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Wetting Agents—The Old, The New, What They Are and What They Do

Concerns over water delivery and usage have certainly come to the forefront this season, leaving many superintendents wishing the sweat dripping from their foreheads could adequately contribute to the amount of water available to their turf. It is even more disconcerting to realize the necessity for not only thinking about getting quality water to the turf, but also what the water does in relation to the physics and chemistry of the turf rhizosphere once it gets there. Wetting agents and surfactants have been leaned on heavily in this drought year to overcome problems associated with the soil-water interaction, which include soil hydrophobicity and localized dry spot formation.

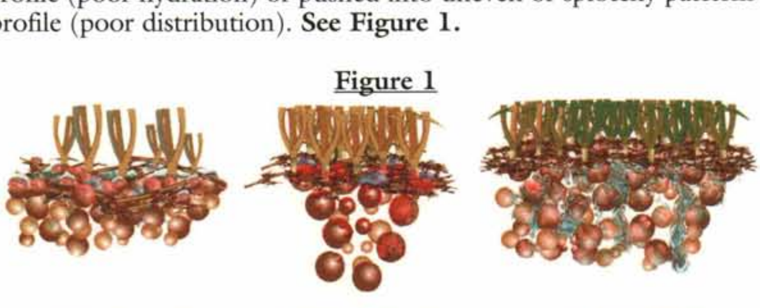
For increased infiltration, wetting agents can act as penetrants. A wetting agent also works within the soil to facilitate hydration and proper water distribution.

Water Chemistry

How water behaves when it gets to the turf, thatch layer and ultimately the soil profile is complex, and is ruled by various factors (including slope, soil type, pore space, etc.) and how they relate to the properties of water. Although going into explicit detail on all of water's properties would be a bit much, the discussion would be incomplete without mentioning a little basic water chemistry. Water is a polar molecule, meaning that it has a large affinity for binding to itself via hydrogen bonds between the oxygen of one molecule and one of the hydrogens on another. These tight cohesive forces cause surface tension and the formation of water droplets.

Adhesion, on the other hand, is water's attraction to other molecules, like soil. The attraction's strength is governed by whether or not the soil molecule is charged (or polar). If charged, the soil will accept or donate an electron readily and bond with water. If the soil molecule has no charge, or is coated by something that is, water will not bond with it. Then cohesive forces will take over, causing the water to preferentially bond to itself rather than the soil. The soil is then termed to be hydrophobic, or fearing of the water. When enough of these hydrophobic molecules get together, they scare away a considerable amount of water that would normally be available to the plant. This "scared" water is either captured up near the surface (poor infiltration), leached through the profile (poor hydration) or pushed into uneven or splotchy patterns in the soil profile (poor distribution). **See Figure 1.**

Figure 1



Poor Infiltration   Poor Hydration   Poor Distribution

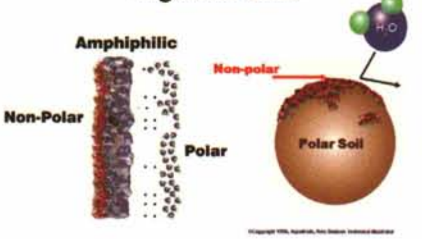
(continued on page 20)

Hydrophobic Soils

Hydrophobic soils are caused by water-repellant coatings from several sources. Organic compounds from decomposing plant materials, microbial deposits and plant exudates are major sources. These organic compounds are amphiphilic (**see Figure 2**), meaning they have portions that are polar and portions that are nonpolar. The polar side adheres to the soil particle and exposes the nonpolar side, therefore taking up a site where water would normally adhere. The situation gets worse when wet-to-dry cycles take place (i.e., irrigation, rain event), presumably because dehydration causes the structure of the organic compound to bend. This bending changes and intensifies the chemical forces of the organic compound while shaping it around a soil particle. This may be one of the reasons why it's hard to rewet a dry sand or soil.

Figure 2

Organic Acids



Another coating source is from soil- and thatch-inhabiting fungi, which explains the link between fairy ring fungi and localized dry spots. The fungi produce a mycelial mat and/or fungal exudates that coat the soil and repel water. In some cases of fairy ring, this can cause a severe burning out of the turf along fairy ring margins. For this reason, adding a wetting agent to fungicide applications has become one of the standard recommendations for attempts at fairy ring control.

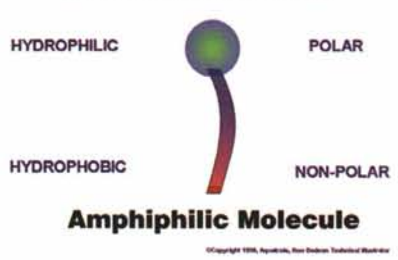
Perhaps a larger area of concern for hydrophobicity is not just the soil, but also the thatch layer. The thatch layer invariably has more organic matter than any part of the rootzone, and therefore has most of the hydrophobic organic compounds and fungi that can cause problems. This seems to be especially true of localized dry spots on fairway turf, as the thicker thatch layer is the main barrier to water infiltration rather than a hydrophobic coating on the soil particle.

