Project: Effect of Primer Applications on Nutrient Leaching in Turfgrass Greens

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Summary: A replicated experiment was designed to evaluate the effect of Primer on the leaching of nutrients on a *Poa annua* golf course green. Following six monthly applications of Primer at 6 oz/1000 square feet, analyses conducted on soil samples from 1, 2 and 4 inches depths revealed no significant differences between treated and untreated plots in levels of over 20 nutrients including, sodium, magnesium, calcium, total salts, and even the highly leachable potassium. In addition, no phytotoxicity and no effects on turf quality were observed in areas treated with Primer.

On the basis of these results, multiple applications of Primer to turfgrass do not increase leaching of nutrients in the soil.

Materials and Methods:

Location and Design: The trial was conducted on Green 5 at San Luis Rey Downs Golf Course, Bonsall, CA. The course has a history of high salinity water and soils. The test area consisted of 100% annual bluegrass. Plots measured 7 by 45 feet and treatments were replicated four times, in a randomized design.

Application: Experimental treatments were applied monthly (see treatment schedule below) with a bicycle sprayer with 8008vs flat fan nozzles powered by CO_2 to deliver 40 psi at the boom and 2.11 gal/1000 sq ft. Calibration of each nozzle was confirmed prior to each application to be within 5% of the desired nozzle flow rate. The boom height was adjusted to 17 inches. The spray swath was 7.2 ft. Speed was monitored using a wheel driven speedometer at 2.0 mph (periodically calibrated to be within 5% of the actual speed). Stainless steel beverage spray tanks were filled with water to the desired dilution volume using a Great Plains Industries digital flow meter, Wichita, KS, calibrated to deliver volumes within 1% of the digital value displayed on the meter. Tanks were agitated by shaking twenty times prior to charging with compressed CO_2.

Ratings and Data Analysis:

- At the start of the trial, irrigation water quality was analyzed by Brookside Labs, New Knoxville, OH.

- Turf quality was rated visually, on a monthly basis, for the duration of the trial. A total of 7 turf quality assessments were made. A scale of 0 - 9 was used to rate turf, with 0 the lowest possible quality and 9 the highest possible quality. A rating of 6.5 or higher was considered acceptable turf.

- Soil chemistry was monitored on each of three evaluation dates by removing 3 two-inch diameter cores from each replicate, and sub-dividing each core into 0-1", 1-2" and 2-4" samples. The cores from each depth were pooled into one sample per replicate and were analyzed at Brookside Laboratories for EC values, pH, sodium, and other cation levels. For EC values, the data reported by Brookside Labs (which relies on a 2:1 soil:water extract) was adjusted to reflect the value that would be obtained from a saturated paste analysis using the following equation:

  Saturated paste EC (mmhos/cm) =
  2.1X (Brookside EC value) + 0.5
  r = 0.87, p= 0.0001

  This equation was developed by comparing Brookside's results on 31 soil sub-samples with results generated at PACE Consulting using a saturated paste assay. The adjusted data appears in Table 3.

- Data for the key parameters of interest (EC, sodium, pH and boron) was subjected to analysis of variance, and treatment means were separated using Fisher's LSD, where $P<0.05$ (data print-out attached). All 23

parameters tested were also subjected to stepwise linear regression to identify significant interactions between these dependent variables and independent variables (soil sampling depth, sampling date, treatment).

Treatments:

PRODUCT	RATE/1000 SQ FT	TIMING AND FREQUENCY
Primer (ACA 864)	6 oz	monthly treatments, 5/96 - 10/96
Non-treated check		

Treatment and Evaluation Schedule:

DATE	EVENT
5/31/96	Turf quality assessment, soil samples collected, 1st application made
6/26/96	Turf quality assessment, 2nd application made
7/23/96	Turf quality assessment, 3rd application made
8/26/96	Turf quality assessment, soil samples collected, 4th application made
9/24/96	Turf quality assessment, 5th application made
10/22/96	Turf quality assessment, 6th application made
11/15/96	Turf quality assessment, soil samples collected

Results and Discussion:

Water Quality: Irrigation water quality was poor (Table 1), with 8 out of the 17 parameters measured above the desired range. Of particular note are the high values reported for electrical conductivity, total dissolved salts, sodium and chloride.

Turf quality: Overall turf quality slowly declined during the course of the trial, but no differences were observed between treated and non-treated plots (Figure 1). The observed decline was probably the result of a variety of factors including consistently high EC values, traffic, compaction and temperature. No phytotoxicity due to Primer applications was observed.

