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Timing soil surfactant applications

Their effect on soil water repellency

By Chris Miller

The past seven years saw dramatic improvements in the diversity and quality of soil surfactant products offered to turfgrass managers. Many of today's surfactants are more effective than their earlier cousins for both treatment and management of localized dry spot symptoms, as well as enhancing penetration of water into the soil profile. With more and more golf course superintendents and athletic field managers using surfactants (wetting agents), demands have been made on manufacturers to provide flexible application regimes to fit into busy schedules.

Trials were conducted on a Penncross creeping bentgrass nursery green at Metedeconk National Golf Club in Jackson, NJ. The soil was a USGA-type sand with a history of soil water repellency related problems.

Due to the natural biodegradation of these surfactant materials in the soil profile over time (Swisher, 1986), surfactant applications have traditionally been made on a somewhat regular basis (ex. monthly) in order to maintain acceptable levels of product performance. Several manufacturers, however, have introduced surfactants that can be applied less frequently, with claims of extended periods of optimal performance between applications. For example, for golf course superintendents in the Northeast or the Midwest, extended performance from such products could translate into a single spring surfactant application resulting in management of soil water repellency that lasts the entire growing season.

Developed for application convenience and the option they give turf managers to treat on a less frequent basis, the marketplace has seen a proliferation of surfactant products available in recent years. However, little research has been conducted on these products to evaluate their effect on soil water repellency (the major cause of localized dry spot symptoms) from the time they are applied to the time when they ultimately biodegrade in the soil. While surfactants applied on a more frequent basis have been proven to maintain consistent performance over time in terms of soil water repellency reduction (Kostka et. al., 1997), questions have arisen as to how long these long-term products ultimately last once applied.

In an effort to answer some of these questions, research was performed that evaluated several different timing regimes for surfactant application, with investigation of application

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frequencies ranging from once per month to applications made one time only. It is hoped that this research will give a better understanding of the implications of surfactant application timing, leading turf managers to make more educated decisions on surfactant use for their operations.

Causes and significance of soil water repellency

Water repellent (hydrophobic) soils have been encountered in a variety of situations not exclusive to highly cultivated turfgrass. Water repellent conditions can occur in uncultivated sandy soils (Tucker, et.al. 1990), and have been reported in grassland soils in Australia (Bond, 1968), as well as burned over areas of forest soils (Osborn et al 1964). However, the most frequent occurrences are in turfgrass areas, particularly those areas situated in sand-based soils (York and Baldwin, 1992). Causes of soil water repellency are still not completely understood. However, there is evidence that microbial breakdown of organic substances (peat moss, roots, shoots), as well as fungal activity in the soil, leads to a wax-like coating of sand particles. Once these coatings dry out, they become extremely water repellent, and rewetting of the soil profile can be difficult. (Karnok and Tucker, 1999)

Drying out of the soil profile and the organic coatings on sand grains is a likely scenario in sand-based soils, due to their relatively poor water holding capacity and frequent wet-to-dry cycles. Wet-to-dry cycles may be triggered by turf managers intentionally (ex. promoting firmness or playability of a surface between irrigation cycles), or may be beyond their control (ex. insufficient irrigation or rainfall in times of excessive plant water use).

Water repellency typically develops in a turf stand 6 to 18 months after establishment, subsequently, it remains in the soil profile, to varying degrees (Karnok & Tucker, 1999). Because of these varying degrees of water repellency across the area of a turf stand, certain sections within the stand may be more prone to exhibit symptoms associated with it. If not managed properly in times of high stress and evaporative demand, sections of turf more severely affected by water repellency will begin to exhibit wilting symptoms and discoloration, primarily due to lack of infiltration and retention of water. These wilted, discolored patches of turf may lie directly adjacent to healthy areas of turf seemingly unaffected by this problem. Since these symptoms of water repellency are typically seen in a patchwork pattern, they are commonly referred to as localized or isolated dry spots.

