IMPORTANCE OF PARTICLE SIZE DISTRIBUTION, APPLICATION RATE AND SAND DEPTH IN DEVELOPING A FAIRWAY TOPDRESSING PROGRAM

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Introduction

Fairway topdressing is a relatively new cultural practice that is being adopted by several golf course superintendents throughout the United States to improve playing conditions. Some of the benefits reported have been improved drainage, less disease and firmer fairways. The benefits to fairway topdressing seem unanimous, but the practice requires a significant budget, considerable labor, time, and commitment to implement properly. Additionally, many questions remain unanswered with regards to topdressing material selection, application rates and the turfgrass management implications as the topdressing layer accumulates.

Sands used in USGA putting green construction and subsequent topdressing have been thoroughly researched to optimize macroporosity while maintaining sufficient water holding capacity. However, due to the strict specifications, these sands are prohibitively expensive when considered for use on larger fairway acreage. Therefore, recommendations for fairway sands are often very general. Although selecting a sand that meets USGA specifications for particle size distribution may not be necessary, it is often subjectively suggested that the sand not be too fine or too coarse.

The cost of a USGA sand does not improve the practicality of implementing this program for many golf courses. The impact of using sand that does not meet USGA specifications, however, has not been thoroughly investigated. Particle size distribution will likely affect infiltration and water retention at the playing surface. Topdressing materials that are too fine may retain excess moisture, whereas, a sand that is too coarse may predispose a large portion of the course to moisture stress. The short and long term impact of topdressing native soils is unknown.

The objectives of this research were to: 1) Determine whether particle size distribution and/or application rate will affect turfgrass color, turfgrass quality, turfgrass cover, disease incidence and earthworm activity, 2) Quantify the effects of particle size distribution and topdressing layer depth on moisture retention, soil temperature, resistance to surface displacement, 3) Use the resultant data to make recommendations to improve the practice of fairway topdressing.

Materials & Methods

This experiment was a 3 x 3 (sand type x application rate) factorial arranged in a random complete block design with three replications. The first factor, sand type, had three levels: Fine, USGA, and Coarse (Table 1). The second factor, application rate, had three levels: $4ft^3/1000ft^2$, $8ft^3/1000ft^2$, and$12ft^3/1000ft^2$. A control was also included that received no topdressing applications. The study was initiated on an L-93 creeping bentgrass (*Agrostis stolonifera*) stand managed as a golf course fairway at the University of Connecticut Plant Science Education and Research Facility, originally seeded in September 2006. The research area was located on a sandy loam soil with a pH of 6.4. Treatments were mowed three times a week at a height of 0.5 inches. Plot sizes were 10 ft wide by 20 ft long. Topdressing applications were initiated on 3 July 2007 and were applied once per month ending in November. In 2008, topdressing applications started in May and ended in November. This design allows the comparisons of each sand type applied at each of the three rates. The three different rates will also enable the development of three different depths of topdressing over time.

Fertilizer applications began on 8 May and were repeated on 21 day intervals with the last treatment being applied on 20 October. Nitrogen application rates varied between 0.5 and 0.75 lbs N $1000ft^{-2}$. The overall fertilizer application for the season was 5.5 lbs. nitrogen, 4.0 lbs. P_2O_5, and 2.0 lb. K_2O. Phosphorus and potassium were applied according to soil test results. Plots were irrigated following fertilizer applications only.

Fungicides were applied predominately on a curative basis to determine the effect of treatments on disease incidence. Heritage was applied on 9 June to control take-all patch at the rate of 0.4 oz $1000ft^{-2}$. Manicure was applied on 1 July to control dollar spot at the rate of 3.2 oz $1000ft^{-2}$. Insignia was applied on 8 July at the rate of 0.9 oz $1000ft^{-2}$ as a continued control measure for take-all patch. Manicure was applied on 29 July to control dollar spot at the rate of 3.2 oz $1000ft^{-2}$.

Data collected in this study included ratings of turfgrass color and quality. This was done by visual rating using a scale of 1 to 9, where 1 = brown/dead turf; 6 = minimum acceptable color/quality; and 9 = optimum quality or dark green color. Digital image analysis was utilized in assessing turfgrass cover. Controlled light conditions were provided through the use of a light box. Images were scanned using Sigma Scan Software using the following threshold values; hue=40-125 and saturation=10-100. Color, quality, and cover data were collected weekly. Volumetric soil moisture was measured using a Trime-FM TDR probe, 5 cm (MESA Systems Co., Medfield, MA). Resistance to surface displacement was measured using a proving ring soil penetrometer (ELE International, Ames, IA). Soil temperature was measured using a digital thermometer (Fisher Scientific, Waltham, MA) at a 5 cm depth. Measurements were taken weekly. On each sampling date, five readings were taken per plot and then averaged. Earthworm castings and dollar spot count data were obtained as incidence occurred. Earthworm castings and dollar spots were quantified using 25 ft^2 grid placed in the center of each plot.

Results and Discussion

This study was initiated in September 2006 with the establishment of the creeping bentgrass fairway. Topdressing treatments began in July 2007 with monthly applications occurring through November 2007. Comprehensive data collection ensued in April 2008. Parameters that were measured in the laboratory and in the field during 2007 and 2008 are discussed in the following sections.

