EFFECTS OF SURFSIDE 37 ON SALT LEACHING FROM A WATER REPELLENT SOIL

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INTRODUCTION

Water repellent soils have been observed for many years in grasslands (1) forests (2) and citrus groves (3). They have become an increasing problem on golf greens since 1960, when the United States Golf Association recommended that golf green topsoil mix should contain at least 90% sand (21). Symptoms of these water repellent soils begin as small irregular shaped areas of drought-stressed turfgrass known as localized dry spots (4,5,6,7,8,9,10,11,12,13,14,15,16,17,23). If left untreated these areas can increase in size and become excessively dry. Large areas of turfgrass can be severely damaged. Research has shown that the sand particles in the localized dry spots are covered with an organic coating, which renders them water repellent (4,5,6,7,8,9, 10,11,12,13,14,15,16,17,18,20). The problem is most evident during late spring, summer and early fall.

Currently, hand-watering, syringing, coring and the use of wetting agents are the best methods for controlling localized dry spots (4,5,6,7,8,9,10,11,12,13,14,15,16,23) caused by water repellent soils. It is generally known that wetting agents can decrease soil water repellency and increase water infiltration into water-repellent soils. However, little research has been conducted to determine other beneficial effects of wetting agents. Since wetting agents can increase water infiltration into a soil, it has been suggested they could possible aid in leaching of salts from soil. Therefore, the objective of this research was to determine the effects of Surfside wetting agent on salt leaching from a wet water repellent soil and dry water repellent soil.

MATERIALS AND METHODS

The salt leaching experiment was initiated August 22, 2004 at the University of Georgia Rhizotron and Turfgrass Facility. Twelve soil cores were pulled from an experimental golf green that was built in 1996 to USGA specifications with a topsoil mix consisting of 85% sand and 15% peat (21). The green consists of 325.2 square meters (3500 $ft.^2$) of 'Penncross' creeping bentgrass (*Agrostis stoloniferous* var. *palustris*). The green was mowed at 0.64 cm (0.25 inch) and irrigated as needed with 0.95 cm (0.375 inch) of water when sufficient rainfall did not occur. Regular maintenance practices (fertilizer and pesticide applications) were performed as needed. The topsoil mix of the green contains 1.8% organic matter and has an average soil water repellency (MED) of 2.9 at the 0.0 to 2.5 cm (0.0 to 1.0 inch) depth and 1.9 at the 2.5 to 5.1 cm (1.0 to 2.0 inch) depth.

The cores, which measured 10.2 cm diameter X 7.6 cm deep (4 inch diameter X 3 inch deep), were allowed to air dry for 7 days. After air-drying, the cores were tightly wrapped in cheesecloth to prevent soil loss. The cores were then placed in large plastic dishpans and soaked in a saline solution that had an electrical conductivity (EC) of 4.79 mS/cm. The saline solution was prepared by adding *Instant Ocean Salt* (Aquarium Systems, Mentor, Ohio) (See Appendix) to 5 liters of distilled water. While the *Instant Ocean Salt* was added to the water, a portable EC meter was used to continuously measure EC of the solution until it reached an EC of 4.79 mS/cm.

After soaking in the saline solution for 24 hours, the cores were removed from the dishpans and the cheesecloth was removed. To investigate salt leaching from a wet, water repellent soil, six cores were allowed to stand until no water dripped from the bottoms and volumetric soil water content was determined to average 20.4%. The 6 remaining cores were allowed to dry to an average volumetric soil water content of 4.1% to investigate salt leaching from a dry water repellent soil. VWC was determined by time-domain reflectometry (TDR) (19). A single pair of stainless steel rods was inserted into the side of the cores (2.5 cm depth) at a parallel distance of 1.9 cm (0.75 inch). The rods were 5.1 cm (2.0 inches) in length and had a diameter of 0.32 cm (0.13 inch). Soil electromagnetic capacitance was determined by pulsing a wave down the soil probes with a Trime-FM (Mesa Systems Co., Framingham, MA). The Trime-FM monitored the reflectance pattern and converted the readings into VWC (% volume/volume). The VWC readings were recorded from the LCD data screen on the Trime-FM.

After drying to the appropriate VWC, the cores were trimmed to a depth of 5.1 cm (2.0 inches) and placed in pots with non-water repellent soil. Pots, which measured 25.4 cm diameter X 25.4 cm deep (10 inch diameter X 10 inch deep), were filled with air-dried, non-water repellent soil (85% sand and 15% peat, VWC = 1.5%, EC = 44 uS/cm) to a depth of 19 cm (7.5 inches) and packed to a bulk density of 1.4 g/cm^3. The cores were placed on top of the non-water repellent soil in the center of the pots. Additional non-water repellent soil was placed around the cores until it reached the same level as the top of the cores. The non-water repellent soil around the cores was also packed to a bulk density of 1.4 g/cm^3.