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It is usually not until these localized dry spots develop, that turf managers begin to notice soil water repellency. A turf manager may not know the potential for a soil to develop water repellency related problems if irrigation practices or natural rainfall prevent the soil from drying to critical moisture levels that encourage its development. Measurement of the severity of the soil water repellency can give the turf manager an indication of the potential for problems associated with it to develop. Water repellent soils in turfgrass areas are most commonly found in the top 2 inches of the soil profile due to most of the root growth and microbial activity being situated in this area (Miller, 1998). Its severity can easily be measured by the water droplet penetration test. Once water repellency severity is assessed, management solutions can be implemented – with the most common being treatment with soil surfactants.

Measurement of severity of soil water repellency

A simple assessment to determine the severity of soil water repellency can be made using the water droplet penetration test. To conduct the test, extract a soil core

(2 cm/ 1 inch diameter is ideal) from a designated turf area to a depth of at least 10 cm. After allowing the core to air-dry for about a week, lie the soil core horizontally, then place small water droplets (about 0.5 cm in diameter) at 1 cm intervals (about 0.5 inches) along the length of the soil core surface, beginning at the thatch-air interface. With water repellent soils, water will bead up on the soil like rain on a freshly waxed car, and not penetrate into the soil. If the soil is minimally water-repellent, the drop should penetrate the soil within 25 seconds. Droplets that do not penetrate within 25 seconds signify soils that may have a tendency to develop water repellency related problems. The more water repellent the soil, the higher the amount of time needed for the drop to penetrate the soil. It should be noted that due to the inherent variability in the levels of soil water repellency inside a given turf area, several samples from different sections of a particular area should be taken to give an overall picture of the area's true water repellency potential.

Addressing soil water repellency

Due to the constant root growth, decomposition of organic matter, and microbial activity in the soil profile that coincides with normal turf growth, materials with the potential to become water repellent are constantly being produced, therefore the eradication of soil water repellency is not realistic. For the turf manager, especially those with sand-based soils, management of the problem is the only alternative. Management options include incorporation of soil amendments, modification of irrigation practices, and cultivation. But, for many turf managers, use of soil surfactants provides the most practical option.

After applying soil surfactants to a turfgrass area, surfactant molecules are chemically attracted to soil particle surfaces where organic acid coatings produced by organic matter breakdown and microbial activity are present. Surfactant molecules then chemically bind to these organic coatings, leaving a portion of the soil surfactant molecule exposed that is hydrophilic, or attracted to water. After this, subsequent irrigation or rainfall, instead of running off or through the soil profile, is more easily maintained in the turf stand, and water repellency related symptoms can be addressed, or even prevented.

TABLE 1.

Treatment [x]	Treatment Application				
	0 Mos.		1 Mo.	2 Mos.	3 Mos.
	5/25	6/1	6/25	7/27	8/30
A. *Primer / 6 oz.*	*Yes* [y]	—	*Yes*	*Yes*	*Yes*
B. *Product B / 8 oz.*	*Yes*	*Yes*	—	—	—
C. *Product C / 8 oz.*	*Yes*	*Yes*	—	—	—

Short-term vs. long-term surfactants

Because of their proficiency in binding to water-repellent surfaces of soil particles, surfactants are effective for preventing the occurrence of water repellency related symptoms. Turf managers can apply soil surfactants to drastically reduce the amount of localized dry spot that is seen at their operation, often resulting in a reduction in hand watering or irrigation.

The trials demonstrate that monthly surfactant application at rates of 4 to 6 oz. per 1,000 sq. ft. can effectively maintain low levels of water repellency in the soil profile.

Today's turfgrass professionals have many soil surfactant products at their disposal. Due to the biodegradation of surfactant products applied to soils, many products have been designed to be applied on a regular basis (every 3 to 4 weeks). The basis of regular application of these materials is the maintenance of effective levels of the surfactant molecules in the soil profile. These products, 'short-term' surfactants, are typically applied to turf at rates ranging from 3 to 8 oz. of product per 1000 sq. ft.