Particle Size Distribution

The particle size distributions of the three sands are detailed in Table 1. The USGA particle size recommendations for putting green construction are included in the table for comparison purposes. The fine sand does not meet the USGA specifications for putting green construction due to the high fine sand content and high very fine sand content. The USGA sand is very close to meeting the specifications, but falls just short with a slightly high fine sand content. The coarse sand does not meeting the specifications due to high very coarse sand content.

Table 1. Particle size analyses of sand types. USGA recommendations for putting green construction are included for reference only.

	Soil Separate %				**% Retained**					
Treatment	**Sand**	**Silt**	**Clay**	**No. 10 Gravel 2 mm**	**No. 18 VCS 1 mm**	**No. 35 CS 0.5 mm**	**No. 60 MS 0.25 mm**	**No. 100 FS 0.15 mm**	**No. 140 VFS 0.10 mm**	**No. 270 VFS 0.05 mm**
Fine Sand (Desiato Mason)	97.3	1.3	0.6	0.8	4.4	11.0	31.6	31.1	12.1	7.1
USGA Sand (Holliston #40)	99.3	0.1	0.5	0.1	2.6	20.2	52.3	20.6	2.7	0.9
Coarse Sand (AA Will Mat. 2mm)	99.5	0.0	0.4	0.1	11.0	31.5	42.0	13.0	1.6	0.4
USGA Rec. for Putting Grn Const.		**≤ 5%**	**≤ 3%**	**≤ 3% Gravel ≤ 10% Combined**		**≥ 60%**		**≤ 20%**	**≤ 5%**	

Turfgrass Color

Topdressing applications resulted in a positive turfgrass color response (Figure 1 and 2). This would typically appear one to two weeks following topdressing applications as an overall rate response (Table 2). A rate response means that regardless of the sand type used, the more sand that is applied, the greater the greening response by the turfgrass. A greening response was also observed during the 2008 spring green up with the plots receiving higher application rates of topdressing greening up faster. Turfgrass color differences between treatments generally equilibrated by mid-June. This color response was fairly consistent throughout the growing season with plots receiving higher rates of topdressing having better color. The color ratings reported in Table 2 were taken approximately two weeks after topdressing applications. The data also clearly indicated that applying some amount of sand, regardless of sand type, consistently improved turfgrass color compared to the control plots.

Figure 1. Plots that received higher topdressing rates showed a faster greening response in April 2008.

Figure 2. The increase in turfgrass color related to topdressing rate was observed throughout the growing season.

Table 2. Effect of sand type and topdressing application rate on turfgrass color, 2008.

	Color[x]						
Sand	April 18	May 16	June 13	July 11	Aug 15	Sept 17	Oct 17
Fine	4.66 a[y]	4.88 a	7.55 a	6.66 a	7.55 a	6.77 a	7.00 a
USGA	4.33 a	4.77 a	6.88 a	6.33 a	7.33 a	6.66 a	7.00 a
Coarse	4.88 a	4.77 a	7.11 a	6.66 a	7.22 a	7.11 a	6.88 a
Control	2.00 b	2.66 b	6.00 a	4.66 b	6.33 b	5.66 b	6.33 b
Significance	*	*	ns	*	*	*	*
Rate (ft^3 $1000ft^{-2}$)							
4	3.44 c	4.22 b	6.88 a	5.88 b	6.88 b	6.33 b	6.88 a
8	4.66 b	4.66 b	7.11 a	6.44 b	7.33 b	6.66 b	7.00 a
12	5.77 a	5.55 a	7.55 a	7.33 a	7.88 a	7.55 a	7.00 a
Control	2.00 d	2.66 c	6.00 a	4.66 c	6.33 c	5.66 c	6.33 b
Significance	*	*	ns	*	*	*	*
Sand x Rate							
Fine (4)	3.66 ef	4.00 c	7.00 bc	6.00 bc	6.66 cd	6.66 bc	7.00 a
Fine (8)	4.66 cd	4.66 bc	7.33 ab	6.66 abc	7.66 ab	6.33 bc	7.00 a
Fine (12)	5.66 ab	6.00 a	8.33 a	7.33 a	8.33 a	7.33 ab	7.00 a
USGA (4)	3.33 f	4.33 c	7.00 bc	6.00 bc	7.00 bcd	6.33 bc	7.00 a
USGA (8)	4.33 de	4.66 bc	6.66 bc	6.00 bc	7.33 bc	6.33 bc	7.00 a
USGA (12)	5.33 bc	5.33 ab	7.00 bc	7.00 ab	7.66 ab	7.33 ab	7.00 a
Coarse (4)	3.33 f	4.33 c	6.66 bc	5.66 cd	7.00 bcd	6.00 c	6.66 a
Coarse (8)	5.00 bcd	4.66 bc	7.33 ab	6.66 abc	7.00 bcd	7.33 ab	7.00 a
Coarse (12)	6.33 a	5.33 ab	7.33 ab	7.66 a	7.66 ab	8.00 a	7.00 a
Control	2.00 g	2.66 d	6.00 c	4.66 d	6.33 d	5.66 c	6.33 a
Significance	*	*	*	*	*	*	ns

x Color ratings: 1 = brown/dead; 6 = minimum acceptable color; 9 = optimum, dark green color
y Means in a column followed by the same letter are not significantly different

