Calcium Treatments to Reduce the Effect of Poor Quality Water on a Simulated Golf Course Green

D.K Tompkins, J.B. Ross and M.A. Anderson

Abstract

This study attempted to create soil problems in a greenhouse environment that mirror those found in the field. A calcareous sand was used to construct a United States Golf Association specified rootzone mixture and was compared with a mixture that does not meet specifications, i.e. low permeability. This experiment was conducted in small columns using a methodology described by Miltner and Stahnke, 2000. Different calcium sources were used to try to influence a variety of factors. Data measured included: infiltration rates and sodium contents at various rootzone depths, pH, SAR, and total alkalinity to characterize rootzone conditions. As well, detailed measurements of drainage characteristics were undertaken. For the most part, the calcium sources had little effect on most of the factors measured. However, infiltration rates and the % potassium present in the tissue were both positively impacted by certain calcium treatments.

Introduction

Irrigation water may contain minerals and other substances that make it unsuitable for irrigation. As a result, many turfgrass problems on golf courses result from the use of poor quality or effluent water, that is high in salts and sodium. These problems include: an increase in salinization leading to physiological drought, permeability problems due to high levels of sodium, and toxicity and nutrient imbalance due to an excess of certain ions. These problems can be magnified on sand-based greens due to a low buffering capacity. Ultimately, the use of poor quality water reduces sustainability and may have a negative financial impact on golf courses.

This project is intended to develop turfgrass management strategies for problem soils that are caused by the use of irrigation water that is high in pH, sodium, bicarbonates or carbonates. Management strategies will include the determination of the rate of acid injection, as well as, the application of various calcium sources in order to flush sodium, and disperse carbonates and bicarbonates from the root zone. Thresholds for the implementation of these strategies will be developed.

Problems with golf course greens resulting from the use of low quality irrigation water has been a growing problem in the province and in other areas over the past few years. For example, there are currently several golf courses in Alberta where the problem has become a major crisis. The cost of renovating a single green can vary widely depending on the golf course and the characteristics of the green, but $20,000 could be viewed as a resonable average figure for the removal and replacement of a single green.

Materials and Methods

This study attempted to create soil problems in a greenhouse environment that mirror those found in the field. A calcareous sand was used to construct a United States Golf Association specified rootzone mixture. This experiment was conducted in small columns using a methodology described by Miltner and Stahnke, 2000. Data measured included: infiltration rates, sodiumcontent, pH, SAR, and total alkalinity to characterize rootzone conditions. As well, detailed measurements of drainage characteristics were undertaken.

Construction of the Soil Profiles

Thirty-two sand-based profiles were constructed in order to simulate a putting green with a twelve-inch deep rooting zone. PVC plastic irrigation pipe with a diameter of four inches was selected as the container in which the sand-based profiles were built. To allow for sampling of the soil profile at various depths, the twelve inch lengths of the tubing were cut into three four inch sections. The pipe were reassembled and three-inch wide duct tape was used to secure the sections of pipe back together. Each piece of pipe was placed vertically into a six inch plastic pot which provided additional stability and support. The lower end of each pipe was wrapped with a porous landscape fabric to hold the contents of the pipe in place while still allowing water to drain from the profile. A one inch layer of crushed granite grit was placed at the bottom of each tube. A soil mix consisting of 10% peat moss and 90% USGA specification sand was used to fill the remainder of each pipe. The difference in particle size between the grit and the sand mixture assisted in the creation of a perched water table within each of the existing rooting zones. Four-inch cores of creeping bentgrass cv. Pencross, were removed from an existing sand-based green and were securely placed at the top of each pipe to simulate the putting green surface.

Pretrial Conditioning of the Soil Profiles

The profiles were placed in a greenhouse environment for four weeks before the start of the trial. A growing environment of 18^0 C during the day and 10^0 C during the night was maintained. Supplemental lighting was used to provide 16 hours of daylight per day. The profiles were watered twice weekly with 200 ml of high sodium content water. A special tight fitting watering sleeve was placed over the tubes to assure that the water percolated into the soil profile. The turf cores received weekly applications of a liquid fertilizer (10-52-10 at a 100 ppm N rate) the first two weeks of the conditioning period. The turf was clipped to a height of 0.5 inches on a weekly basis over course of the trial.