Surfactant applications every three to four weeks may not be practical for some turf managers. Soil surfactant manufacturers have recently addressed this issue, and have introduced products that can be applied on a less frequent basis. These "long-term" surfactants are typically applied at higher rates than their "short-term" counterparts. With application rates usually ranging from 8 to 16 oz. of product per 1000 sq. ft., long-term surfactant products come with label claims of management of water repellency related problems lasting from 3 months, to an entire season.

Timing surfactant application

In an effort to answer some of the questions on how long both long-term and short-term surfactant products last once they are applied, research was performed that evaluated several different timing regimes for surfactant application.

Two trials were conducted: the first involved application of both short-term and long-term surfactants and evaluated the effect of these treatments on soil water repellency over the course of a four-month period. The second trial involved regular application of short-term surfactants at varying time intervals, also with evaluation of the treatments' effect on soil water repellency over the course of a four-month period.

TABLE 2.

SURFACTANT TREATMENTS / DATES OF APPLICATION - TRIAL 2. METEDECONK NATIONAL GC, 1999

Treatment ˣ	Treatment Application				
	0 Mos.	1 Mo.		2 Mos.	3 Mos.
	5/25	6/25	7/8	7/27	8/30
A. *Primer / 6 oz.*	*Yes*	*Yes*	—	*Yes*	*Yes*
D. *Primer / 4 oz.*	*Yes*	—	*Yes*	—	*Yes*
E. *Primer / 6 oz.*	*Yes*	—	—	*Yes*	—

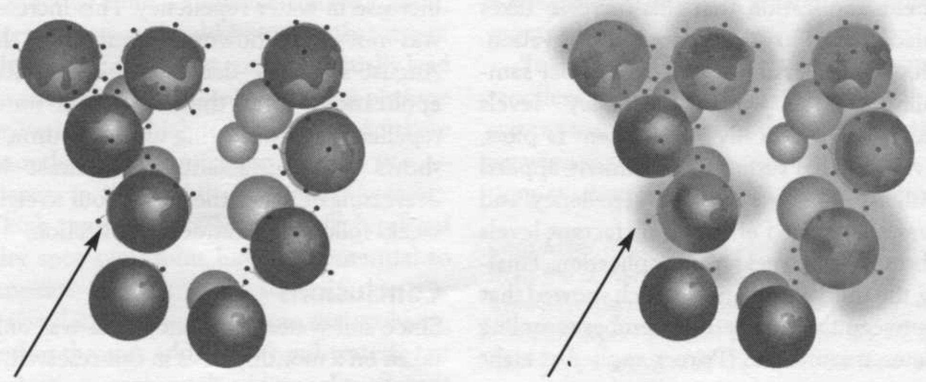
x = Rates for each treatment per 1000 sq. ft. Each treatment applied in a spray volume of 2 gal. per 1000 sq. ft. Letters preceding treatments are for reference only.

Both trials were conducted at the same site, a Penncross creeping bentgrass nursery green at Metedeconk National Golf Club in Jackson, NJ. The soil was a USGA-type sand with a history of soil water repellency related problems. Surfactant treatments were applied to 6-by-6-ft. plots (arranged in a randomized complete block design) using a backpack CO^2 sprayer calibrated to deliver two gallons of water per 1000 sq. ft. To measure water repellency, soil cores were taken from each plot area on a monthly basis. The first set of soil cores was taken immediately prior to initial treatment application and the final set of soil cores was taken one month after the final treatment applications. Soil cores were air-dried and subjected to the water droplet penetration test (Letey, 1969) at 1 cm intervals beginning at the thatch-air interface. Data was subjected to analysis of variance (ANOVA) and significant means among treatments were separated using Duncan's multiple range test.

TRIAL 1 - SHORT TERM VS. LONG TERM

Treatments and their application frequencies are listed in Table 1. Primer treatments, representative of short-term surfactant chemistries, were applied on a monthly basis at a rate of 6 oz. per 1000 sq. ft. Both Product B and Product C, representative of long-term surfactant chemistries, were applied at the initiation of the trial in two separate applications of 8 oz. per 1000 sq. ft., each spaced one week apart (16 oz. total). No further applications of either Product B or Product C were made during the remainder of the trial.