Turfgrass Quality

Topdressing applications resulted in an increase in turfgrass quality. This increase in turfgrass quality also appeared as an overall rate response with plots receiving higher rates of topdressing getting higher quality ratings (Table 3.). An increase in turfgrass quality was noted for plots receiving higher rates of topdressing during the spring green up and throughout the majority of the growing season. Mid-October was one exception with a significant overall rate effect indicating that plots topdressed at the high and medium rates had lower turfgrass quality than the low application rate. This change in response may be due to the decreased growth rate of the turfgrass at that time of year resulting in more sand remaining at the surface, reducing the overall appearance of the turfgrass.

Table 3. Effect of sand type and topdressing application rate on turfgrass quality, 2008.

	Turfgrass Quality[x]						
Sand	April 18	May 16	June 13	July 11	Aug 15	Sept 17	Oct 17
Fine	4.00 ab[y]	4.44 a	6.66 a	5.88 a	6.88 a	6.22 a	4.88 ab
USGA	3.55 b	4.11 a	6.11 ab	6.11 a	6.66 a	6.00 a	5.33 a
Coarse	4.22 a	4.55 a	6.66 a	6.22 a	6.66 a	6.44 a	4.66 b
Control	2.00 c	2.66 b	5.33 b	4.66 b	5.33 b	5.00 b	5.33 a
Significance	*	*	*	*	*	*	*
Rate (ft^3 1000ft^{-2})							
4	3.11 c	3.88 b	6.22 a	5.22 c	6.22 b	5.77 bc	6.00 a
8	3.88 b	4.55 a	6.44 a	6.11 b	6.88 a	5.88 b	5.33 b
12	4.77 a	4.66 a	6.77 a	6.88 a	7.11 a	7.00 a	3.55 c
Control	2.00 d	2.66 c	5.33 b	4.66 c	5.33 c	5.00 c	5.33 b
Significance	*	*	*	*	*	*	*
Sand x Rate							
Fine (4)	3.33 cd	3.66 b	6.33 a	5.00 de	6.33 cd	6.00 bcd	6.33 a
Fine (8)	3.66 bc	4.66 a	6.33 a	5.66 cd	6.66 bc	5.66 cd	5.00 c
Fine (12)	5.00 a	5.00 a	7.33 a	7.00 a	7.66 a	7.00 ab	3.33 d
USGA (4)	2.66 de	3.66 b	6.00 a	5.33 cde	6.00 d	5.66 cd	6.00 ab
USGA (8)	3.66 bc	4.33 ab	6.33 a	6.00 bc	7.00 b	5.66 cd	6.00 ab
USGA (12)	4.33 ab	4.33 ab	6.33 a	7.00 a	7.00 b	6.66 abc	4.00 d
Coarse (4)	3.33 cd	4.33 ab	6.33 a	5.33 cde	6.33 cd	5.66 cd	5.66 abc
Coarse (8)	4.33 ab	4.66 a	7.00 a	6.66 ab	7.00 b	6.33 abc	5.00 c
Coarse (12)	5.00 a	4.66 a	6.66 a	6.66 ab	6.66 bc	7.33 a	3.33 d
Control	2.00 e	2.66 c	5.33 a	4.66 e	5.33 e	5.00 d	5.33 bc
Significance	*	*	ns	*	*	*	*

x Quality ratings: 1 = dead turf; 6 = minimum acceptable quality; 9 = optimum quality

y Means in a column followed by the same letter are not significantly different

Turfgrass Cover

The turfgrass cover data reported was collected just prior to the next topdressing application, with the exception of April 11. An overall rate effect was significant for the 6 out of the 7 dates data was collected. Greater turfgrass cover was observed on plots topdressed with higher application rates (Table 4). Therefore, sand type had no effect on turfgrass cover at the end of each month. Sand type did have an effect immediately following topdressing applications with the coarse sand having less turfgrass cover (data not shown).

Table 4. Effect of sand type and topdressing application rate on turfgrass cover, 2008.

