Research Update: Determining Soil Potassium Requirements of Sand-Based Putting Greens

An interim report to the Canadian Allied Turfgrass Research Office, 15 Feb. 2016

Doug Soldat, Ph.D.

University of Wisconsin-Madison

Introduction

Potassium is an essential primary macronutrient required in relatively large quantities by turfgrass plants. Potassium does not have any structural role in the plant, but plays important roles in regulating osmotic pressure and facilitating enzymatic reactions. Potassium fertilization is thought to reduce many environmental stresses including heat, cold, and drought stress. It has also been associated with both increased and decreased disease pressure. Despite all these claims and associations, very few research studies have carefully examined how the soil and tissue levels of potassium influence turfgrass quality, growth, and disease pressure. The handful of studies that have addressed these topics often do not report soil test levels or tissue potassium content. In addition, many potassium studies are conducted over short time-scales (< 2 years) and do not quantify the long-term effects of various potassium fertilization strategies.

Because of the lack of quality data, turfgrass managers have hedged their bets and often apply large doses of potassium to turfgrass (>6 lbs per thousand square feet) – particularly to putting greens. However, with more accurate information, we feel that turfgrass managers will be able to confidently reduce their potassium applications, thus saving time and money, while not reducing and possibly enhancing the quality of the turfgrass they manage. The objective of this research is to evaluate putting green quality, growth, and disease incidence over a wide range of soil test and tissue potassium levels.

Methods and Materials

This project was initiated in 2011 at the O.J. Noer Turfgrass Research Facility in Madison, WI on a USGA putting green with 'A4' creeping bentgrass. The experiment is a randomized complete block design with four replications. The treatments include five different levels of biweekly liquid potassium sulfate at rates ranging from zero to 0.6 lbs/M every two weeks (~ 0 – 8 lbs K2O/M annually depending on the exact start and stop dates of the applications). Paired soil and plant tissue samples are collected monthly along with measurements of clipping yield. The soil samples are taken to a depth of 7 cm, and the plant tissue is collected by a walking greens mower, dried at 60°C, cleaned of debris (sand) and then dry weight is recorded. The dried turfgrass tissue is then analyzed for mineral nutrient content (N, P, K, S, Ca, Mg, Fe, Mn, Zn, Cu, and B) using a C/N/S analyzer and sulfuric acid digestion followed by inductively coupled plasma atomic emission spectroscopy. The soil samples are air dried, then analyzed for available nutrients using the Mehlich-3 method. Turfgrass color is evaluated biweekly using a reflectance meter that measures wavelengths corresponding to chlorophyll reflectance (CM-1000, spectrum technologies). Visual turfgrass quality is also evaluated biweekly using the standard National Turfgrass Evaluation Program rating scale of 1-9, where 1 represents completely brown or dead turf, 6 represents the minimally acceptable turf quality, and 9 represents the greatest possible quality. A golf cart traffic simulator is used six times per week to create wear stress on the plots, as potassium has been associated with wear tolerance in the past. The traffic simulator is a pull-behind unit consisting of two axels each holding six golf cart wheels. Above the wheels, approximately 500 kg of weight is added using water tanks. Although golf cart traffic does not duplicate foot traffic, it creates a great deal of wear stress on the turfgrass. Finally, because we are interested in how potassium may affect common diseases, we apply fungicides only rarely – usually in cases where we are concerned about losing the entire stand. In fact, only one fungicide has been applied during the past four years – a dollar spot control application was made last summer after a prolonged outbreak. Disease incidence is quantified by counting infection centers and by the grid intersection method, where an 81 point grid is placed on the plot and the presence/absence of the disease is recorded directly under each intersection.

Results from 2015 Season

In 2015, we began to see visual signs of potassium deficiency for the first time since the study began in 2011. As shown in Table 1, the season average for color and quality were lowest in the control treatment (no K), significantly lower than treatments receiving K in most cases. Color and quality ratings for individual dates (Tables 2 and 3) show that the lower color and quality were most apparent in the first part of the growing season. Clipping data show that no significant differences were detected among treatments on all of the collection dates, with the exception of August sampling when the control had significantly more clippings than the 0.2 lbs K/M treatment (Table 4). This exception does not seem to correspond to any clear treatment effect.

Soil samples are taken monthly and the Mehlich-3 soil test results for potassium, calcium, and magnesium are show in Tables 5, 6, and 7, respectively. The monthly soil samples show clear trends in differences in soil K values, and the differences closely follow the fertility treatments. With the few exceptions, the Mehlich-3 extractable Ca and Mg remained statistically similar among the treatments (Tables 6 and 7).

Turfgrass tissue samples are collected and analyzed for nutrients monthly (one the same date as the soil sampling). Tissue concentrations of K, Ca, and Mg are reported in Tables 8, 9, and 10, respectively. These data show that the potassium fertilizer treatments strongly influenced the potassium in the leaf. Also, they show that the treatments strongly influenced the Mg, and Ca in the leaf despite the soil levels of these nutrients remaining constant. This was expected because increasing leaf potassium typically results in a decrease in other cations. The K ranges from below 1.0% in the no K treatment in June to over 2.0% in the high K treatment in July, demonstrating that our treatment applications have been successful in creating conditions suitable for testing the impact of K on turfgrass responses.