Water repellency data is illustrated in graphical form in Figure 1. This uppermost region of the soil profile, represented by this graph, was where the most severe water repellency was found in this trial. Throughout the first two months of the trial — May and July — all surfactant treatments maintained lower levels of water repellency than those found in the control plots. As the trial progressed through August and September, water repellency in the plots began to increase, as evidenced by the high water droplet penetration times seen in the control plots. Throughout the trial, the Primer treatment, applied monthly, maintained significantly lower levels of water repellency than in the control plots. However, during the months of August and September, significant increases in water repellency were observed in plots treated with Prod-



Soil surfactant applications enable previously water repellent areas of the soil profile to retain moisture, resulting in the management of water repellency related symptoms such as localized dry spot.

ucts B and C. This is evidence that, despite the high rates applied in May, levels of Product B and Product C were not adequate to maintain a low level of soil water repellency during the months of August and September.

TRIAL 2 – APPLICATION OF SHORT-TERM SURFACTANTS AT VARYING TIME INTERVALS

Treatments and their application frequencies are listed in Table 2. In this second trial, Primer was applied at three different timing intervals, monthly (treatment A), every six weeks (treatment D) and every eight weeks (treatment E). Initial treatment applications coincided with initial treatments applied in Trial 1, applied May 25, with subsequent applications made over the course of a four-month period.

Water repellency data for Trial 2 is illustrated in in the graph in Figure 2. This graph represents the portion of the soil profile where the most severe water repellency was found. Throughout the first two months of the trial — May to July — all surfactant treatments were able to maintain lower levels of water repellency than those found in the control plots. Water repellency in the plots began to increase in August and September, as is evidenced by the high water droplet penetration times seen in the control plots during these two months. The monthly Primer treatment maintained a significantly lower level of water repellency than the control plots throughout the trial. However, during the months of August and September, plots treated with Primer on a less frequent basis showed inconsistent results.

Plots treated every six weeks with Primer (treatment D) showed a drastic increase in water repellency between the July and August sampling dates. This is evidence that between the period from two weeks to six weeks after treatment D application, the surfactant level in the soil was diminishing. At the rates in treatments D and E, it's likely that surfactant levels start to diminish in the soil and lose efficacy between four and eight weeks .

This hypothesis is based on three observations from Trial 2. First, data from the July sampling date for treatment D showed low water repellency levels, evidence the treatment is maintaining effective surfactant levels at least through two weeks after treatment application. Between the July and August sampling dates (two and six weeks after application of treatment D), water repellency levels greatly increase. It is most likely at least four weeks after treatment application that this increase takes place, due to the second observation. Between the August and September sampling dates, water repellency levels decreased drastically in treatment D plots, evidence that surfactant treatment, applied August 30, lowered water repellency, and was maintained effective surfactant levels through four weeks after application. Finally, the third observation, which showed that between the July and September sampling dates, treatment E (Primer applied at eight week intervals) also showed a dramatic increase in water repellency. This increase was not seen, however, until after the August sampling date, four weeks after application With the increase in water repellency not occurring until this time, it shows that surfactant levels must be decreasing between the period four to eight weeks following treatment application.

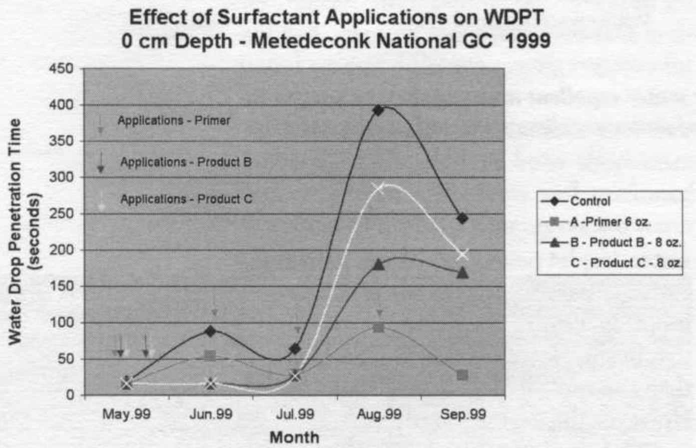


Figure 1. The effect of 'long term' surfactant applications (Products B and C) and primer soil surfactant on the time (in seconds) for water drop penetration into air-dried soil cores (Metedeconk National Golf Club, Jackson, NJ—1999)