Soil chemistry: Analysis revealed that soil salinity exceeded the threshold levels for annual bluegrass (Table 2, Table 3) at the 1 inch sampling depth, where the majority of bluegrass roots are located. These relatively high levels of salinity were maintained throughout the trial, in both treated and non-treated plots. The lack of the increase in salinity typically seen as the season progresses was due to an aggressive management program (aerification, leaching) undertaken by the course superintendent to avoid turf damage.

Using analysis of variance, no significant differences ($P<0.05$) between treated and non-treated plots (Table 3, Figure 2) were observed:

Using stepwise linear regression ($P<0.05$), a significant interaction was observed between depth of soil sampling (1, 2 and 4 inch samples were evaluated) and all of the variables analyzed (Table 4). Most values (pH was a notable exception) decreased with increasing depth of soil sampling. This trend is probably due to the formation of a layer in the soil profile, at a depth of 1 - 2 inches, which prevented adequate water movement and therefore the ability to successfully leach salts. A significant interaction was also observed between sampling date (0, 11 or 23 weeks after treatment) and 17 out of the 23 variables analyzed, indicating (not surprisingly) that the level of nutrients in the soil changed over time. However, no significant interactions were identified between any of the variables analyzed and treatment, indicating, as the analysis of variance tests did, that treatment

with Primer had no effect on nutrient or pH levels.

The location selected for this trial, San Luis Rey Downs Golf Course, has a history of poor quality water and resulting high soil salinity. Water and soil chemistry analyses indicate that this situation was repeated in 1996, with soil salinity values above the tolerance level for annual bluegrass. Under these circumstances, improved leaching of nutrients and salts would have been readily evident in both soil chemistry analyses and visual quality of turf.

On the basis of these results, multiple applications of Primer to turfgrass do not increase leaching of nutrients in the soil.

References:

Harivandi, M.A., Butler, J.D. and Wu, L. 1992. Salinity and turfgrass culture. Pages 207-229 in Turfgrass (Waddington, D.V., Carrow, R.N. and Shearman, R.C. eds) Series No. 32. American Society of Agronomy, Madison, WI.

Table 1. Analysis of irrigation water from San Luis Rey Downs, Bonsall, CA. Reported values are compared against a desired range of values that are based on current scientific literature plus PACE Consulting's database. Values above the desired level are noted by shaded boxes.

Parameter	Desired range	870 Reported Values
pH	6.5 - 8.4	7.58
Electrical Conductivity EC (dS/m)	< 1.2	2.23
Sodium Absorption Ratio SAR	< 6.0	3.57
Total Dissolved Salts TDS (ppm)	<800	1427.20
Carbonate CO_3 (ppm)	<50	0
Bicarbonate HCO_3 (ppm)	<90 (1.5 meq/l)	295.38
Calcium Ca (ppm)	<100 (5.0 meq/l)	160.32
Magnesium Mg (ppm)	<40 (3.0 meq/l)	86.37
Potassium K (ppm)	<160 (4.1 meq/l)	4.43
Sodium Na (ppm)	<160 (7 meq/l)	225.37
Boron B (ppm)	<0.50	0.21
Chloride Cl (ppm)	<100 (2.8 meq/l)	343.82
Copper Cu (ppm)	<0.05	0.02
Iron Fe (ppm)	<5.00	0.24
Manganese Mn (ppm)	<0.20	0.19
Sulfate SO4 (ppm)	<200 (4.2 meq/l)	506.19
Zinc Zn (ppm)	<2.00	0.04

Table 2. Relative tolerance of turfgrasses to soil salinity (Harivandi et. al. 1992).

Sensitive < 3 dS/m	Moderately Sensitive 3-6 dS/m	Moderately Tolerant 6-10 dS/m	Tolerant > 10 dS/m
Annual bluegrass	Annual ryegrass	Bent. cv. Seaside	Alkaligrass
Colonial bentgrass	Chewings fescue	Perennial ryegrass	Bermudagrass
Kentucky bluegrass	Creeping bentgrass	Tall fescue	Seashore paspalum
Rough bluegrass	Hard fescue	Buffalograss	St. Augustinegrass
Centipedegrass	Bahiagrass	Zoysiagrass	

Table 3. Changes in soil chemistry (electrical conductivity, sodium, boron and pH) over time, in non-treated check plots and plots treated monthly with Primer. San Luis Rey Downs, Bonsall, CA. Green 5. There were no significant differences detected among treatments for any of the parameters measured (Fisher's LSD, P<0.05).