Potassium treatments affected pink snow mold severity, but not dollar spot (Table 11). The three treatments receiving potassium fertilizer had greater amounts of snow mold damage. This effect has been consistent for the last several years of the study. The 2016 season will provide more data on the impact of potassium fertilization, soil concentrations, and tissue potassium levels on turfgrass visual responses and disease pressure.

Table 1. Average turfgrass color, quality and daily clipping mass for the 2015 season. Color is measured using the Spectrum CM-1000 on a scale from 1-999 (greenest) and quality is rated using the NTEP scale of 1-9 (best). Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	Color	Quality	Clippings*
	1-999	1-9	g/plot
0.2 lb Ca/M (gypsum)	178 AB	4.1 BC	1.8 A
Control (no application)	172 B	4.0 C	1.7 A
0.1 lb K2O/M (K2SO4)	182 A	4.4 AB	1.6 A
0.2 lb K2O/M (K2SO4)	182 A	4.3 ABC	1.6 A
0.6 lb K2O/M (K2SO4)	181 A	4.5 A	1.8 A

* Data set incomplete for clippings (see Table x)

Table 2. Turfgrass color during the 2015 season as measured using the Spectrum CM-1000 on a scale from 1-999 (greenest). Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	8 May	5 June	1 July	4 Aug.	1 Sept.	8 Oct.
	--1-999--					
0.2 lb Ca/M (gypsum)	137 AB	145 AB	187 AB	214 A	208 A	252 A
Control (no application)	134 B	139 B	178 B	211 A	199 A	251 A
0.1 lb K2O/M (K2SO4)	137 AB	148 A	197 A	217 A	210 A	244 A
0.2 lb K2O/M (K2SO4)	137 AB	149 A	191 A	221 A	210 A	242 A
0.6 lb K2O/M (K2SO4)	141 A	147 AB	190 AB	216 A	210 A	245 A

Table 3. Visual turfgrass quality during the 2015 season. Visual quality is evaluated using the NTEP scale of 1-9 where 1 represents completely brown or dead turf and 9 represents the highest possible quality. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	8 May	5 June	1 July	4 Aug.	1 Sept.	8 Oct.
	---------------------------------1-9, (9=best quality)---------------------------------					
0.2 lb Ca/M (gypsum)	4.5 A	2.5 AB	6.0 BC	5.3 AB	2.3 A	5.5 A
Control (no application)	4.5 A	2.3 B	5.5 C	4.8 B	3.0 A	5.8 A
0.1 lb K2O/M (K2SO4)	3.8 B	3.0 A	6.8 A	5.8 A	2.8 A	5.3 A
0.2 lb K2O/M (K2SO4)	3.8 B	2.8 AB	6.5 AB	5.5 AB	2.3 A	5.3 A
0.6 lb K2O/M (K2SO4)	4.0 AB	3.0 A	6.8 A	5.8 A	2.8 A	5.3 A

Table 4. Clipping yield measured during the 2015 season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	8 May	5 June	1 July	4 Aug.	1 Sept.	8. Oct.
	--------------------------------------g dry wt./plot--------------------------------------					
0.2 lb Ca/M (gypsum)	11.32 A	1.8 A	1.8 A	2.95 AB	3.56 A	7.14 A
Control (no application)	13.25 A	1.8 A	1.5 A	3.39 A	3.40 A	7.58 A
0.1 lb K2O/M (K2SO4)	12.36 A	1.7 A	1.5 A	2.88 AB	3.46 A	6.69 A
0.2 lb K2O/M (K2SO4)	11.00 A	1.7 A	1.5 A	2.52 B	3.75 A	6.63 A
0.6 lb K2O/M (K2SO4)	11.27 A	1.9 A	1.6 A	2.93 AB	3.87 A	6.47 A

Table 5. Mehlich-3 soil test potassium levels during the 2015 summer growing season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	**May**	**June**	**July**	**August**	**September**	**October**
	------------------------------- K mg/kg -------------------------------					
0.2 lb Ca/M (gypsum)	16.4 c	19.6 c	19.2 b	20.9 c	20.4 b	20.7 c
Control (no application)	16.0 c	19.1 c	18.6 b	20.3 c	23.9 b	20.4 c
0.1 lb K2O/M (K2SO4)	19.9 bc	27.4 bc	24.5 b	27.5 b	25.8 b	25.7 bc
0.2 lb K2O/M (K2SO4)	24.2 b	30.9 b	35.1 a	33.5 a	22.5 b	29.9 b
0.6 lb K2O/M (K2SO4)	33.5 a	49.4 a	42.0 a	39.2 a	38.1 a	42.0 a