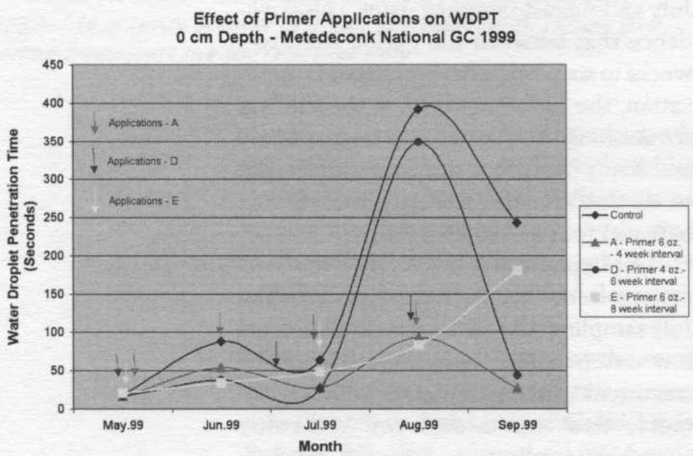


Figure 2. The effect of timing of Primer soil surfactant applications on the time (in seconds) for water droplet penetration into air-dried soil cores (Metedeconk National Golf Club, Jackson, NJ—1999)

Conclusions

Since soil water repellency data was only taken on a monthly basis in this research, it is difficult to pinpoint the exact time when soil surfactant levels, either short-term or long-term, diminish to the point of decreased performance. At application rates of 4 to 6 oz. per 1000 sq. ft., evidence points to this time as being between four to eight weeks after application. At application rates higher than this, which were investigated in Trial 1 with Products B and C, it would naturally be expected that the time to decreased performance would be greater. While this is true, at this test site, data from trial 1 suggest that effective levels of these 'long-term' surfactants are only sustained in the soil from two to three months after application.

What does this research mean to the turf manager? With the advent of long-term surfactants in the marketplace, today's turf managers have a number of options at their disposal to help with the management of soil water repellency and the problems associated with it. Turf managers should be aware of the pros and cons associated with each of these options, the two most common being regular monthly surfactant application and less frequent or 'one-time' application of long-term surfactants.

The research from these trials demonstrates that monthly surfactant application at rates of 4 to 6 oz. per 1000 sq. ft. can effectively maintain low levels of water repellency in the soil profile. Through regular monthly applications, turf managers can be confident that adequate surfactant levels in the soil will be maintained that will manage the symptoms associated with this water repellency such as localized dry spot.

While applications of surfactants on a

less frequent or 'one-time' basis may be attractive from a convenience standpoint, turf managers should be aware that use of this type of surfactant could potentially lead to problems. If the biodegradation of these materials — which took place two to three months after application at this site — occurs in the middle of stressful weather (high temperatures, low rainfall) localized dry spot symptoms have the potential to appear. At that point, the turf manager must decide how to manage the problem, either through additional hand-watering or irrigation, or through additional surfactant applications.

Soil water repellency and the problems that go with it will always be present, a consequence of growing healthy turfgrass. If application of long-term surfactants at high rates is the method of choice to help manage this problem, the turf manager should be aware that additional applications might ultimately be necessary to maintain acceptable levels of performance, especially if the growing season is greater than three months long.

To maintain low levels of soil water repellency and manage the associated symptoms, regardless of the length of the growing season monthly surfactant applications at lower rates may be the best option.

Chris Miller holds a BS in plant and soil science from the University of Delaware and a MS from Michigan State University. He was an assistant superintendent at Franklin Hills CC in Michigan, then worked for Aquatrols for five years, until the end of 2000, as senior research agronomist, responsible for overseeing and organizing turfgrass related research involving the company's product line as well as new products. He now teaches computer programming at Computer Learning Centers, Inc. in Cherry Hill, NJ.

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