		Depth of Soil Samples					
		1 inch		2 inches		4 inches	
		Treated	Check	Treated	Check	Treated	Check
0 weeks after treatment (5/31/96)							
	EC (dS/m)	3.5 a	3.6 a	2.4 a	2.2 a	1.1 a	1.0 a
	Na (ppm)	335.8 a	315.3 a	219.0 a	214.0 a	113.8 a	102.8 a
	B (ppm)	2.6 a	2.4 a	1.4 a	1.4 a	0.8 a	0.7 a
	pH	7.1 a	6.9 a	7.3 a	7.2 a	7.5 a	7.5 a
11 weeks after treatment (8/26/96)							
	EC (dS/m)	3.2 a	3.4 a	2.5 a	2.3 a	0.9 a	1.0 a
	Na (ppm)	285.8 a	275.8 a	230.5 a	223.5 a	98.3 a	103.0 a
	B (ppm)	2.6 a	2.6 a	1.9 a	1.9 a	0.8 a	0.9 a
	pH	7.1 a	7.0 a	7.3 a	7.1 a	7.4 a	7.4 a
23 weeks after treatment (11/15/96)							
	EC (dS/m)	3.3 a	3.4 a	1.8 a	1.5 a	0.9 a	0.9 a
	Na (ppm)	242.8 a	247 a	172.0 a	157.3 a	79.0 a	90.8 a
	B (ppm)	2.4 a	2.2 a	1.2 a	1.1 a	0.6 a	0.6 a
	pH	7.2 a	7.0 a	7.4 a	7.5 a	7.3 a	7.5 a

Table 4.. Factor analysis using linear regression. Factors analyzed were 1) depth of soil samples (1", 2" vs. 4"), 2) WAT, or weeks after the first Primer treatment (11 weeks vs. 23 weeks) and 3) treatment (non-treated check vs. Primer). P values less than 0.05 indicate a significant interaction between the factor and the dependent variable, and are indicated in shaded boxes.

P VALUES

Dependent Variable	Depth	WAT	Treatment
TEC (meq/100g total exchange capacity)	0.000	0.008	0.919
pH	0.000	0.103	0.420
OM (% organic matter)	0.000	0.058	0.988
N (ppm nitrogen)	0.000	0.000	0.608
S (ppm sulfur)	0.000	0.000	0.962
Bray II P (ppm phosphorous)	0.000	0.297	0.222
Easily extractable P (ppm phosphorous)	0.000	0.959	0.625
Ca (ppm calcium)	0.000	0.018	0.825
Mg (ppm magnesium)	0.000	0.007	0.755
K (ppm potassium)	0.000	0.000	0.325
Na (ppm sodium)	0.000	0.000	0.821
Ca %	0.000	0.124	0.652
Mg%	0.000	0.007	0.916
K%	0.000	0.701	0.303
Na%	0.000	0.597	0.872
Other cations %	0.000	0.103	0.420
H (hydrogen)%	0.000	0.409	0.932
EC (dS/m electrical conductivity)	0.000	0.027	0.816
B (ppm boron)	0.000	0.000	0.483
Fe (ppm iron)	0.000	0.003	0.975
Mn (ppm manganese)	0.000	0.950	0.840
Zn (ppm zinc)	0.000	0.004	0.356
Cu (ppm copper)	0.000	0.000	0.395

Figure 1.

