BY JOHN R. STREET AND DEBORAH D. HOLDREN

The fertilzer/disease link

How nitrogen source, rate and timing application method effect creeping bentgrass quality and dollar spot

Dollar spot *(Sclerotinia homoeocarpa)* is a major problem on high maintenance turfgrasses such as bentgrass (*Agrostis palustris* Hudollar *spot*), annual bluegrass (*Poa annua*), Kentucky bluegrass (*Poa pratensis* L.) and perennial ryegrass (*Lolium perenne* L.).

Foliar and granular fertilization programs were compared on bentgrass performance and dollar spot incidence at various nitrogen rates and application frequencies. The granular fertilizer source consistently resulted in lower color ratings than the foliar sources. Good to excellent color responses didn't always result in acceptable dollar spot suppression; however, foliar fertilization consistently resulted in less dollar spot than comparable granular treatments. Foliar sources provided dollar spot suppression for at least 70 to 80 days and 154 days without fungicide at 0.25 of a pound of N/M weekly (every seven days) in 2004 and 2005, respectively.

This research suggests foliar feeding with sufficient nitrogen can reduce dollar spot severity and potentially result in less fungicide use.

PREMISES AND OBJECTIVES

Dollar spot continues to be problematic on high maintenance turfgrasses such as bentgrass, annual bluegrass, Kentucky bluegrass and perennial ryegrass. As such, golf course superintendents reportedly spend more money on fungicides to control dollar spot than for any other turfgrass disease (Vargas, 1994).

Superintendents managing bentgrass fairways are reporting more intense dollar spot pressure and increased difficulty in dollar spot control. Many reasons for these problems have been hypothesized, including resistance in field populations of *S. homoeocarpa* to chemicals, lower nitrogen fertility programs, fungicide interactions and plant growth regulator use.

Chlorothalonil has been used as a standard contact fungicide for dollar spot management throughout the years. Recently, chlorothalonil use by golf courses has been restricted to a certain seasonal limit. This restriction has significantly influenced superintendents' fungicide-usage programs and their chemical family alteration strategies for dollar spot management.

The purpose of this research project was to:

1. Reiterate previous Ohio State research about the effects of nitrogen fertilization rate, (light rates vs. traditional heavier rates), frequency (seven-day vs. 14-day application schedule) and application method (foliar feed vs. granular feed) on bentgrass quality and dollar spot severity; and

2. Determine the latter interactions on dollar spot incidence, fungicide efficacy, reduced fungicide rates and extended fungicide application intervals.

Table 1. Fertilizer rates, frequencies and timings

N rate		Frequency	Total N / month	
lb N/M	kg N/ha		lbs N/M	kg N/ha
0.175	8.6	weekly	0.70	34.4
0.25	12.2	weekly	1.0	48.8
0.35	17.1	biweekly	0.70	34.4
0.50	24.4	biweekly	1.0	48.8
Untreated check	---	--	--	--

Fertilizer treatments received either no fungicide, half rate or full rate "predisease" applied at 30-day intervals beginning May 11, 2004 and May 26, 2005.

MATERIALS AND METHODOLOGY

This study was conducted in 2004 and 2005 at the Ohio Turfgrass Foundation Research and Education Facility at The Ohio State University in Columbus, Ohio. The study was a randomized complete block design with three replications. The creeping bentgrass cultivar was 'Lopez'.

Four fertilizers (three liquid and one granular), four nitrogen rates and two timing frequencies were used (Table 1). The granular fertilizer Tee Time 20-4-12 (The Andersons) was applied using a drop spreader. The liquid and water-soluble fertilizers were applied using a CO_2 pressurized sprayer using two flat-fan nozzles calibrated to deliver two gallons per 1,000 square feet.

Tee Time is a granular fertilizer containing 1 percent polymer – coated ammoniacal nitrogen – and 19 percent urea nitrogen with 12 percent of the urea as microprilled sulfur-coated urea. Bulldog 28-8-18 is a dry, water-soluble fertilizer with 2.1 percent ammoniacal nitrogen, 5.4 percent nitrate nitrogen and 20.5 percent urea nitrogen for liquid/foliar feeding.

ACLF 20-2-1 and HPF 19-1-1 (Agro-Culture Liquid Fertilizers) are liquid fertilizers also designed for liquid/foliar feeding composed of urea, nitrate and ammoniacal nitrogen with micronutrients.

The nitrogen rates were 0.175 of a pound of nitrogen per 1,000 square feet and 0.25 of a pound of nitrogen per 1,000 square feet applied every seven days, and 0.35 of a pound of nitrogen per 1,000 square feet and 0.5 of a pound of nitrogen per 1,000 square feet applied every 14 days.

Chlorothalonil (Daconil Ultrex) was split across the fertilizer source/rate/timing treatments as no-fungicide, half rate (1.625 ounces per 1,000 square feet), and full rate "predisease" (3.25 ounces per 1,000 square feet), resulting in 54 total treatments. Applications were made on about a 30-day treatment schedule beginning May 11 and ending Sept. 14, 2004, and again on May 26 and ending Sept. 30, 2005.