Trial Testing

The testing began on February 5, 2004. Over the next five weeks, a variety of calcium sources were applied twice (Feb 5th & Feb 19th), primarily as a topical treatment.

The calcium treatments included:

- Control
- Gypsum
- Calcium carbonate
- Dolomite lime
- Calcium chloride
- Calcium nitrate
- Calphlex and
- Calcium complex.

All of the calcium sources, excluding the insoluble dolomite lime, were dissolved in 200 ml of the sodic water and poured evenly over the turf core. The dolomite lime was applied as a dry compound to the turf and watered into the root zone.

Infiltration rates were determined on a weekly basis using a watering sleeve and a stopwatch. The amount of time in seconds for a 200 ml application of water to percolate into the profile was recorded.

The salts in the profile were leached three times over the testing period. The leachate from the final flushing was collected for salinity analysis. Leaching was accomplished by increasing the amount of sodic water to 500 ml. The higher volume of water was allowed to percolate through the soil profile and was discharged from the bottom of the container.

At the completion of the testing period, the soil in the profiles was destructively sampled. The top three-inch section was removed from the profile. It was allowed to air dry and was sent for salinity analysis. Samples were sent to the Enviro-Test Laboratories (Calgary AB.) for analysis. All data was analyzed using Analysis of Variance (ANOVA). When treatment effects were significant based on ANOVA; LSD was used for mean separation.

Results and Discussion

There were significant differences present in the infiltration rates (Table 1) and these differences became more pronounced as the experiment progressed. Infiltration rates were most consistently higher for the Calcium complex, the calcium nitrate and the gypsum. By 26 Feb, the Calphlex also had infiltration rates similar to the previously mentioned treatments. Unfortunately, these treatments were not significantly better than the control treatment aside from the 19 Feb measurements. If the experiment was repeated so that there were more replications and greater precision, some of these treatments might differ significantly from the control treatment as treatments such as the calcium complex, gypsum and calcium nitrate, numerically, seemed to show consistent improvement.

Table 1. Infiltration rates for profiles treated with different calcium sources.

Calcium Treatment	Infiltration Rate (seconds/200ml)				
	Feb 5[1] 0 DAT	Feb 12 7 DAT	Feb 19 14 DAT	Feb 26 21 DAT	Mar 4 21 DAT
Control	12.8a	15.5a	13.0 bc	10.5a	9.3abc
Gypsum	11.8a	9.3a	10.8ab	8.3a	6.8ab
Calcium Carbonate	13.5a	12.3a	10.3ab	12.3a	15.5 d
Dolomite Lime	16.5a	15.0a	16.3 c	19.0 b	13.5 cd
Calcium Chloride	13.3a	11.5a	9.3ab	11.5a	10.8 bc
Calcium Nitrate	10.0a	9.8a	6.3a	7.8a	6.8ab
calcium	14.0a	11.0a	11.3 b	9.5a	8.3ab
Calcium Complex	13.3a	9.0a	6.5a	8.8a	6.3a

[1]Within a column, for each source of variation, numbers followed by the same letter are not significantly different at p=0.05.

In terms of the salts collected from the leachate, there is really nothing to report. Higher levels of chloride were associated with the calcium chloride treatment, which would be expected, but aside from this there were no significant differences for any of the salt levels (Table 2) or for any or the chemical characteristics measured such as EC, SAR, TDS or pH (Table 3).

Table 2. Salts collected from leachate.

Calcium Treatment	Salts in Leachate (mg/l)				
	Calcium[1]	Potassium	Magnesium	Sodium	Sulphate
Control	37a	17a	6a	558a	591a
Gypsum	27a	14a	5a	505a	447a
Calcium Carbonate	33a	19a	6a	556a	506a
Dolomite Lime	34a	16a	6a	530a	462a
Calcium Chloride	33a	15a	6a	549a	486a
Calcium Nitrate	42a	18a	8a	612a	679a
Calphlex	39a	17a	7a	575a	635a
Calcium Complex	36a	18a	6a	570a	544a

[1]Within a column, for each source of variation, numbers followed by the same letter are not significantly different at p=0.05.