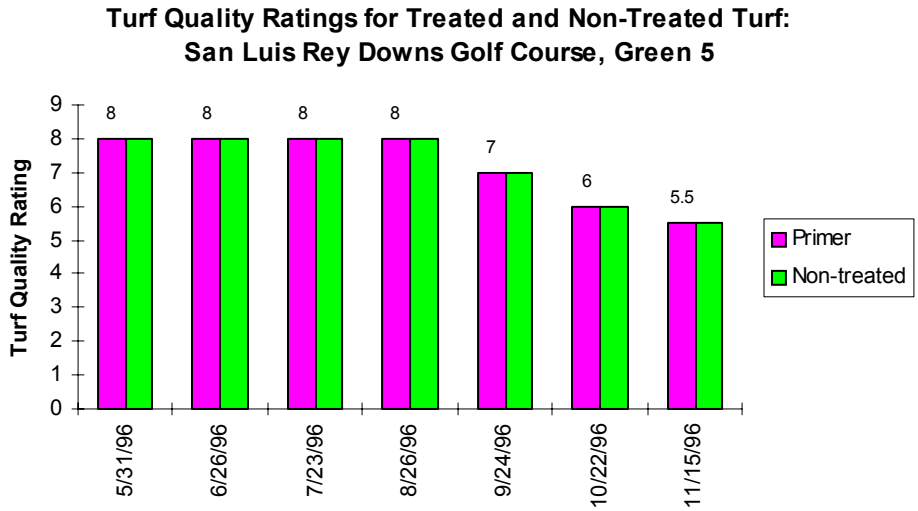
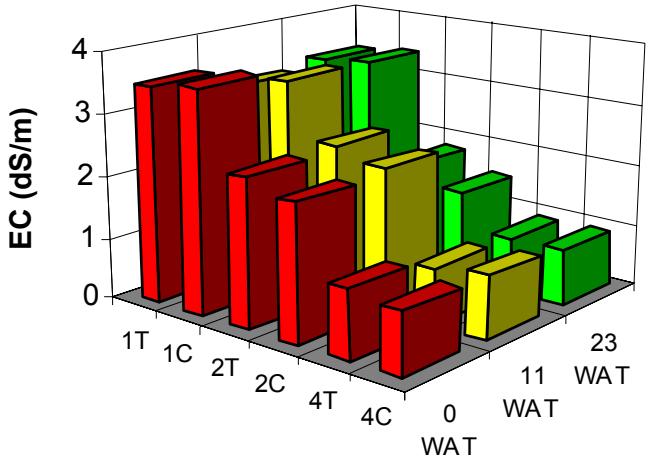
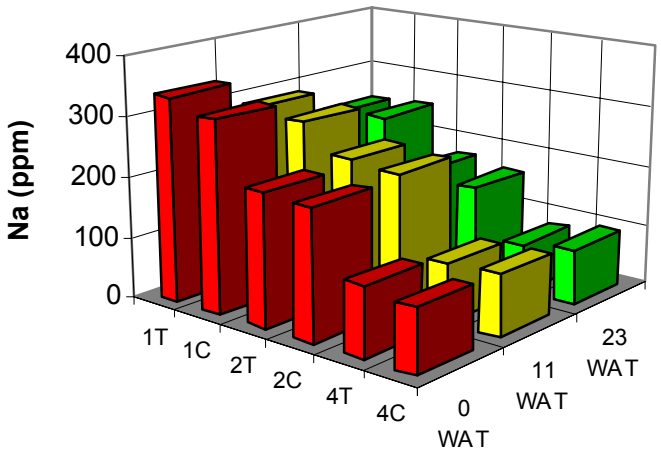

Turf Quality Ratings for Treated and Non-Treated Turf:
San Luis Rey Downs Golf Course, Green 5
Turf Quality Rating
9
8
7
6
5
4
3
2
1
0
8
8
8
8
7
6
5.5
5/31/96
6/26/96
7/23/96
8/26/96
9/24/96
10/22/96
11/15/96
Primer
Non-treated

Figure 2. Changes in soil chemistry (electrical conductivity, sodium, boron and pH) over time, in non-treated check plots and plots treated monthly with Primer. Soil was sampled at depths of 1, 2 and 4 inches. San Luis Rey Downs, Bonsall, CA. Green 5.

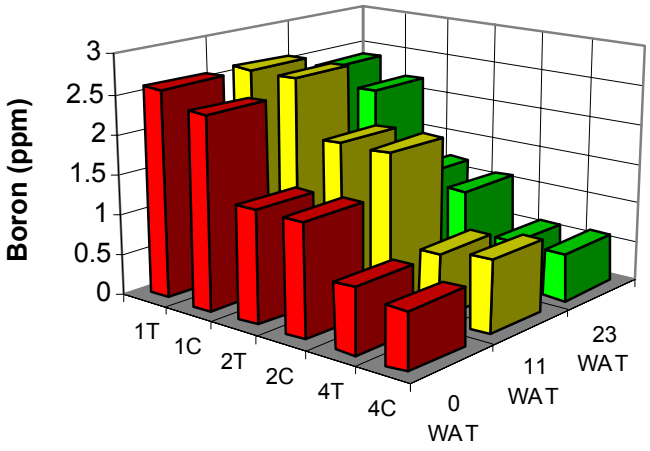
EC Values Over Time in Treated (T) and Check (C) Plots at 1, 2 and 4 inch Sampling Depths. San Luis Rey Downs, Green 5



Sodium (ppm) in Treated (T) and Check (C) Plots at 1, 2 and 4 inch Sampling Depths. San Luis Rey Downs, Green 5



Boron (ppm) Values in Treated (T) and Check (C) Plots at 1, 2 and 4 inch Sampling Depths. San Luis Rey Downs, Green 5



pH Values Over Time in Treated (T) and Check (C) Plots at 1, 2 and 4 inch Sampling Depths. San Luis Rey Downs, Green 5