Additionally, on April 27, 2005, a preseason preventive rate of chlorothalonil was applied as a blanket application to the entire study. This preseason application was designed to bring all plots to 0 percent prior to 2005 treatments.

Mowing was performed three times a week (Monday, Wednesday and Friday) using a Toro 3100 triplex mower with a bench setting of 0.5 inch, and clippings were removed. The site was irrigated regularly to prevent wilt. Insecticide

Table 2. Dollar spot severity as affected by nitrogen source, rate and application frequency

			% Dollar Spot					
Fertilizer source	N rate (kg ha^{-1}	Timing	Aug. 2, 2004			Sept. 22, 2005		
			No fungicide	Half	Full	No fungicide	Half	Full
Tee Time	8.6	7 day	56.7	33.3	20	25	21.7	11.7
ACLF	8.6		20	16.7	10	21.7	20	8.3
Bulldog	8.6		8.3	10	5	16.7	11.7	8.3
HPF-N	8.6		18.3	15	11.7	16.7	11.7	6.7
Tee Time	12.2	7 day	46.7	31.7	18.3	28.3	28.3	18.3
ACLF	12.2		1.7	1.7	0	11.7	8.3	3.3
Bulldog	12.2		0	0	0	1.7	1.7	0
HPF-N	12.2		1.7	0	0	6.7	1.7	1.7
Tee Time	17.1	14 day	46.7	21.7	23.3	33.3	25	18.3
ACLF	17.1		21.7	20	13.3	28.3	25	16.7
Bulldog	17.1		26.7	13.3	8.3	21.7	13.3	10
HPF-N	17.1		28.3	16.7	18.3	20	18.3	11.7
Tee Time	24.4	14 day	30	20	16.7	26.7	25	16.7
ACLF	24.4		20	10	6.7	25	18.3	10
Bulldog	24.4		18.3	8.3	3.3	1.7	0	0
HPF-N	24.4		21.7	6.7	6.7	10	8.3	3.3
Unfertilized	–	–	46.7	35	26.7	30	25	18.3
			LSD (0.05) 10.52			LSD (0.05) 12.56		

applications were made for cutworms, white grubs and black turfgrass ataenius. Preemergent herbicide was applied each year in April.

Dollar spot ratings were taken during active dollar spot period. Dollar spot was active in May and June and again in late July through September 2004 and August and September 2005. Dollar spot was rated subjectively as an estimate of percent plot infected with no visible disease and total dollar spot cover.

Turfgrass color ratings were taken biweekly using a scale of one to nine with one representing poorest color, six representing just acceptable and nine representing best (dark green).

Clippings were harvested on Sept. 13, 2004, and Sept. 20, 2005, by making a single pass down the center of each nitrogen treatment with a commercial walk-behind greensmower. Clippings were bagged, dried at 149 F for 72 hours and analyzed for total nitrogen content of clippings (percent by weight) using the standard Kjeldahl method.

DOLLAR SPOT

Dollar spot severity is reported for the peak period in August 2004 and September 2005 (Table 2). Only one major outbreak of dollar spot occurred in 2005 (August, September and October).

All granular treatments resulted in consistently more dollar spot when compared to equivalent foliar treatments. Among the granular no-fungicide treatments, 0.5 pound N/M every 14 days resulted in the least amount of dollar spot and was the only granular no-fungicide treatment to exhibit a dollar spot reduction less than the unfertilized no-fungicide check.

All granular treatments with or without fungicide in 2004 and 2005 failed to provide levels of dollar spot control that would be acceptable among most golf course superintendents (Table 2).

Among the no-fungicide foliar treatments, all sources at 0.25 pound N/M every seven days consistently exhibited the least amount of dollar spot (see photo at right) and provided remarkable dollar spot suppression for 80 days and 154 days in 2004 and 2005, respectively. The no-fungicide 0.25-pound N/M treatment with all three foliar sources resulted in dollar spot suppression equivalent to the latter nitrogen rate with half- and full-rate fungicide. This clearly points to the importance of nitrogen rate, source, and application timing in nitrogen fertility and dollar spot interactions.

All the foliar treatments at 0.25 pound N/M every seven days in combination with half-rate fungicide resulted in less than 3 percent dollar spot in 2004, less than 10 percent dollar spot in 2005, and minimized peaks in dollar spot severity as compared with fertilizer treatments alone, and dollar spot control was equivalent to the full-fungicide rate.

At the foliar nitrogen rates of 0.175 of a pound N/M and 0.35 of a pound N/M every seven and 14 days, respectively, Bulldog was the only foliar source that consistently exhibited a trend toward acceptable dollar spot control at the half- and full-fungicide rates in 2004 and 2005.

All the foliar sources at 0.25 pound N/M every seven days consistently provided better dollar spot control than the foliar sources at 0.5 pound N/M every 14 days.