Table 3. Chemical characteristics of leachate.

Calcium Treatment	Chemical characteristics of leachate.				
	Chloride (mg/l)[1]	EC (ms/cm)	SAR	TDS	pH
Control	3a	2.3a	22a	1480a	8.5a
Gypsum	3a	2.0a	24a	1292a	8.5a
Calcium Carbonate	5a	2.2a	23a	1430a	8.6a
Dolomite Lime	3a	2.1a	22a	1357a	8.4a
Calcium Chloride	61 b	2.2a	23a	1442a	8.4a
Calcium Nitrate	4a	2.5a	24a	1612a	8.5a
Calphlex	4a	2.4a	23a	1535a	8.5a
Calcium Complex	5a	2.3a	24a	1502a	8.4a

[1]Within a column, for each source of variation, numbers followed by the same letter are not significantly different at p=0.05.

There were higher sulphate levels in the soil associated with the calcium complex treatment (Table 4), but there were no differences in calcium, potassium, magnesium or sodium levels.

Chloride levels in the soil were higher with the calcium chloride treatment (Table 5), but EC, SAR, TDS and pH all were not significantly affected by the calcium treatment.

Table 4. Salts present in soil.

Calcium Treatment	Salts present in soil (mg/l)				
	Calcium[1]	Potassium	Magnesium	Sodium	Sulphate
Control	24a	10a	8a	196a	107 b
Gypsum	24a	9a	7a	219a	112 b
Calcium Carbonate	21a	5a	4a	210a	109 b
Dolomite Lime	26a	12a	9a	220a	118 b
Calcium Chloride	17a	4a	3a	197a	114 b
Calcium Nitrate	19a	6a	4a	215a	140ab
Calphlex	32a	9a	8a	230a	131ab
Calcium Complex	21a	4a	4a	236a	168a

[1]Within a column, for each source of variation, numbers followed by the same letter are not significantly different at p=0.05.

Table 5. Chemical characteristics of soil.

Calcium Treatment	Chloride (mg/l)[1]	EC (ds/cm)	SAR	% Saturation	pH
Control	4a	0.8a	10a	29a	8.8a
Gypsum	5a	0.9a	11a	27a	8.9a
Calcium Carbonate	4a	0.9a	11a	28a	8.9a
Dolomite Lime	4a	0.9a	11a	28a	8.9a
Calcium Chloride	10 b	0.8a	12a	29a	8.9a
Calcium Nitrate	3a	0.9a	12a	29a	8.9a
Calphlex	3a	0.9a	10a	28a	8.8a
Calcium Complex	4a	1.0a	12a	28a	8.9a

[1]Within a column, for each source of variation, numbers followed by the same letter are not significantly different at p=0.05.

Table 6. Salts present in tissue.

	Salts present in tissue (%)			
Calcium Treatment	Calcium[1]	Potassium	Magnesium	Sodium
Control	0.6a	0.8 bc	0.2a	0.6a
Gypsum	0.6a	1.0ab	0.2a	0.7a
Calcium Carbonate	0.6a	0.6 c	0.2a	0.7a
Dolomite Lime	0.7a	0.8 bc	0.2a	0.8ab
Calcium Chloride	0.6a	0.9abc	0.2a	0.6a
Calcium Nitrate	0.6a	1.1ab	0.3a	1.1 c
Calphlex	0.5a	1.2a	0.3a	1.0 bc
Calcium Complex	0.6a	1.0ab	0.3a	1.0 c

[1]Within a column, for each source of variation, numbers followed by the same letter are not significantly different at p=0.05.

In the tissue samples, higher levels of potassium were associated with the Calphlex (compared to the control) (Table 6). This may be important as potassium, like sodium is a monovalent cation and plants do need to be taking up potassium rather than sodium. One thing that happens on sodic soils is that the sodium interferes with the ability of the plant to take up potassium. Unfortunately, the control treatment was one of the treatments that also had the lowest levels of sodium present in the tissues.

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