Wetting Agents

The basic structure of a wetting agent, surfactant or "high-tech detergent" as one of my colleagues would call it, is very similar to an organic compound that makes soils hydrophobic in that it too is amphiphilic. It has at least one polar or hydrophilic "head" and at least one nonpolar or hydrophobic tail (**see Figure 3**). This structure can serve many functions in the soil profile to assist infiltration, hydration and distribution.

Figure 3

Surfactant Molecule



For increased infiltration, wetting agents can act as penetrants. A penetrant binds to water via the hydrophilic head, leaving the hydrophobic tail exposed to pull the water droplet towards the nonpolar soil or thatch surface (**see Figure 4**). In this way, surface tension is overcome and the water droplet is spread out over the surface for easier infiltration into the soil.

A wetting agent also works within the soil to facilitate hydration and proper water distribution. In this case, the hydrophobic tail of the wetting agent attaches to the hydrophobic soil coating, leaving the hydrophilic head exposed. The hydrophilic surface attracts water and holds it into the soil particle through adhesion. The cohesive forces of surrounding water molecules bind to the adhered one, creating a more uniform water distribution. For a well-designed wetting agent, water then gets out by gravity, leaving pore spaces filled with both air and water.

So how then do wetting agents differ? Shouldn't it be "one size fits all"? The answers to these questions all lie in the miracles of high-tech chemistry. Wetting agents differ in their construction, with the main difference being the length and chemical structure of the hydrophobic tail. This affects molecular weight, size, shape, structure and how intimate the wetting agent is with the hydrophobic soil coating, which translates into different performance characteristics. Who couldn't tell the difference between a hydroxyl-terminated methyl oxirane-oxirane copolymer, an akyl ether of the methyl oxirane-oxirane copolymer or an ethoxylated alkylphenol?

Comparing Wetting Agents

Results with the first wetting agents to hit the market were varied and in some instances unsatisfactory. Major complaints were that they held too much water in the top few inches of the soil profile, or needed to be applied at rates that were too high or at intervals that were too short. In response, industry developed newer wetting-agent technologies (i.e., different hydrophobic tails) to address some of these issues. These newer wetting agents, which are all related to the block copolymer chemistry, have been introduced into the market

Figure 4

in the last five to eight years. The problem was, superintendents were hit with all of the new products in a relatively short span, and it was difficult if not impossible to sort out the research that backed product claims.

In response, the GCSAA and USGA took the ball and ran by cosponsoring a huge, detailed study comparing turf quality and efficacy of ten different wetting agents in nine states (see April 2005 issue of *Golf Course Management* with the update available in the August issue). Although the test wasn't perfect and a minor retraction had to be made for the water droplet test results (which in reality will probably not change the results that much), I wholeheartedly applaud this effort by the two organizations and the cooperators for reacting to the need of treating wetting agents like most commercially available pesticides and turf varieties.

So how to interpret the results? It seems most logical to pick the state closest to Chicago that participated in the survey (Michigan or Missouri) since the climate and precipitation *should* be fairly similar. Others might want to pick a site based on turf type or rootzone mix, although most of the greens in the study had USGA rootzones and there were no native soil push-up greens. If Michigan is chosen, all of the wetting agents tested, except Naiad, had higher turf-quality ratings than the control plot for both years. Between the different newer wetting-agent chemistries though (which excludes Naiad), turf quality was not statistically different at the Michigan site.

Of course, there is a caveat. If only the Michigan site is used in analysis for our location, it is hard to relate to some of the findings at some of the other sites, especially Georgia's results, which are significantly different. Luckily, Clark Throssell from the GCSAA and Kevin Frank from Michigan State are set to speak at this year's Illinois Professional Turfgrass Conference (IPTC), so the data revisions and answers to these questions can be revealed then.

The Newest Wetting-Agent Chemistries

Revolution and Dispatch are two of the newest wetting-agent chemistries that were not included in the USGA/GCSAA wetting-agent study. Dispatch was released three years ago as a soil penetrant that is injected into irrigation water to increase infiltration rates. At this time, more than 50 golf courses in Chicagoland are applying it weekly at 12-24 oz./acre over all irrigated turf.

Revolution, on the other hand, is the more traditional boom-applied wetting agent sprayed monthly at 6 oz./1,000 ft^2. Just released this year, it has taken Chicagoland by storm with more than 75 golf courses currently using the product. Product claims by the manufacturer are that it produces a more uniform water distribution through the soil profile because the akyl capping of the Revolution molecule reorients the hydrophilic oxirane chains towards hydrophobic soil coatings. This would allow for a tighter binding of water molecules to actual soil particles, thereby increasing pore space and allowing water and air to move through the profile. Early reports from superintendents using the new product have been favorable, but like any new product, it is advised to test the product for yourself and find out if it provides benefits for your situation.

Wetting agents differ in their construction, with the main difference being the length and chemical structure of the hydrophobic tail.

As alluded to earlier, this is a very complex and detailed subject that deserves a lot more explanation from a much more qualified source. To further wet your whistle, I would recommend taking one of the GCSAA seminars taught by Dr. Keith Karnok (online version of "Managing Localized Dry Spots" can be found at www.gcsaa.org/learn/online/lds.asp) and *definitely* attending the presentations by Kevin Frank and Clark Throssell on the subject at this year's IPTC.

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