Finally, granular treatments had lower foliage nitrogen levels than the foliar treatments within the same rate/frequency programs with average foliar nitrogen contents of 5 percent in 2004. In 2004, all three foliar sources at the 0.25-pound N/M rate, which consistently resulted in the least dollar spot incidence among treatments, exhibited foliage nitrogen contents of 5.3 percent (Table 3).

In 2005, granular treatments again showed a trend for lower foliage nitrogen levels than the foliar treatments within the same rate/frequency programs. Foliage nitrogen levels in 2005 were on the average 0.5 to 1.0 percent higher than in 2004, which might reflect a buildup of residual nitrogen or conditions more conducive to nitrogen use efficiency (i.e. 2005 summer temperatures relative to 2004). The granular treatments (Table 3) in 2005 resulted in foliage nitrogen levels ranging from 5.56 to 5.9 percent. Dollar spot incidence was still significant at these latter foliage nitrogen levels suggesting factors other than foliage nitrogen content might be connected to higher dollar spot incidence with granular vs. foliar feeding.

TURFGRASS COLOR

Among all nitrogen source/rate and application frequency treatments, turfgrass color wasn't influenced by fungicide rate (i.e. zero, half and full) in either year. For example, the turfgrass color ratings for ACLF at each rate and frequency within any rating date were the same whether at zero, half or full rate of chlorothalonil. This trend was consistent within each fertilizer source/rate and frequency treatment throughout both seasons.

Within the granular treatments, initial green-up responses were significantly slower than any of the foliar treatments in 2004 and 2005. After green-up, seasonal color responses with all granular treatments were acceptable with color ratings ranging from six to seven in 2004 and six to 7.5 in 2005. The granular treatments within any comparative fertilizer rate and frequency consistently resulted in color ratings of one to three units less than foliar treatments. Within the granular treatments, the highest and most consistent turf color resulted with the 0.5-pound N/M rate biweekly.

The foliar treatments consistently provided higher turf color than the granular treatments. All the foliar treatments provided good to excellent green-up responses. All the foliar treatments also provided good to excellent color responses throughout the season. The highest and most consistent turf color among all the foliar sources occurred at the 0.25-pound N/M weekly treatment with average seasonal ratings from 8.5 to nine.

This photo shows the differences among dollar spot severity of the 0.25-pound-nitrogen, seven-day foliar treatment (yellow box on the left) vs. 0.5-pound-nitrogen, 14-day foliar treatment (yellow box in the middle) and 0.5-pound-nitrogen, granular 14-day treatment (yellow box on right) with no fungicide and one-half-rate fungicide applied (red boxes).

IMPACT ON THE BUSINESS

Treating dollar spot preventively saves in more ways than one

BY CINDY CODE

Dollar spot is one of the most recognized and ubiquitous diseases on golf courses, wreaking havoc on cool-season turf but less destructive to warm-season turf such as bermudagrass.

Its economic impact is hard to quantify, but it's considered enough of a threat that most superintendents work proactively to treat dollar spot rather than wait for the disease to make an appearance.

However, that wasn't always the case. In the past, if superintendents were surveyed with the question of when they first spray fungicides to manage dollar spot, many would answer after they first see it. Historically, this was true because there was no sure way of predicting it. Depending on the year, the first outbreaks of dollar spot might appear any time from June to early July, and were treated on an as-needed basis.

Now, superintendents work to treat their courses for dollar spot because they prefer not to see the familiar round, tan spots on their courses.

"Superintendents are spending more money on pesticides because they don't want to see insect or disease infestations," says Stan Zontek, Mid-Atlantic director for the USGA Green Section. "Many courses figure it's easier and cheaper to spend money upfront to prevent a problem than to fix it."

Treating diseases is becoming much more of a preventive than curative proposition because turf blemishes are unacceptable, Zontek says.

"It becomes a real problem if you get into treating a disease because if you have dollar spot on fairways and a golfer or a g.m. asks you, 'Why does that grass look the way it does?' Some try to save money and wait until they see a problem and then try to react as quick as they can," he says. "A huge percent of cases that I see, people just don't want to see dead grass, particularly if it's preventable."

Consequently, superintendents decide to spend the money upfront. In many cases, it's the separation between the better clubs and average courses.

Contact and systemic fungicides are used to treat dollar spot. While systemics must enter a plant, go through a transformation and be metabolized by the plant to manage dollar spot, contacts act more as a topical skin cream but can easily wash off. As a result, many superintendents tank mix contact and systemic fungicides to create twice the chemical to cure the disease and prevent the next outbreak.

Most superintendents are sensitive to criticism. Each club has to make judgment decisions. Some choose to wait while others don't.

Dollar spot has become more prevalent during the past five to eight years, says Terry Bonar, CGCS, at Canterbury Golf Club in Beachwood, Ohio.

"I don't know if it's a different variety from years ago, but it's more of a problem today," he says. "Before, we could outgrow it by putting nitrogen down and growing the grass. Now when it affects the turf, it takes it down to the dirt. It's a disease to be reckoned with and very prevalent in this part of the country. It's a problem for every course."