	Turfgrass Cover[x]						
	%						
Sand	April 11	May 5	May 29	June 27	August 1	August 29	Sept 25
Fine	78.3 a[y]	92.1 a	92.9 a	98.6 a	94.5 a	98.9 a	97.4 a
USGA	78.5 a	92.9 a	92.6 a	98.3 a	92.7 b	99.0 a	96.7 a
Coarse	76.3 a	93.1 a	93.3 a	98.9 a	95.2 a	99.1 a	97.0 a
Control	65.3 a	86.5 a	86.7 a	96.3 a	90.8 c	98.8 a	95.9 a
Significance	ns	ns	ns	ns	*	ns	ns
Rate (ft^3 $1000ft^{-2}$)							
4	75.3 b	90.3 b	91.1 c	97.9 b	92.9 b	98.9 a	96.5 bc
8	78.8 a	93.1 a	93.1 b	98.8 ab	93.7 b	99.0 a	96.9 ab
12	79.0 a	94.6 a	94.7 a	99.1 a	95.7 a	99.2 a	97.6 a
Control	65.3 c	86.5 c	86.7 d	96.4 c	90.8 c	98.8 a	95.9 c
Significance	*	*	*	*	*	ns	*
Sand x Rate							
Fine (4)	74.3 cd	89.7 d	91.1 c	97.7 ab	94.1 cd	98.8 a	97.5 ab
Fine (8)	77.9 bc	91.5 bcd	92.3 bc	98.8 a	93.2 de	98.9 a	96.9 abc
Fine (12)	82.6 a	95.0 a	95.4 a	99.4 a	96.0 ab	99.0 a	97.6 a
USGA (4)	78.2 bc	91.3 cd	90.6 c	97.8 ab	91.6 ef	98.9 a	95.8 c
USGA (8)	78.7 ab	93.1 abc	92.3 bc	98.5 a	92.1 ef	98.9 a	96.5 abc
USGA (12)	78.5 ab	94.3 ab	94.9 a	98.7 a	94.3 bcd	99.2 a	97.6 a
Coarse (4)	73.3 d	89.9 d	91.5 c	98.3 a	93.0 de	98.9 a	96.3 bc
Coarse (8)	79.7 ab	94.6 a	94.6 a	99.1 a	95.8 abc	99.2 a	97.3 ab
Coarse (12)	75.8 bcd	94.5 ab	93.7 ab	99.3 a	96.7 a	99.1 a	97.5 a
Control	65.3 e	86.5 e	86.7 d	96.4 b	90.7 f	98.7 a	95.9 c
Significance	*	*	*	*	*	ns	*

x Percent cover was calculated using Sigma Scan software; # of green pixels compared to total # of pixels
y Means in a column followed by the same letter are not significantly different

Volumetric Soil Moisture

Volumetric soil moisture in the top 2 inches of the root zone profile was affected by both sand type and application rate. An overall sand type effect was significant for 6 out of the 7 days data was collected. Generally, the coarser the texture of the sand, the less moisture was retained at the surface of the root zone. The overall rate effect indicated that the higher the topdressing application rate, the less moisture was retained at the surface of the root zone (Table 5). The only exception to these trends was observed on September 14 when the soil moisture was particularly high, there was an overall sand type effect indicating that the Fine and USGA sands were retaining more moisture in the top two inches than the Coarse sand or the control.

Table 5. Effect of sand type and topdressing application rate on volumetric soil moisture, 2008.

	Volumetric Soil Moisture[x]						
	%						
Sand	April 18	May 16	June 13	July 11	Aug 15	Sept 14	Oct 10
Fine	27.78 b[y]	35.77 b	26.41 b	24.03 b	24.49b	56.06 a	30.02 b
USGA	27.40 b	35.50 b	26.87 b	24.38 b	22.41bc	56.80 a	25.84 c
Coarse	26.00 b	32.97 c	23.61 c	22.38 c	20.49c	51.98 b	22.81 d
Control	32.34 a	42.26 a	35.74 a	34.52 a	34.91a	52.42 b	39.74 a
Significance	*	*	*	*	*	*	*
Rate (ft^3 $1000ft^{-2}$)							
4	29.66 b	38.12 b	30.94 b	29.53 b	28.80b	55.57 a	33.90 b
8	27.07 c	34.64 c	25.17 c	24.14 c	22.87c	55.17 a	26.17 c
12	24.46 d	31.47 d	20.79 d	17.13 d	15.71d	54.10 a	18.61 d
Control	32.34 a	42.26 a	35.74 a	34.52 a	34.91a	52.42 a	39.74 a
Significance	*	*	*	*	*	ns	*
Sand x Rate							
Fine (4)	29.74 bc	38.58 b	31.02 b	29.41 b	29.74 b	57.30 ab	36.17 b
Fine (8)	27.34 cd	35.02 cd	25.76 de	23.94 c	23.65 cd	54.74 abcd	28.79 d
Fine (12)	26.28 de	33.71 de	22.46 ef	18.73 d	20.08 d	56.12 abc	25.08 ef
USGA (4)	29.95 ab	38.51 b	31.92 b	29.88 b	29.26 b	56.86 abc	33.50 c
USGA (8)	27.91 bcd	35.72 cd	26.64 cd	24.71 c	23.04 d	57.72 a	26.28 de
USGA (12)	24.35 ef	32.26 e	22.03 f	18.57 d	14.92 e	55.81 abc	17.76 g
Coarse (4)	29.30 bc	37.28 bc	29.86 bc	29.30 b	27.40 bc	52.55 cd	32.03 c
Coarse (8)	25.95 cd	33.18 de	23.10 ef	23.76 c	21.93 d	53.03b cd	23.44 f
Coarse (12)	22.75 de	28.45 f	17.87 g	14.09 e	12.13 e	50.36 d	12.98 h
Control	32.34 a	42.26 a	35.74 a	34.52 a	34.91 a	52.42 cd	39.74 a
Significance	*	*	*	*	*	*	*