After the pots were prepared, treatments were applied with a CO_2 backpack sprayer. The following treatments were applied:
1. Surfside 37 - 152.8 l/ha (48 oz./1000 $ft.^2$) in 814.9 liters of water/ha (2.0 gallons/1000 $ft.^2$)
2. Control - 814.9 liters of water/ha (2.0 gallons/1000 $ft.^2$).

Each pot was placed into a separate plastic dishpan. Pots were irrigated with tap water in 0.64 cm (0.25 inch) increments until leachate began flowing from the bottoms. Once leachate appeared at the bottoms of the pots, one-half the amount of water needed to reach that stage was determined. That amount of water was then applied in 0.64 cm (0.25 inch) increments to each pot to ensure the pots were completely flushed. A total of 8.9 cm (3.5 inches) of water was applied to the pots that contained the wet cores and a total of 9.5 cm (3.75 inches) of water was applied to the pots that contained the dry cores. Each pot and matching dishpan was covered with a plastic bag to prevent evaporation. Pots were allowed to completely leach for 24 hours.

Leachate was collected from the dishpans and total leachate from each pot was measured. A sample of each leachate was sent to the University of Georgia Soil Testing Laboratory for EC measurements. Five soil cores were pulled from the water repellent cores in the center of each pot using 1.3 cm (0.5 inch) diameter PVC pipe that had been cut into 15.24 cm (5 inches) lengths. Each soil core was removed from the PVC pipe and sectioned into 2.5 cm (1.0 inch) increments to a depth of 10.2 cm (4.0 inches) (i.e. 0-2.5 cm, 2.5-5.1 cm, 5.1-7.6 cm and 7.6-10.2 cm). The 2.5 cm (1.0 inch) soil increments were combined into one bulk sample per 2.5 cm (1.0 inch) increment per pot and allowed to air-dry for 48 hours. After drying, 100 grams of each sample was retained for soil water repellency testing. The remaining amount of each soil sample was sent to the University of Georgia Soil Testing Laboratory for EC measurements.

Soil water repellency of the 0.0 to 2.5 cm (0.0 to 1.0 inch) depth and 2.5 to 5.1 cm (1.0 to 2.0 inch) depth of each core was determined by the molarity of ethanol droplet test (22). Samples were dried for 24 hours in an oven at 35 C (95 F). After drying, samples were removed from the oven and allowed to equilibrate to room temperature [21.1 - 23.9 C (70 -

75 F)} and humidity (60 - 65%). Samples were sieved through a 2 mm (#10 United States Standard Series) mesh screen and the MED test was performed on the sieved, dried soil.

The soil was placed in a 5 cm (2.0 in.) diameter X 1 cm (0.39 in.) deep dish to provide a uniform surface and depth. A series of 40 uL aqueous ethanol droplets at 0.4 M intervals were placed on the soil surface. The molarity of the droplet that completely infiltrated within 5 seconds was recorded as the soil MED value (0 = non-water repellent, 4 = extremely water repellent). Experimental design was completely randomized with three replications per treatment. Data were subjected to analysis of variance (ANOVA) procedures with treatment means separated by Duncan's Multiple Range Test at the 0.05 level of probability.

RESULTS AND DISCUSSION

Dry Soil Cores

Dry, water repellent soil treated with Surfside 37 had lower EC readings at the 0.0 to 2.5 cm (0.0 to 1.0 inch) depth and 2.5 to 5.1 cm (1.0 to 2.0 inch) depth (Table 1), as compared to the control. Lower EC readings at these depths indicate the presence of less salt. No differences in EC were detected between the Surfside 37 treated soil and the control at the 5.1 to 7.6 cm and 7.6 and 10.2 cm depths (Table 1). However, soil at these depths was below the 5.1 cm core that was soaked in the saline solution.

Electrical conductivity of the leachate collected from the Surfside 37 treated pots was not different than the EC of the leachate collected from the control pots (Table 2). However, a significantly larger amount of leachate was collected from the Surfside 37 treated pots (Table 3). This indicates that Surfside 37 treated soil allows more water to infiltrate through the soil profile. The higher volume of leachate likely diluted the solution, thus no difference in EC was detected between the Surfside 37 treated pots and the control pots.

Soil water repellency of the Surfside 37 treated water repellent soil was lower than the control at the 0.0 to 2.5 cm and 2.5 to 5.1 cm depths (Table 4). The reduction in soil water repellency allowed more water to infiltrate through the Surfside 37 treated soil. Therefore, the higher volume of water passing through the soil was able to remove more salt from the Surfside 37 treated soil.