Bonar preventively sprays light rates of fungicide every week – rather than every other week – to manage dollar spot. Daconil is his primary contact fungicide of choice.

"Once you have dollar spot, you have to increase your fungicide rates to get rid of it," he says. "Certainly not the whole course, but you need to spray where it's infected. Once it appears, the next time disease pressure appears, dollar spot pops up. So, it's certainly easier to keep it out."

Bonar follows research conducted by The Ohio State University that shows treating dollar spot in the early spring knocks the innoculant down. For superintendents who only spray three times a season, Michigan State University recommends that spring is the most important application, he says.

"Superintendents are spending more money on pesticides because they don't want to see insect or disease infestations." – STAN ZONTEK

Bonar generally applies a systemic fungicide (Bayleton) in early April and then turns to a weekly program beginning in May until the first or second week of September. By the end of the season, dollar spot isn't a problem. Bonar will spot spray in the fall, but it's not just for dollar spot; he's also treating snow mold.

Canterbury spends about $35,000 a year treating turf diseases, which is comparable to other private clubs. Bonar says he's fortunate to have the resources to keep dollar spot at bay. He's been superintendent at Canterbury since 1984 and says dollar spot appears the worst on tee edges and fairways. GCI

Table 3. Effect of nitrogen rate, timing and application method on nitrogen content of creeping bentgrass foliage*

Treatment	Rate (lb N/M)	Timing	% Total N**	
			2004	2005
1. ACLF	0.175	7 day	5 efg	5.95 abcd***
2. HPF-N	0.175	7 day	4.8 fgh	5.94 abcd
3. Tee Time	0.175	7 day	4.7 gh	5.60 d
4. Bulldog	0.175	7 day	5.0 efg	5.92 abcd
5. ACLF	0.25	7 day	5.5 abc	6.38 a
6. HPF-N	0.25	7 day	5.3bcd	6.16 abc
7. Tee Time	0.25	7 day	4.7 gh	5.90 abcd
8. Bulldog	0.25	7 day	5.6 ab	6.13 abc
9. ACLF	0.35	14 day	5.1 def	5.75 cd
10. HPF-N	0.35	14 day	4.9 efgh	5.61d
11. Tee Time	0.35	14 day	4.6 h	5.56 d
12. Bulldog	0.35	14 day	5.2 cde	5.85 bcd
13. ACLF	0.5	14 day	5.6 ab	6.16 abc
14. HPF-N	0.5	14 day	5.8a	6.24 abc
15. Tee Time	0.5	14 day	5 defg	5.72 cd
16. Bulldog	0.5	14 day	5.7 ab	6.29 ab
17. Check	--	--	3.7 i	4.93 e
LSD			0.35	0.53

* Clippings collected on Sept. 13, 2004 and Sept. 20, 2005
** Nitrogen content determined by the Kjeldahl method
*** Numbers followed by the same letter aren't significantly different

CONCLUSIONS

A positive relationship exists between dollar spot control/suppression, nitrogen rate and application frequency with foliar nitrogen sources. Nitrogen rate and application frequency are important.

This research to date suggests dollar spot control/suppression is impacted by higher nitrogen rates (i.e. one pound N/M) than are typically being used by golf course superintendents. Foliar fertilization provides consistently superior dollar spot suppression than equivalent granular fertilization. Foliar fertilization every seven days results in better dollar spot control than foliar fertilization every 14 days (see photo on page 88).

It's also apparent that nitrogen source responses that produce acceptable color responses might not be sufficient monthly or seasonal totals to impact dollar spot suppression significantly. The nitrogen content of foliage among the various treatments suggests dollar spot suppression via nitrogen fertility requires foliage nitrogen levels at the upper end of the sufficiency range of 3 to 6 percent with a target of at least 5 percent or greater.

This research suggests foliar feeding with sufficient nitrogen can reduce dollar spot severity and potentially result in less fungicide use. The impact of foliar feeding on dollar spot severity might be related to a number of factors, including more efficient use of foliar-applied nitrogen, a simple dosage response relative to slow-release granulars, an interaction with the pathogen on the leaf surface, a physiological response because of the production of a chemical that suppresses the pathogen in or on the foliage or simply related to a critical nitrogen rate.

More research needs to be conducted about foliar feeding, foliar feeding efficiency, nitrogen rate and fungicide programming and plant growth regulator/foliar feeding responses. **GCI**

John Street is a professor of agronomy at The Ohio State University, department of horticulture and crop science in Columbus, Ohio. Deborah Holdren is a research associate for The Ohio State University.

Literature cited for this article can be found on our Web site, www.golfcourseindustry.com. posted with this article.