x Volumetric soil moisture was measured using a portable Trime-FM TDR probe (5 cm)

y Means in a column followed by the same letter are not significantly different

Soil Penetrometer

The soil penetrometer is used to measure the surface's resistance to displacement (Figures 3 and 4). The higher the soil penetrometer value (Newtons), the greater the surface's resistance to displacement or the firmer the surface. One of the reasons many superintendents have adopted the practice of fairway topdressing is to reduce golf course closures and cart traffic restrictions following heavy rains. There has been anecdotal evidence to suggest that fairway topdressing helps to firm the surface of fine textured, waterlogged fairways. An overall sand effect and an overall rate effect were observed in April and May (Table 6). The overall sand type effect indicated that the Fine and USGA sands were firmer than the Coarse sand and Control. The rate effect showed that the higher rates of topdressing were more firm than lower rates and the Control. The sand type effect continued into June with the Fine and USGA sands showing greater firmness than the Coarse and Control. The sand type effect from July and August showed that the Fine and USGA sands were not significantly different from the control. The coarse sand was less than the Control, Fine sand and USGA sand. The rate effect was not significant from June through October.

Figure 3. Conical head of the soil penetrometer.

Figure 4. Head of penetrometer is forced into soil surface.

Table 6. Effect of sand type and topdressing application rate on soil penetrometer values, 2008.

	Resistance to Displacement[x]						
	Newtons						
Sand	April 18	May 19	June 13	July 11	Aug 15	Sept 12	Oct 10
Fine	313.1 a[y]	550.9 a	818.1 a	819.2 a	740.9 a	752.2 a	740.1 a
USGA	327.3 a	536.8 a	797.0 ab	801.9 a	716.4 a	708.5 ab	739.1 a
Coarse	285.3 b	492.5 b	727.2 c	722.2 b	656.4 b	645.2 c	696.2 a
Control	215.4 c	442.8 c	756.3 bc	838.3 a	745.6 a	696.2 b	701.4 a
Significance	*	*	*	*	*	*	ns
Rate (ft^3 $1000ft^{-2}$)							
4	264.7 c	496.8 b	789.3 a	799.5 a	710.0 a	713.9 a	720.7 a
8	314.5 b	533.9 ab	787.0 a	786.1 a	706.0 a	709.3 a	728.5 a
12	346.3 a	549.5 a	765.9 a	757.7 a	697.8 a	682.7 a	726.3 a
Control	215.4 d	442.8 c	756.3 a	838.3 a	745.6 a	696.2 a	701.4 a
Significance	*	*	ns	ns	ns	ns	ns
Sand x Rate							
Fine (4)	277.1 de	516.5 bcd	805.5 abc	808.9 abc	743.2 ab	743.6 ab	743.7 a
Fine (8)	303.9 cd	545.9 abc	814.7 ab	829.4 ab	724.0 abc	758.8 a	734.4 a
Fine (12)	358.4 ab	590.2 a	834.0 abc	819.1 abc	755.5 a	754.2 a	742.3 a
USGA (4)	270.8 de	494.7 cde	803.9 a	838.5 a	708.1 abc	720.0 abc	727.5 a
USGA (8)	335.2 bc	545.2 abc	797.5 abc	788.5 abc	719.0 abc	716.0 abc	745.8 a
USGA (12)	375.8 a	570.5 ab	789.5 abc	778.8 abc	722.2 abc	689.4 abc	744.1 a
Coarse (4)	246.4 ef	479.1 de	758.5 bcd	751.1 bcd	678.6 bcd	678.0 bc	690.8 a
Coarse (8)	304.8 cd	510.6 cd	748.9 cd	740.4 cd	674.8 cd	653.2 cd	705.3 a
Coarse (12)	304.7 cd	487.7 de	674.2 d	675.1 d	615.7 d	604.4 d	692.4 a
Control	215.4 f	442.8 e	756.3 a	838.3 a	745.6 a	696.2 abc	701.4 a
Significance	*	*	*	*	*	*	ns

x Resistance to surface displacement was measured using a soil proving ring penetrometer
y Means in a column followed by the same letter are not significantly different

Soil Temperature

The effect of sand type and application rate on soil temperature at a 2 inch depth appears to be different for different times of the year. On July 11 when all application rates are averaged for each sand type, sand topdressing slightly reduces root zone temperatures compared to the control (Table 7). Additionally, when all sand types are averaged for each application rate, sand topdressing slightly reduces root zone temperatures compared to the control. This means that regardless of sand type and application rate, if some type of sand is applied at some rate soil temperature will be slightly reduced. On July 18 and August 29, this phenomenon is supported by a significant rate effect on each date. These data indicate that generally, the more sand that is applied, the lower the root zone temperatures. More specifically, on July 18 plots receiving 12ft^3 1000ft^{-2} had significantly lower root zone temperatures than plots receiving 4ft^3 1000ft^{-2} or the untreated Control. On August 29, plots with sand applied at the 8 and 12ft^3 1000ft^{-2} rates had lower root zone temperatures than plots receiving 4ft^3 1000ft^{-2} or the untreated Control. On September 19 and October 10 minimal differences between treatments were observed. By November, when all application rates are averaged for each sand type, sand topdressing slightly increases root zone temperatures compared to the control. Additionally, there was a significant rate effect, indicating that the more sand that was applied the greater the root zone temperature. It appears that the sand topdressing helps to moderate soil temperatures at a 2 inch depth, slightly reducing root zone temperatures in the summer and slightly increasing root zone temperatures in the fall.

