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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:

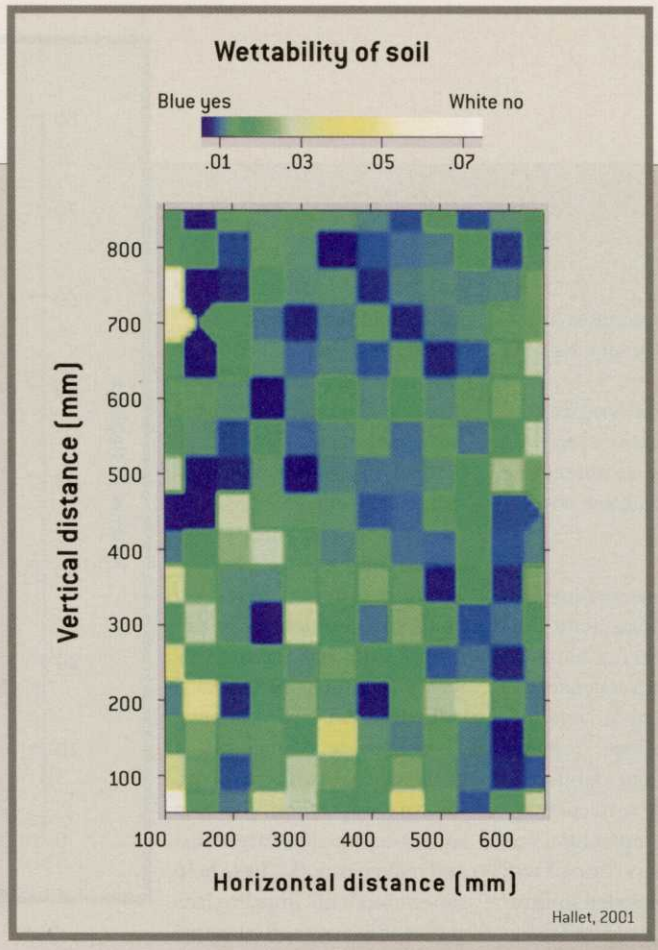
- Turfgrass quality and localized dry spot were improved significantly by surfactant treatments.
- Weekly surfactant treatments produced more consistent quality ratings than the monthly treatments and maintained higher turf quality ratings than the control throughout the test period.
- Improved turfgrass 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.)

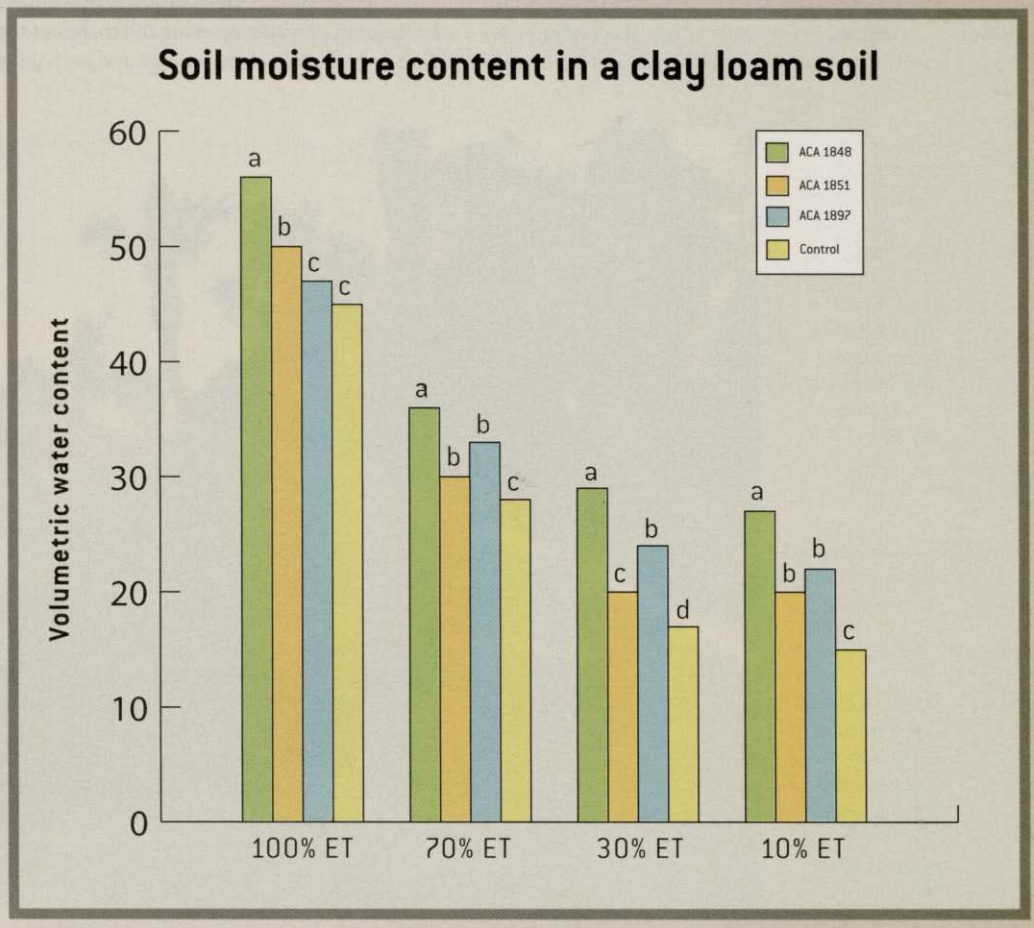
Turfgrass quality and localized dry spot symptoms were monitored visually and with an active infrared/red sensor (Park, et al., 2005). The results were:

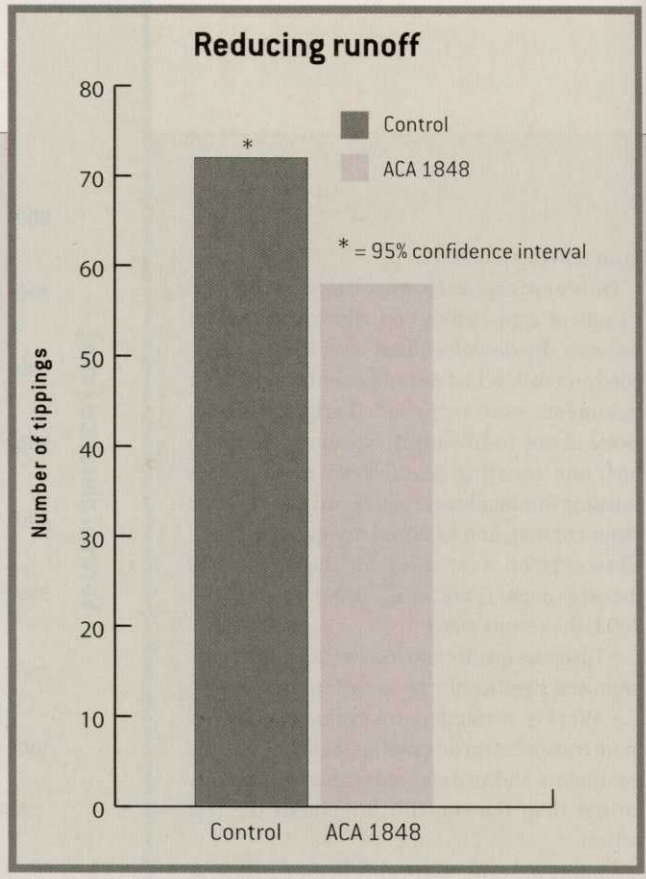
- Nonirrigated surfactant-treated plots (treatment three) statistically had significantly equal visual quality ratings as the irrigated plots



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**