BY S.J. KOSTKA, J.L. CISAR, S. MITRA, D.M. PARK, C.J. RITSEMA, L.W. DEKKER AND M.A. FRANKLIN

Irrigation efficiency

Soil surfactants can save water and help maintain turfgrass quality

Golf courses are highly visible users of water, and the impact of their irrigation practices is scrutinized continually. Increasing regulatory mandates by government agencies and water utilities are driving the need for irrigation efficiency and conservation. Water might be conserved by maximizing input effectiveness (irrigation, precipitation) or minimizing output losses (transpiration, evaporation, runoff and leaching or drainage below the root zone).

Soil water repellency is a barrier that inhibits effective water management and conservation. Soil water repellency is a well-established phenomenon occurring worldwide in diverse soil types and with a range of crops and cropping systems (Wallis and Horne, 1992; Dekker et al., 2001). The phenomenon is attributed to the accumulation of hydrophobic organic compounds as coatings on soil particles and aggregates, as well as physiochemical changes that occur in decomposing soil organic matter of plant or microbial origin (Miller and Williamson, 1977; Hallett, 2001).

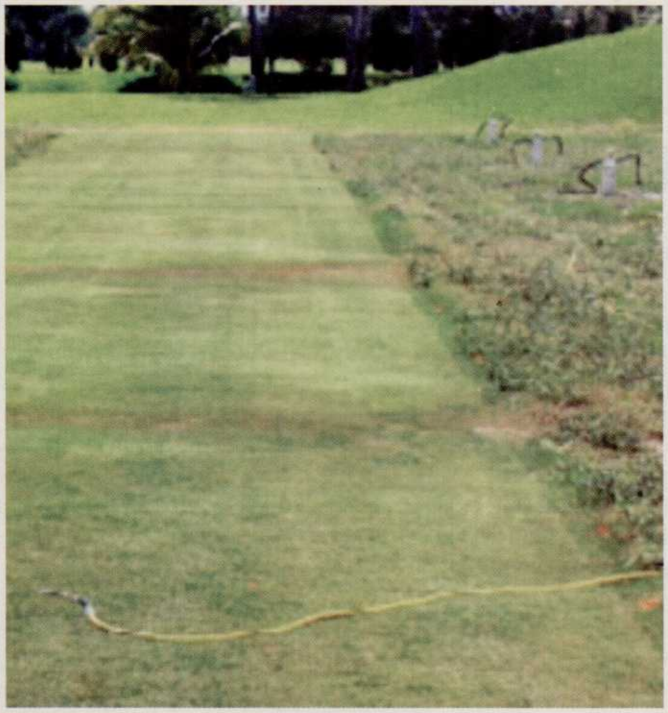
Soil water repellency decreases infiltration of irrigation water and precipitation, causes nonuniform wetting of soil profiles, increases runoff and evaporation and increases leaching due to preferential flow (Dekker et al., 2001). This nonuniform wetting deprives the plant of a consistent supply of water and impacts turf health because of ineffective delivery and nonuniform distribution of soil-directed fungicides, insecticides and fertilizers.

Even small amounts of hydrophobic material can dramatically influence wetting in soils and the effectiveness of soil-directed products. When hydrophobic sand particles were mixed with hydrophilic sand in a model porous substrate system, as few as five to six hydrophobic particles per 100 (5 to 6 percent) induced resistance to spontaneous wetting (Bauters et al., 1998). At 3 percent hydrophobic particles, the infiltration wetting pattern shifted from a wide horizontal wetting front to an unstable fingered pattern. Even at only 1 percent hydrophobic particles, flow behavior was modified negatively, yet the substrate was still considered wettable (Crist et al., 2004).

TOOLS FOR CONSERVING WATER

Soil surfactant use is well documented for the management of soil water repellency in thatch and soils, for control of localized dry spot on golf greens and for improved turf quality in highly managed turfgrass (Miller and Kostka, 1998; York and Baldwin, 1992; Cisar et al., 2000; Kostka, 2000; Karnok and Tucker, 2001). Recently, research and superintendent use have proven some soil surfactants can be used in best management practices to:

Soil water repellency is a barrier that inhibits effective water management and conservation. Photo: Rain Bird



UNTREATED

Even during periods of heat and water stress, surfactant-treated turf (shown here) provides soil root-zone moisture and better turf quality.

TREATED

• Improve irrigation efficiency;

• Increase delivery and distribution of soil-directed fungicides, insecticides and fertilizers; and

• Conserve water.

Following is a review of recently published and nonpublished research conducted about irrigated soils to illustrate the effects of surfactant treatments on soil wetting, runoff, turfgrass performance and water conservation strategies.

CALIFORNIA CASE STUDY

A two-year study was conducted at the Center for Turf Irrigation and Landscape Technology at the California State Polytechnic University in Pomona (Mitra et al., 2003). Twenty-four plots of bermudagrass (*Cynodon* spp. 'GN-1'), growing in a clay loam soil and maintained under fairway management conditions, were laid out in a replicated, split-plot design. Treatments included three different surfactants and an untreated control. The plots were irrigated at 100 percent of the reference cumulative monthly evapotranspiration demand in May, and were reduced to 70 percent ETo in June, followed by a further reduction to 30 percent ETo in July and finally, 10 percent ETo in August. Soil volumetric water content was monitored throughout the experiment using time domain reflectrometry. The results were:

• All surfactants improved water retained in the root zone when compared to the control.