Wet Soil Cores

No differences in EC were detected at any depth between the Surfside 37 treated pots and the control pots (Table 5). Therefore, the results indicate that the same amount of salt was removed from both the Surfside 37 treated soil and the untreated soil (control). Past research has shown that water can easily infiltrate wet, water repellent soil. Since the water repellent soil used in this experiment was wet, enough water was able to pass through to lower the amount of salt to a level comparable to the treated soil.

Electrical conductivity of the leachate collected from the Surfside 37 treated pots was not different than the EC of the leachate collected from the control pots (Table 6). However, a significantly larger amount of leachate was collected from the Surfside 37 treated pots (Table 7). This indicates that Surfside 37 treated soil allows more water to infiltrate through the entire soil profile. The higher volume of leachate likely diluted the solution, thus no difference in EC was detected between the Surfside 37 treated pots and the control pots.

Soil water repellency of the Surfside 37 treated water repellent soil was lower than the control at the 0.0 to 2.5 cm depth (Table 8). However, no difference in soil water repellency was detected between the treated and untreated soil at the 2.5 to 5.1 cm depth (Table 8). Past research has shown that excessive rainfall or irrigation can temporarily lower the water repellency of a water repellent soil. Excessive water is believed to physically remove and/or rehydrate some of the organic coating on the sand particles, thus allowing it to be leached away. The soil water repellency of the untreated soil at the 2.5 to 5.1 cm depth was 0.0 (Table 8). This indicates that most of the organic coating was probably removed when the pots were flushed with the large volume of water.

SUMMARY

Under the conditions of this study, the data indicate that Surfside 37 can promote leaching of salt from a dry, water repellent soil. However, when water repellent soil is wet, Surfside 37 has very little effect on salt leaching. The data also indicate that Surfside 37 does lower soil water repellency and facilitates the movement of water through a soil profile.

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APPENDIX

Composition of *Instant Ocean Salt* (Aquarium Systems, Mentor, Ohio)

Constituent	Percent By Weight
Cl	55.07
Na	30.62
SO_4	7.72
Mg	3.68
Ca	1.17
K	1.10
HCO_3	0.40
Br	0.19
Sr	0.02
B	0.01
F^-	0.01

Table 1. Electrical conductivity of dry water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	Depth (cm) 0.0-2.5	2.5-5.1	5.1-7.6	7.6-10.2
	Electrical Conductivity (uS/cm)			
Surfside - 152.8 l/ha	101.7b*	48.3b	35.7a	31.3a
Control	250.0a	100.3a	59.0a	50.7a

*Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 2. Total leachate collected from dry water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	Leachate Amount (ml)
Surfside - 152.8 l/ha	1525.0a*
Control	1250.0b

*Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 3. Electrical conductivity of leachate collected from dry water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	Electrical Conductivity (uS/cm)
Surfside - 152.8 l/ha	312.0a*
Control	349.0a

*Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 4. Soil water repellency of dry water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	------Depth (cm)----- 0.0-2.5	2.5-5.1
	-Soil Water Repellency[1]-	
Surfside - 152.8 l/ha	1.1b[2]	0.0b
Control	3.1a	1.7a

[1]Soil Water Repellency - 0.0 to 4.0 (0.0 = non-water repellent and 4.0 = extremely water repellent).
[2]Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 5. Electrical conductivity of wet water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	----------Depth (cm)---------- 0.0-2.5	2.5-5.1	5.1-7.6	7.6-10.2
	----------Electrical Conductivity (uS/cm)----------			
Surfside - 152.8 l/ha	80.3a*	43.0a	43.7a	46.7a
Control	69.0a	38.5a	60.0a	89.0a

*Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 6. Electrical conductivity of leachate collected from wet water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	Electrical Conductivity (uS/cm)
Surfside - 152.8 l/ha	457.0a*
Control	561.0a

*Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 7. Total leachate collected from wet water repellent soil after leaching as affected by Surfside 37 wetting agent.

Treatment	**Leachate Amount (ml)**
Surfside - 152.8 l/ha	1553.3a*
Control	1260.0b

*Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.

Table 8. Soil water repellency of wet water repellent soil after leaching as affected by Surfside 37 wetting agent.

	------Depth (cm)------	
Treatment	**0.0-2.5**	**2.5-5.1**
	-Soil Water Repellency[1]-	
Surfside - 152.8 l/ha	0.0b[2]	0.0a
Control	3.1a	0.0a

[1]Soil Water Repellency - 0.0 to 4.0 (0.0 = non-water repellent and 4.0 = extremely water repellent).
[2]Means in the same column joined by the same letter are not different at the 0.05 level of probability according to Duncan's Multiple Range Test.