Volumetric water content of treated plots.

Treatment	18-Apr	6-Jun	16-Jun	23-Jun	30-Jun	8-Jul	14-Jul	20-Jul	28-Jul	8-Aug	31-Aug	7-Sep	16-Sep	30-Sep	5-Oct
ACA 1820 granular	7.9	26.7 ab	28.5 c	25.7 bc	32.1 cd	30.3 b	32.1 b	26.6 b	27.2 b	29.6	29.2 c	29.9 c	27.2 c	27.5 b	28.9 b
ACA 1820 liquid	7.7	27.3 a	28.8 bc	26.3 ab	33.2 ab	30.0 b	31.8 b	26.2 b	27.4 b	29.7	29.4 bc	30.3 bc	27.6 bc	27.9 b	29.4 b
Cascade Plus	9.0	26.8 ab	28.2 c	25.0 c	33.5 a	29.9 b	31.8 b	26.8 b	27.1 b	29.2	29.6 bc	29.8 c	27.6 bc	27.9 b	29.2 b
Control	8.7	26.2 b	29.4 ab	22.0 d	31.8 d	30.3 ab	32.2 ab	27.7 a	27.0 b	29.6	30.0 ab	30.8 ab	28.0 ab	29.3 a	29.7 a
Primer 604	7.9	26.2 b	29.9 a	27.1 a	32.6 bc	31.0 a	32.8 a	28.1 a	28.7 a	30.4	30.7 a	31.3 a	28.8 a	30.0 a	30.3 a
lsd p=0.05	NS	0.7	0.8	1.1	0.7	0.7	0.7	0.8	0.9	NS	0.8	0.8	0.8	0.8	0.8

[1] Volumetric water content (%) from ThetaProbe; values are means of 20 readings x 4 replicates. Means within columns followed by the same letter are not significantly different (Fisher's protected lsd, p=0.05).

Table 7. Water drop penetration test timings for cores removed from treated plots