• There were notable differences observed between surfactant treatments.

• ACA 1848 (APG-EO/PO block copolymer surfactant blend, currently commercialized as patented Dispatch) maintained adequate soil moisture between irrigation cycles.

• ACA 1848 performed better than other surfactants, and the effects were more pronounced under elevated moisture stress (30 percent and 10 percent of ETo). See chart on bottom of page 93.

FLORIDA CASE STUDY

A three-year study, 2002-04, was conducted on bermudagrass (*Cynodon dactylon* X *Cynodon transvaalensis* 'Tifdwarf") growing in a sand root zone at the University of Florida, (Fort Lauderdale Research and Education Center). One surfactant, ACA 1848, was tested and compared

RETURN ON SURFACTANT INVESTMENT

State	Yearly water consumption (millions of gallons)	Yearly water and energy costs	Yearly cost - surfactant	Net dollar savings
Rhode Island	20	$20,000	$3,000	$1,000
Texas	110	$120,000	$6,000	$18,000
California	115	$125,000	$7,500	$17,500

to an untreated control.

Plots were exposed to a dry-down period after treatment applications and allowed to recover between dry-down/declines with irrigation applied on a daily schedule until monthly surfactant treatments were reapplied. Turfgrass quality (scale of one to 10 with 10 equaling dark green turf, one equaling dead/brown turf, and six equaling minimally acceptable turf), volumetric water content, and localized dry spot (percent), when evident, were taken for the duration of the experiment (Park, et al., 2004). In 2002 and 2003, the results were:

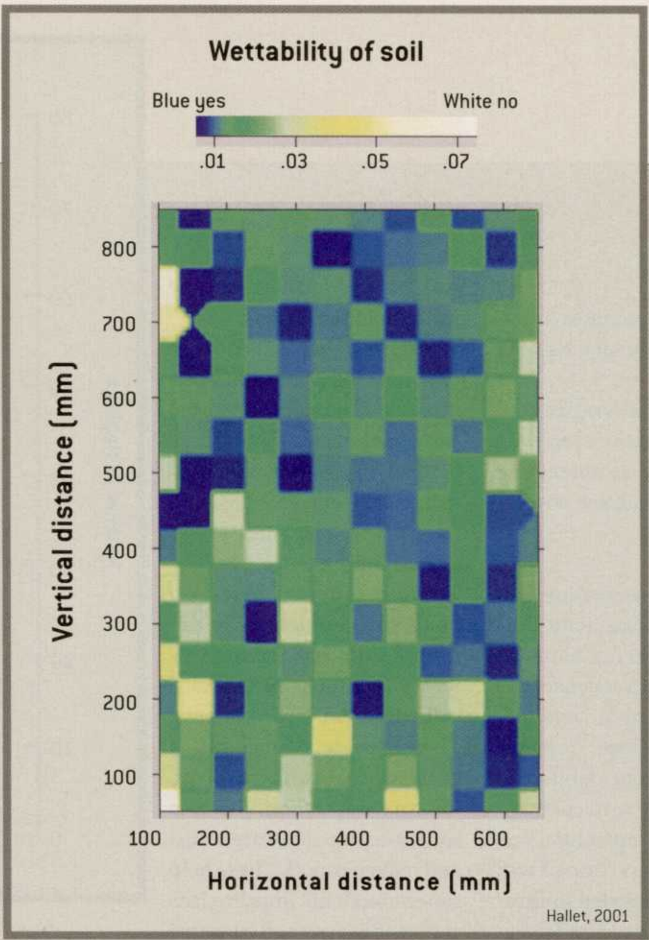
- Turfgrass quality and localized dry spot were improved significantly by surfactant treatments.
- Weekly surfactant treatments produced more consistent quality ratings than the monthly treatments and maintained higher turf quality ratings than the control throughout the test period.
- Improved turfgrass quality in the surfactant-treated plots was a consequence of increased root-zone moisture.
- Surfactant-treated plots showed turf quality was maintained even at reduced ET replacement rates.
- Surfactant treated plots showed acceptable turf quality despite water deficits and severe stress conditions. This was achieved at 41 percent ET replacement in 2002 and 62 percent ET replacement in 2003.

In 2004, the protocol was modified. Studies were conducted to see what influence the surfactant had on turf quality when irrigation was reduced. Three sets of replicated turf plots were exposed to three, three-day dry-down periods. All plots were irrigated once before initiation of each dry-down period.

1. Treatment one didn't include a surfactant but received irrigation during the next three days. (100 percent ET replacement)
2. Treatment two didn't receive a surfactant application or irrigation.
3. Treatment three received surfactant applications but no irrigation. (Nonirrigated surfactant treatment.)