Table 7. Effect of sand type and topdressing application rate on soil temperature, 2008.

	Soil Temperature^x ºC					
Sand	July 11	July 18	Aug 15	Aug 29	Sept 19	Oct 10	Nov 7
Fine	29.58 b	28.79 a	23.11 a	23.59 b	20.51 a	16.70 a	15.80 a
USGA	29.26 b	28.43 a	22.82 a	23.62 b	20.17 b	16.63 a	15.79 a
Coarse	29.53 b	28.58 a	22.93 a	23.70 b	20.30 ab	16.60 a	15.94 a
Control	30.02 a	28.86 a	22.62 a	24.04 a	20.12 b	16.60 a	14.92 b
Significance	*	ns	ns	*	*	ns	*
Rate (ft^3 1000ft^{-2})							
4	29.46 b	28.93 a	22.98 a	23.84 a	20.22 a	16.64 a	15.55 c
8	29.34 b	28.59 ab	22.94 a	23.60 b	20.34 a	16.62 a	15.90 b
12	29.57 b	28.29 b	22.94 a	23.47 b	20.42 a	16.66 a	16.08 a
Control	30.02 a	28.86 a	22.62 a	24.04 a	20.12 a	16.60 a	14.92 d
Significance	*	*	ns	*	ns	ns	*
Sand x Rate							
Fine (4)	29.40 bc	29.13 a	23.20 a	23.80 abc	20.32 a	16.60 b	15.54 d
Fine (8)	29.28 bc	28.73 a	23.18 a	23.44 de	20.46 a	16.62 b	15.85 b
Fine (12)	30.06 a	28.52 a	22.95 a	23.54 cde	20.26 a	16.86 a	16.02 ab
USGA (4)	29.45 bc	28.76 a	22.86 a	23.82 abc	20.03 a	16.66 b	15.52 d
USGA (8)	29.35 bc	28.54 a	22.76 a	23.80 abc	20.30 a	16.69 b	15.82 bc
USGA (12)	29.00 c	27.99 a	22.84 a	23.24 e	20.17 a	16.54 b	16.03 ab
Coarse (4)	29.52 abc	28.90 a	22.88 a	23.90 ab	20.32 a	16.65 b	15.59 cd
Coarse (8)	29.40 bc	28.48 a	22.88 a	23.56 cde	20.25 a	16.56 b	16.04 ab
Coarse (12)	29.66 ab	28.37 a	23.04 a	23.63 bcd	20.35 a	16.59 b	16.20 a
Control	30.02 a	28.86 a	22.62 a	24.04 a	20.12 a	16.60 b	14.92 e
Significance	*	ns	ns	*	ns	*	*

x Soil temperature was measured using a digital thermometer at a 5 cm depth
y Means in a column followed by the same letter are not significantly different

Dollar Spot Counts

The severity of dollar spot was reduced by sand topdressing. There was a significant rate effect observed in October 2007 and June 2008 (Figures 5 and 6). When all sand types are averaged for each application rate, plots receiving $12ft^3$ $1000ft^{-2}$ had significantly lower dollar spot counts than plots receiving the low and medium application rates and the Control.