Table 1. Mehlich-3 soil test calcium levels during the 2015 summer growing season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	**May**	**June**	**July**	**August**	**September**	**October**
	------------------------------ Ca mg/kg ------------------------------					
0.2 lb Ca/M (gypsum)	678 a	881 a	841 a	790 a	662 ab	870 a
Control (no application)	713 a	777 a	771 a	665 a	759 ab	741 a
0.1 lb K2O/M (K2SO4)	723 a	767 a	721 a	753 a	792 a	786 a
0.2 lb K2O/M (K2SO4)	850 a	775 a	811 a	704 a	554 b	768 a
0.6 lb K2O/M (K2SO4)	847 a	789 a	689 a	671 a	583 ab	739 a

Table 7. Mehlich-3 soil test magnesium levels during the 2015 summer growing season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	May	June	July	August	September	October
	------------------------------ Mg mg/kg ------------------------------					
0.2 lb Ca/M (gypsum)	131 b	162 a	154 a	145 a	131 ab	158 a
Control (no application)	150 ab	171 a	166 a	150 a	170 a	154 a
0.1 lb K2O/M (K2SO4)	152 ab	175 a	156 a	165 a	174 a	161 a
0.2 lb K2O/M (K2SO4)	169 a	160 a	177 a	154 a	119 b	160 a
0.6 lb K2O/M (K2SO4)	173 a	172 a	154 a	152 a	136 ab	153 a

Table 8. Potassium concentration in turf tissue during the 2015 summer season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	May	June	July	August	September	October
	----------------------------- % K in tissue -----------------------------					
0.2 lb Ca/M (gypsum)	0.62 b	0.96 c	1.37 d	1.14 c	1.55 c	1.16 c
Control (no application)	0.50 b	0.96 c	1.39 d	1.05 c	1.54 c	1.18 c
0.1 lb K2O/M (K2SO4)	0.63 b	1.30 b	1.64 c	1.34 b	1.76 b	1.45 b
0.2 lb K2O/M (K2SO4)	0.95 a	1.37 b	1.86 b	1.54 a	1.93 a	1.51 a
0.6 lb K2O/M (K2SO4)	1.16 a	1.52 a	2.06 a	1.65 a	1.90 a	1.65 a

Table 9. Calcium concentration in turf tissue during the 2015 summer season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	May	June	July	August	September	October
	----------------------------- % Ca in tissue -----------------------------					
0.2 lb Ca/M (gypsum)	0.84 ab	0.98 a	0.78 a	0.74 a	0.53 a	0.54 a
Control (no application)	0.92 a	0.83 b	0.68 ab	0.67 ab	0.51 ab	0.48 b
0.1 lb K2O/M (K2SO4)	0.76 bc	0.71 c	0.58 c	0.61 bc	0.45 bc	0.43 c
0.2 lb K2O/M (K2SO4)	0.65 cd	0.65 c	0.62 bc	0.58 cd	0.43 c	0.41 c
0.6 lb K2O/M (K2SO4)	0.59 d	0.64 c	0.53 c	0.54 d	0.39 c	0.38 d

Table 10. Magnesium concentration in turf tissue during the 2015 summer season. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	May	June	July	August	September	October
	----------------------------- % Mg in tissue -----------------------------					
0.2 lb Ca/M (gypsum)	0.41 b	0.39 b	0.37 b	0.36 a	0.28 a	0.29 b
Control (no application)	0.50 a	0.43 a	0.40 a	0.35 ab	0.29 a	0.31 a
0.1 lb K2O/M (K2SO4)	0.39 b	0.37 b	0.34 bc	0.32 bc	0.27 ab	0.28 bc
0.2 lb K2O/M (K2SO4)	0.34 bc	0.34 c	0.35 b	0.31 cd	0.27 ab	0.27 c
0.6 lb K2O/M (K2SO4)	0.30 c	0.33 c	0.32 c	0.30 d	0.25 b	0.25 d

Table 11. Pink snow mold (PSM) and dollar spot disease severity was quantified by counting infection centers and/or visually estimating the percentage of plot area occupied by infection in March and May 2015. Results followed by different letters within each column are statistically different according to Fisher's Least Significant Difference (alpha=0.05).

Treatment	17 March 2015 PSM Infection Centers	17 March 2015 PSM Damage	8 May 2015 PSM Infection Centers	8 May 2015 PSM Damage	11 Sept. 2015 Dollar Spot Infection Centers
	#/plot	% area	#/plot	% area	#/plot
0.2 lb Ca/M (gypsum)	3.8 B	1.5 BC	3.8 B	3.3 A	209 A
Control (no application)	2.3 B	1.0 C	3.3 B	1.8 A	253 A
0.1 lb K2O/M (K2SO4)	14.3 A	5.5 AB	18.8 AB	6.0 A	281 A
0.2 lb K2O/M (K2SO4)	16.3 A	8.8 A	25.0 A	7.5 A	209 A
0.6 lb K2O/M (K2SO4)	14.8 A	7.5 A	16.3 AB	6.0 A	215 A