The Relationship Between **Water** and **Soils**

By **James Spindler**, *CPAg, CCA, CPSS*

"Often, there is not one single issue with one single solution. The best solution for the management and conservation of water may be to combine technologies."

Water management has become a major issue in the turf industry over the last decade or more. In the past, water was considered an unlimited resource and was a concern only when an occasional drought occurred. Today, all regions have experienced a change in attitude regarding water. Influenced by rising costs, recurrent drought, use restrictions, politics and social pressures, turf managers are expected to do more with less.

The cost of water in many markets, including "water-rich" regions, has increased dramatically since the turn of the century. Surveys have revealed that the cost of water has risen by 25 to 30 percent in many municipalities, with increases reaching as high as 300 percent or more in some regions. These cost increases have caused many property owners to reconsider watering lawns and landscapes when seasonal dry periods occur. Is money better spent on other budgetary items than on irrigation? Whether working on commercial or residential properties, finding ways to manage water from an economical sense has become important to everyone.

Although there are many definitions of drought, Florida's turfgrass and landscape industries are most concerned with agricultural drought, a situation where the amount of moisture in the soil no longer meets the needs of a particular crop, including turf and ornamentals. Inadequate soil moisture can occur at any time, even in "water-rich" regions. Agricultural drought can be caused by soil conditions, cultural practices or a number of other factors. The challenge is managing moisture throughout the soil profile, so it can be made available to the plant. This article will focus on technologies that can help managers use the water they can afford or are allotted by the most efficient means.

Beyond the advancements in irrigation hardware and software, there are many other technologies available for the management of water in the soil. Understanding each technology and soil/water interaction will help turf and landscape managers decide which strategy is best suited for their specific situation.

Technologies for Optimizing Soil Moisture Management

Hygroscopic Humectants

Though they are not new to the industry, hygroscopic humectants are continuing to gain favor with turf and green industry professionals as products that are very effective at reducing overall water requirements. With a history in golf, these products have been gaining greater attention due to their recent performance in drought stricken areas of California, Texas and other western states.

Hygroscopic humectants manage and conserve water through two modes. As the name suggests, there is a hygroscopic compontent and a humectant component. Each has a critical function in the performance

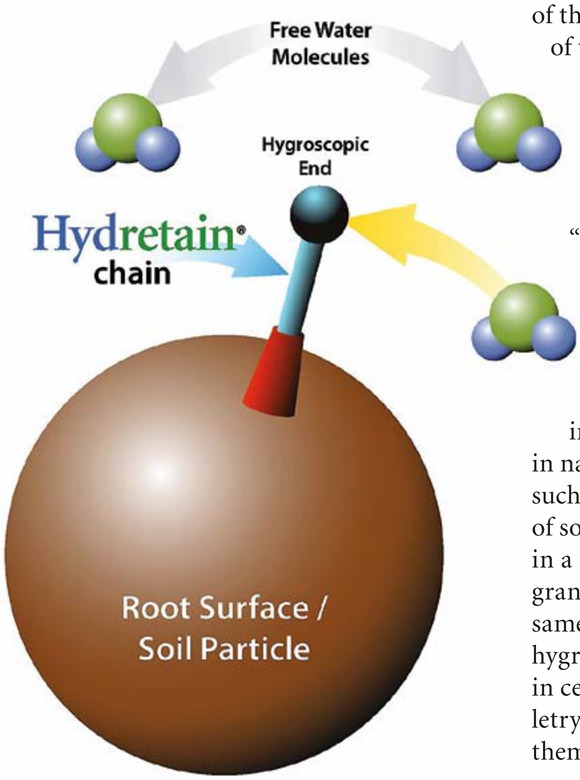
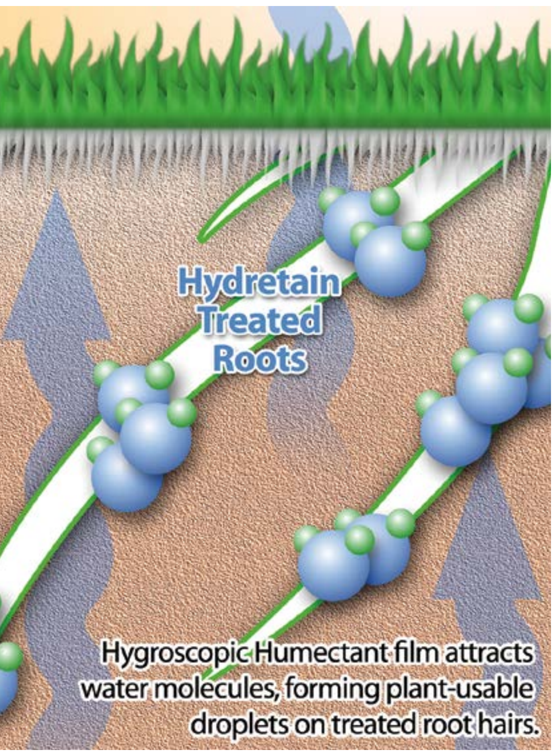