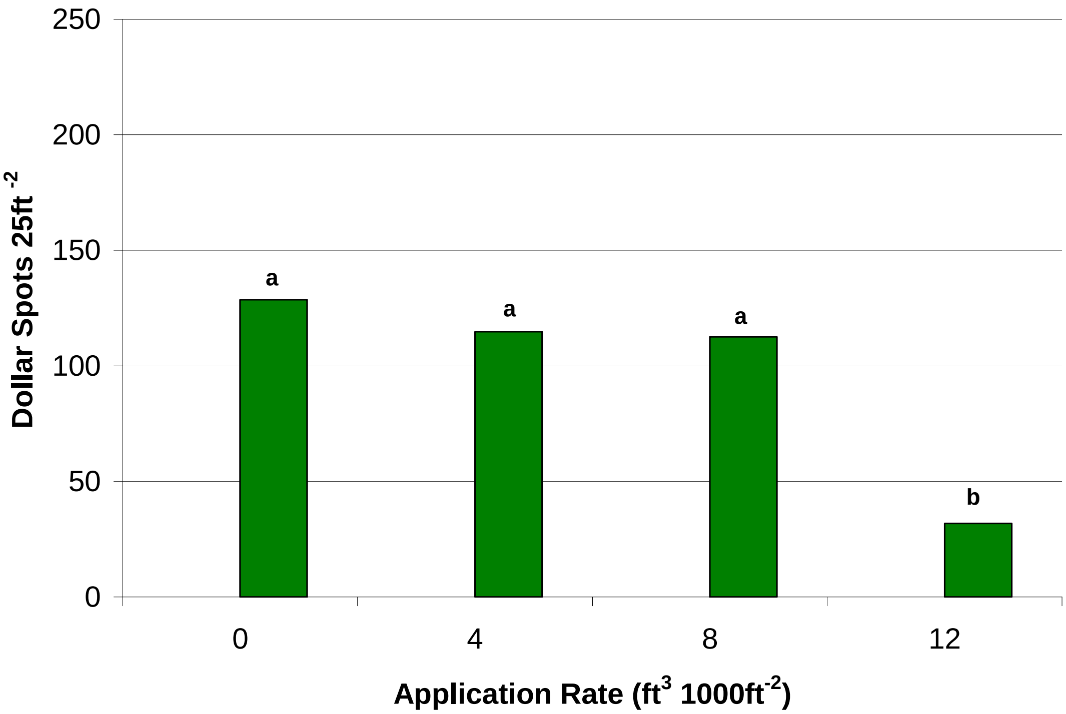

Figure 5. Overall topdressing rate effect on dollar spot counts, October 12, 2007.

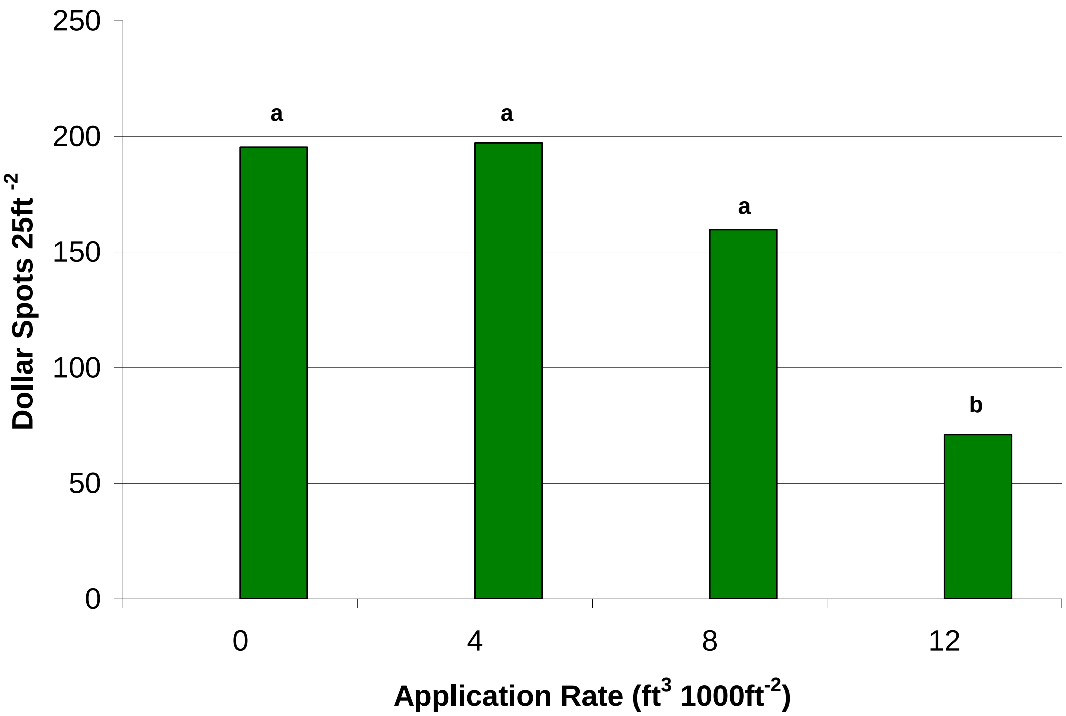

Figure 6. Overall topdressing rate effect on dollar spot counts, June 27, 2008.

Earthworm castings

Earthworm castings were reduced by sand topdressing. There was a significant rate effect observed in November 2008 (Figures 7, 8, and 9). When all sand types are averaged for each application rate, plots receiving 8 and 12 ft^3 $1000ft^{-2}$ had significantly lower earthworm castings than plots receiving the low application rate and the Control. Additionally, plots receiving 4 ft^3 $1000ft^{-2}$ had significantly lower earthworm castings than the Control.