Treatment	4/29	6/21	7/5	7/20	8/4	8/17	8/30	9/19	10/3
					0 cm depth				
ACA 1820 granular	390.9 a	319.6 b	203.3 b	197.7 b	202.2 d	130.6 c	153.0 c	93.6 c	119.6 c
ACA 1820 liquid	317.3 a	223.9 b	205.1 b	176.1 b	147.6 d	103.8 c	151.9 c	47.1 c	117.3 c
Cascade Plus	120.2 b	31.0 c	69.7 c	174.7 b	335.6 c	362.1 ab	332.5 b	417.8 a	402.8 b
Control (Water only)	301.0 a	557.6 a	442.1 a	563.6 a	576.4 a	472.2 a	401.8 ab	498.5 a	570.3 a
Primer 604	347.7 a	498.5 a	399.6 a	521.0 a	470.5 b	354.7 b	454.0 a	292.8 b	333.3 b
lsd p=0.05	132.9	97.8	121.6	94.2	105.8	116.6	116.1	92.8	101.1
					1 cm depth				
ACA 1820 granular	203.7 a	170.7 b	33.8 b	69.1 b	45.1 d	36.2 c	48.9 c	36.6 c	26.4 c
ACA 1820 liquid	288.1 a	38.5 c	29.8 b	49.5 b	66.2 d	47.5 c	48.6 c	43.4 c	31.8 c
Cascade Plus	56.6 b	91.3 bc	14.3 b	130.8 b	262.9 c	277.6 b	224.3 b	307.8 ab	208.3 b
Control (Water only)	251.0 a	497.1 a	206.3 a	444.4 a	490.3 a	397.0 a	335.5 a	388.3 a	382.1 a
Primer 604	336.7 a	420.1 a	227.8 a	369.7 a	360.4 b	246.8 b	239.8 b	278.3 b	224.1 b
lsd p=0.05	137.5	104.8	90.5	91.5	97.2	92.4	89.2	109.3	95.7
					2 cm depth				
ACA 1820 granular	113.8 b	194.2 b	18.7 bc	32.4 c	36.1 b	46.7 b	41.9	29.5 c	24.6 b
ACA 1820 liquid	249.4 a	106.9 b	59.5 a	42.9 bc	45.7 b	51.5 b	79.3	36.9 bc	31.6 b
Cascade Plus	11.9 b	128.6 b	6.8 c	75.8 bc	146.6 a	126.9 a	77.2	111.7 a	57.8 b
Control (Water only)	107.1 b	165.4 b	25.5 bc	164.7 a	114.5 a	111.2 ab	149.1	70.2 b	100.6 a
Primer 604	317.9 a	391.7 a	50.4 ab	107.7 ab	133.6 a	129.5 a	130.2	49.1 bc	65.6 ab
lsd p=0.05	134.4	139.7	33.4	68.5	68.0	66.3	NS	36.9	42.8
					3 cm depth				
ACA 1820 granular	279.4 a	331.5 a	17.6 ab	48.1	35.8	33.5	33.9	21.0 b	19.3 b
ACA 1820 liquid	281.7 a	153.9 bc	26.6 a	22.6	39.9	44.2	53.4	20.1 b	18.9 b
Cascade Plus	5.5 c	156.6 bc	3.8 b	65.4	60.3	61.4	72.7	46.0 a	33.4 ab
Control (Water only)	92.1 bc	122.5 c	17.6 ab	50.7	46.6	38.6	56.8	28.4 b	45.2 a
Primer 604	237.4 ab	307.9 ab	34.9 a	43.0	62.5	51.6	72.0	15.5 b	28.8 ab
lsd p=0.05	149.0	164.7	20.6	NS	NS	NS	NS	17.1	19.2
					4 cm depth				
ACA 1820 granular	253.8 a	306.1	18.0	22.2	16.0	18.6	23.0	9.8	10.6
ACA 1820 liquid	142.7 b	151.7	13.8	10.0	25.1	18.6	21.2	6.4	12.0
Cascade Plus	2.7 c	135.7	1.4	25.9	22.9	24.6	36.4	13.7	16.4
Control (Water only)	24.4 c	134.1	4.4	23.3	17.5	10.6	45.2	8.0	18.6
Primer 604	183.2 ab	269.2	5.5	13.7	22.7	23.7	17.4	5.2	13.5
lsd p=0.05	19.8	NS	NS	NS	NS	NS	NS	NS	NS
					5 cm depth				
ACA 1820 granular	164.0 a	183.3	8.9	10.5	2.1	6.6 b	9.9	3.7	4.6
ACA 1820 liquid	65.6 bc	146.7	3.2	3.2	5.3	5.5 b	9.3	3.8	5.8
Cascade Plus	0.5 c	72.1	30.4	7.4	5.5	12.3 a	11.9	5.2	6.4
Control (Water only)	11.7 c	83.5	0.9	8.4	4.7	3.6 b	15.2	3.1	7.3
Primer 604	154.6 ab	175.8	1.4	4.7	7.3	5.3 b	5.4	1.7	5.6
lsd p=0.05	95.6	NS	NS	NS	NS	5.3	NS	NS	NS
					6 cm depth				
ACA 1820 granular	70.6	89.8	1.1	4.1	2.2	2.7	4.1	1.0	2.6
ACA 1820 liquid	60.7	94.5	0.8	1.3	1.4	3.2	3.8	1.0	2.5
Cascade Plus	0.2	38.1	0.2	3.3	2.8	5.3	3.6	1.1	3.9
Control (Water only)	39.0	19.7	0.8	3.9	2.5	2.0	7.1	1.7	3.2
Primer 604	55.1	86.1	0.4	1.2	2.1	1.8	3.1	0.8	2.4
lsd p=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Time (sec) for a 35 μL droplet of distilled water to penetrate core (max 600 sec). Mean of 5 cores x 4 replicates. Means within columns followed by the same letter are not significantly different (Fisher's protected lsd, p=0.05).

The "single" application treatment (Cascade Plus) showed its largest effect soon (11 days) after application, and the levels of hydrophobicity rebounded later in the experiment.

The levels of hydrophobicity declined over the season from the starting values at all deeper rootzone levels (2 cm – 6 cm), but there were no detectable treatment effects involved in this decline, which was likely due to a wet summer and good growing conditions, leading to a deep healthy root system in the turf.