Diagram of the hygroscopic component on a soil particle. (Courtesy of Hydretain)



of the technology. The mode of action of the hygroscopic component is to condense soil water vapor or soil humidity back into liquid droplets of water. The hygroscopic ability of these materials can be compared to condensation or "sweat" that occurs on the side of a cold drink. Root zone humidity that cannot be absorbed by plant roots is converted into plant usable micro-droplets of water.

There are other materials used in this industry that are hygroscopic in nature. These include fertilizers, such as urea. The hygroscopic nature of some fertilizers may cause bridging in a spreader or can turn a bag of granular fertilizer into a "brick." The same hygroscopic materials utilized in hygroscopic humectants are also used in certain foods, such as breads and toiletry groups (e.g.: toothpaste), to keep them moist and pliable.

The humectant components hold the water droplets condensed by the hygroscopic components. Do not confuse a humectant with a humate. They are completely different substances with different molecular structures. The humectant component holds the droplets tightly enough to prevent it from leaving the proximity of the root, but lightly enough to allow the root to absorb the water through osmosis. The humectants in hygroscopic humectants are also utilized in cosmetics, shampoos, and other body care products where they help hold moisture in the skin and hair.

Available in both liquid and granular options, hygroscopic humectant technologies must be watered-in, at which point the active ingredients will coat plant roots, soil particles and organic particles in the root zone. The hygroscopic humectant molecules are too large to be absorbed by the roots. Once these components attach to the roots and soil particles, they remain attached and are resistant to further movement in the soil. The ingredients are primarily derived from plant byproducts. (Some brands are rated at 93 percent biobased* by the USDA BioPreferred Program.) Therefore, they are eventually broken down by soil microbial activity. Research and users have demonstrated that the most effective hygroscopic humectant products have been able to reduce water use by up to 50 percent and will typically perform for up to 90 days. In addition to providing general conservation of water, hygroscopic humectants aid in seed germination, transplant establishment and in establishing sod and sprigs. Hygroscopic humectants have also been used to suppress dust on baseball infields, horse arenas, dirt race tracks, dirt roads, etc.

Super Absorbant Polymers

Super absorbant polymers are a technology that track their orgin to a patent by Monsanto in 1963. They described polymers as "strings of large molecules that chemists use like Tinker Toys, adding, subtracting or linking them together to create diverse uses ranging from filling for disposable diapers to dental products" (*Messina, 1991*).

Polymers have been adapted for use in soil to improve water availability to plants. They are utilized to "increase a soil's water holding capacity, increase pore sizes and numbers in the soil, increase germination rates, and decrease or mitigate the effect of soil compaction on plant growth" (*Orzolek, 1993*). The five main types of soil polymers available commercially include:

- Cross-linked polyacrylamides (gel forming)
- Non-cross-linked polyacrylamides (water soluble)
- Polyacrylates
- Polyacrylontrile
- Starch-grafted copolymers

The most commonly used polymer is the cross-linked polyacrylamide. Soil polymers occur in a crystalline form. When exposed to water, they expand into a gelatin-like block. When used in soils, they function as mini-reservoirs of water. They absorb water and hold it until the plant removes the water. The literature indicates that cross-linked

Sports field under water restrictions. Plot treated with a hygroscopec humectant. (Courtesy of Hydretain)

Golf course slope treated with hygroscopic humectant under water restrictions. (Courtesy of Lesco Moisture Manager)

polyacrylamide polymers used in the field will absorb and hold 80 to 200 times their weight in water or more. Their ability to hold soil water is influenced by the amount of polymer in the soil, the type of polymer utilized and soil characteristics, such as salt content (*Polhemus, 1992*). As the concentration of ions increases in water, the amount of hydration by the polymer decreases (*Orzolek, 1993*). The lifespan of polymers is thought to range from 2 to 10 years, depending on the type of polymer and soil conditions (*Polhemus, 1992*).