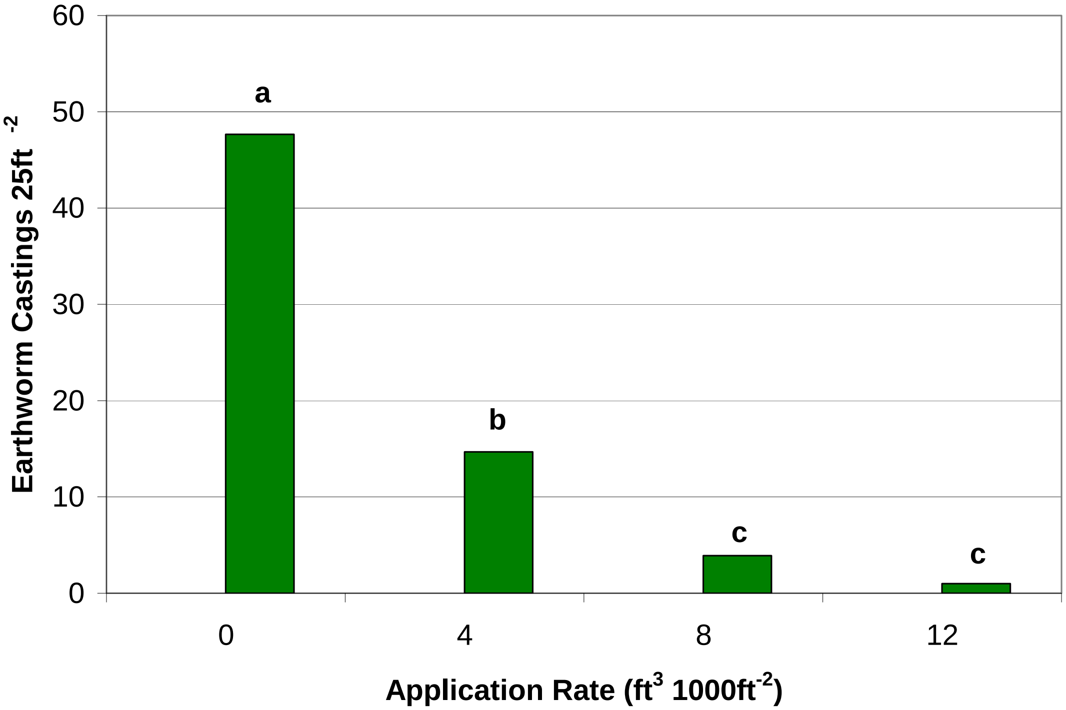

Figure 7. Overall topdressing rate effect on earthworm castings, November 12, 2008.

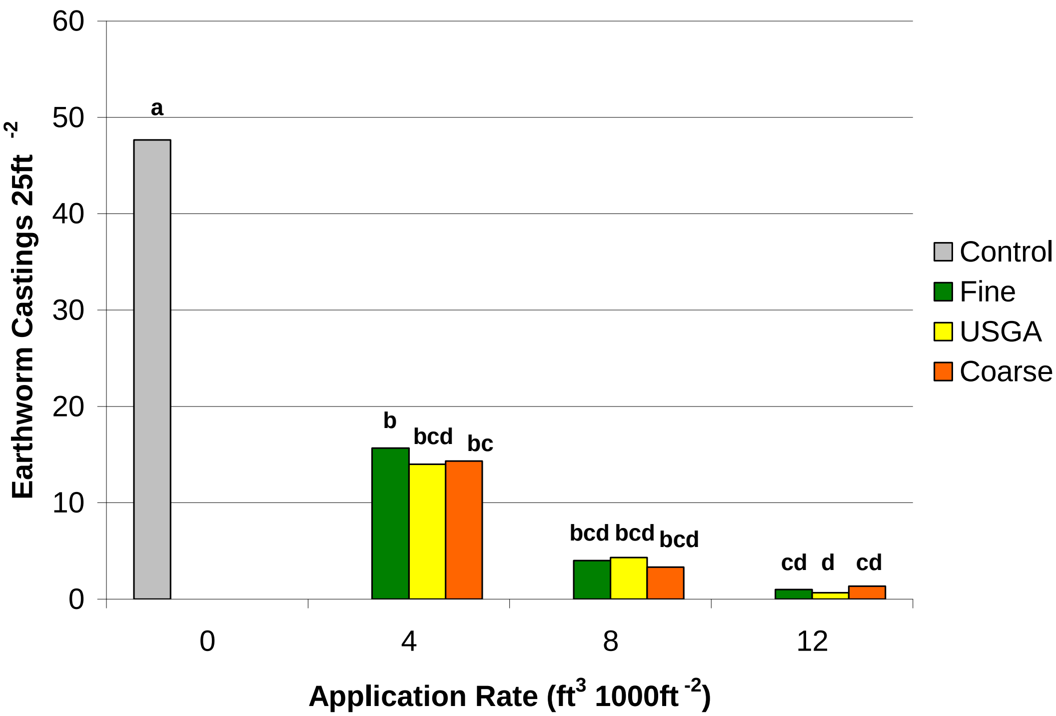

Figure 8. Topdressing treatment effects on earthworm castings, November 12, 2008.

Figure 9. A sample plot showing the reduction in earthworm casting, Fine sand applied at the high rate. Notice the untreated alley located between the plots, November 12, 2008.

Summary to Date

The results of this study are preliminary and are not conclusive due to the short duration of this research to date. Given the data collected to date, it is apparent that there are many positive effects associated with the practice of fairway topdressing including, increased turfgrass color, quality, cover, reduced surface moisture retention, firmer surfaces and root zone temperature moderation. However, this practice remains expensive, labor intensive, extremely time consuming and rough on equipment. The good news is that the majority of the responses appear to be related to application rate rather than sand type, which could result in a significant cost savings associated with sand purchases. This study will be continued as long as funding can be obtained to support further investigations. The turfgrass management implications as the topdressing layer continues to form will hopefully offer more information into this cultural practice. Please continue to work closely with your accredited laboratory to conduct all the appropriate testing procedures to select all your topdressing materials.