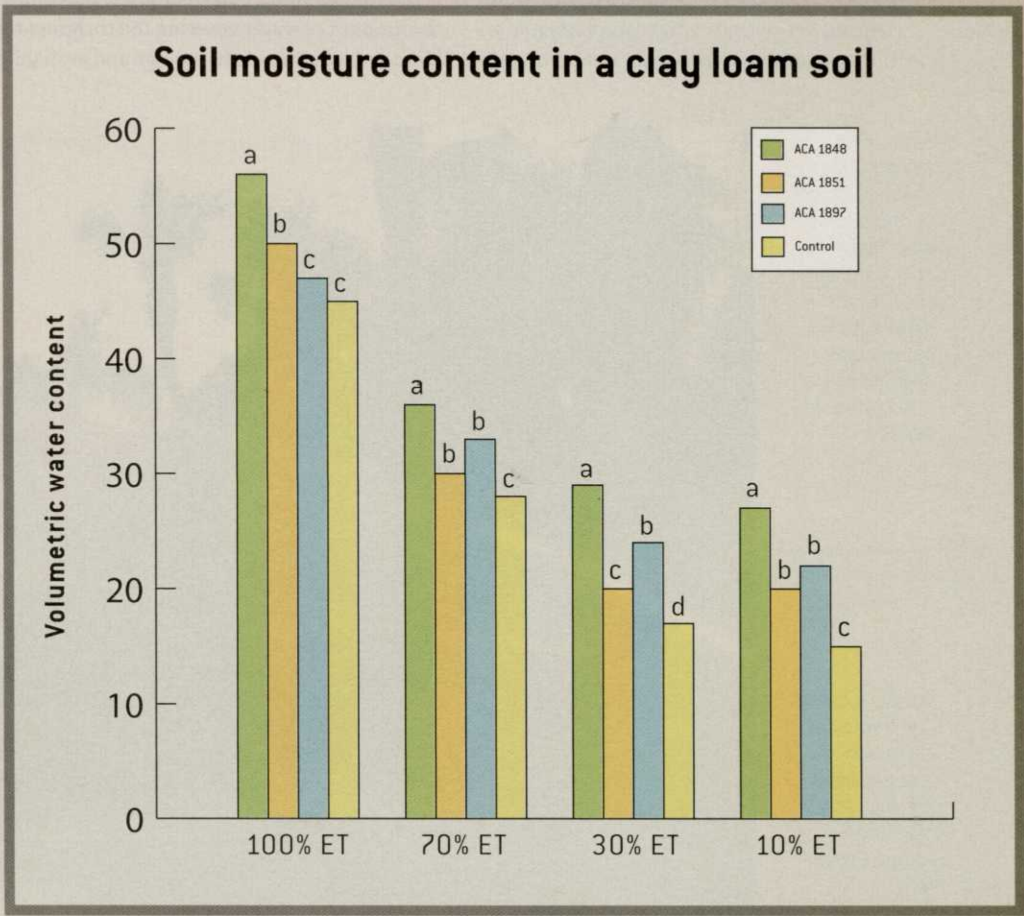
Turfgrass quality and localized dry spot symptoms were monitored visually and with an active infrared/red sensor (Park, et al., 2005). The results were:

- Nonirrigated surfactant-treated plots (treatment three) statistically had significantly equal visual quality ratings as the irrigated plots



Even low levels of soil water repellency dramatically influence wetting of soil and, therefore, distribution of fertilizers, fungicides and insecticides (left).

ACA 1848 improved soil moisture content better than any of the other surfactant formulations and the control (below).



(treatment one)

• Nonirrigated surfactant treated plots (treatment three) had less localized dry spot than the irrigated plot (treatment one)

• Even with reduced water, the nonirrigated surfactant treated plot (treatment three) showed equal photosynthetic activity as treatment one and significantly better than treatment two.

OHIO CASE STUDY

Surfactant effects on water conservation and runoff were evaluated at The Ohio State University Turfgrass Research Center in Columbus on established bentgrass (*Agrostis stolonifera* L. 'L93'). Plots were established on a wettable, silt loam soil with a 4-percent slope. Controls received no surfactant treatment, while the remaining plots received weekly surfactant applications (ACA 1848). Soil water potential was monitored with in-ground sensors. Runoff was during periods when rainfall exceeded infiltration capacity of the soil. It was measured using tipping buckets installed at the lowest end of each plot (Sepulveda, 2004). The results were:

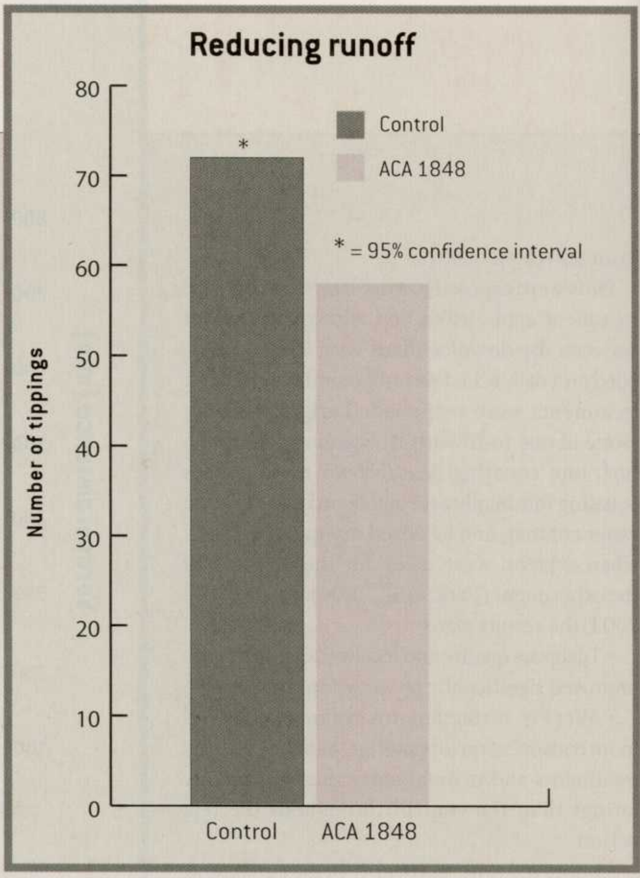
• During dry periods when supplemental irrigation was used, the surfactant treatment provided more available root-zone water than the control.

• During wet periods when inputs exceeded the infiltration capacity of the soil, runoff from surfactant treated plots was 20 percent less than from the control plots (P equals 0.05).

CONCLUSION

These results are based on multi-year evaluations in different soils supporting different turf types in dramatically different environments. They provide science-based evidence that surfactants can improve infiltration, increase soil root-zone moisture status and reduce runoff. These help superintendents improve irrigation efficiency and conserve water.

The key to water conservation is maximizing the amount of water entering the turfgrass root zone and maximizing its storage and availability



ACA 1848 significantly reduced runoff on the sloped area (chart above right). Less runoff means more of the water and pesticides percolated into the soil.

Soil surfactants can improve infiltration and increase soil root-zone moisture status. Photo: Toro once in the root zone (Carrow et al., 2005).

Best management practices propose a diversity of options for conserving water including the potential for use of surfactants (Barton and Colmer, 2004; Carrow et al, 2005). Surfactant use as demonstrated in these studies provides a low-cost, high-return strategy to:

- Improve delivery of water to the root zone and reduce losses to runoff;
- Conserve water;
- Maintain golfer and management expectations for quality turfgrass; and
- Manage resources effectively – be those resources water or energy required for pumping, or fertilizer, fungicide and other products.

Future research is planned to:

- Further substantiate water conservation estimates;
- Establish effects on agrichemical runoff and leaching;
- Quantify improvements in irrigation efficiency and distribution uniformity; and
- Develop an understanding of surfactant use and its relation to soil nutrient availability, and the effect on fungicide and insecticide performance. **GCI**

Literature cited for this article can be found on our Web site, www.golfcourseindustry.com , posted with this article.

Research and superintendent use have proven some soil surfactants can be used to improve irrigation efficiency. Photo: Toro

IMPACT ON THE BUSINESS

Making financial sense of surfactants

Manufacturers say surfactants offer a low-cost, high-return benefit for golf courses. Research indicates a well-planned, well-executed surfactant program can reap considerable rewards, including improved delivery of water to the root zone, reduced run-off and better stress resistance. They can also help manage inputs including water, fertilizer and pest management products more effectively.

FINANCIAL RETURN

Surfactants can have an impact on overall water usage. Originally developed to hold water for better plant performance, golf course superintendents are using them now to stretch limited water resources. With average water expenditures topping $50,000 per course – and significantly higher in the Southwest and other year-round golf regions – a properly managed surfactant program can save thousands of dollars per year.

UP-FRONT INVESTMENT

Spot treatments can have an excellent agronomic impact, but the business impact is limited. However, by using surfactants as part of a fertigation or fairway application program, the return on investment can be extended substantially. Fertigation systems cost between a few hundred dollars to several thousand. But, for facilities that pay a considerable amount of money for water, the use of surfactants through fertigation systems can more than pay for itself in the first year.

DROUGHT MANAGEMENT

Water restrictions have become a fact of life throughout the country. In some cases, the restrictions are short-term. In others, they are permanent. Surfactants and other water management tools are essentially "Hamburger Helper" for irrigation. A facility with a well-implemented water management program is likely to be green and healthy far longer than one that is not.

DOWNSIDES

The biggest downside to any water management tool is misapplication. Some need to be watered in properly at the time of application, while others are good from the time they're put down. Use research from manufacturer's Web sites and other sources to ensure a product is being applied as effectively as possible.

THE BOTTOM LINE

Surfactants and wetting agents can be excellent tools for golf course superintendents, either in stand-alone situations or in combination with other products. Superintendents should consults their peers and check with researchers, USGA agronomists and other experts before embarking on a particular wetting agent program. **GCI**