The literature reports that the time between irrigation events can be extended with the use of polymers, but the actual water savings with use of these products is dependent on application rates and soil conditions. Cost of these products may be a limiting factor for effective application rates.

Initially, polymers were used to help manage water in potted plants, ornamental beds and in planting trees and shrubs. Over the years, soil-applied polymer use has expanded to turf applications. They are utilized in the establishment of sod and sprigs, improving seed germination and in general turf use. The challenge in utilizing polymers on established turfgrass is delivering the polymer crystal to the root zone. Some turf managers will aerate the turf and drag the crystal into the holes. In addition to this practice, there are now machines that will inject or "plant" the polymer crystals into the soil.

Dry vs. Hydrated Polymers

Surfactants/Wetting Agents

Surfactants or wetting agents are probably the most common products used to manage soil moisture. These materials are utilized for a number of applications in turf and plant management, including relief from localized dry spots, improved drainage, assist the efficiency of various pesticides, reduced dew and frost accumulation, improved seed germination, reduced fairy ring damage, alleviation of soil compaction, improved irrigation efficiency, diminished dust on dirt paths, enhanced firmness of golf course bunker sand and more (*Karnock, Xia, & Tucker, 2004*).

Surfactants stand for SURFace ACTive AgeNTS (SURFACTANTS). These are agents that affect the surface of a liquid or solid. As previously stated, the formation of waxy, non-polar coatings on soil particles is the cause of hydrophobic conditions. The non-polar soil particle surface will not attract, and may actually repel, the polar water molecule, which prevents irrigation water or rainfall from infiltrating soils to hydrate plants. Creating a polar surface allows water molecules to enter and fill the soil. The surfactant has a non-polar and a polar end on the molecule. The non-polar end of the surfactant molecule aligns with the non-polar surface of the organic soil coating, leaving the polar end exposed outward from the soil particle. This allows the polar water molecules to be attracted to the polar surfactant molecules therefore overcoming the hydrophobic condition (*Karnock, Xia, & Tucker, 2004*).

There are many different kinds of surfactants, most of which fall into these four basic categories:

- **Anionic**—Form negatively-charged ions in water
- **Cationic**—Form positively-charged ions in water
- **Nonionic**—Do not ionize in water
- **Amphoteric**—Take on the ionization of the water

Non-ionic surfactants are the most common products used in the turf industry due to their safety, compatibility with other products and ease of use. As technology has improved, a number of categories of non-ionic surfactants have been developed. These include:

- **Polyoxyethylene (POE)**—This is older technology originally developed to treat localized dry spots. They can be phytotoxic.
- **Block Co-Polymer Surfactants**—These are the most commonly used turfgrass surfactants. They are safer and are effective in treating soil water repellency, improving soil water content and plant-available water. This category has two sub categories: straight block co-polymers and reverse co-polymers.
- **Alkyl Polyglucoside Surfactants**—These are made from sugar molecules reacted with a fatty acid and are considered naturally derived. When blended with a block co-polymer, the performance appears to be better than either technology alone. These blended technologies appear to increase water infiltration, improve water availability and enhance irrigation efficiencies.
- **Modified Methyl Capped Block Co-Polymer**—This is a class of surfactant that is a modification of the co-polymer class. This technology forms a thinner, more continuous film around the soil particle.
- **Humic Substance Redistribution Molecules**—"These molecules allow water penetration through the soil profile by disrupting the hydrophobic supramolecular humic association, most prevalent in the top one to two centimeters on the soil, which lead to localized dry spots."
- **Multi-branched Regenerating Wetting Agents**—Most surfactants have linear molecules. These products have a much higher molecular weight and multiple branched molecules. Each branch essentially functions as wetting agent itself (*Zonteck & Kostka, 2012*).

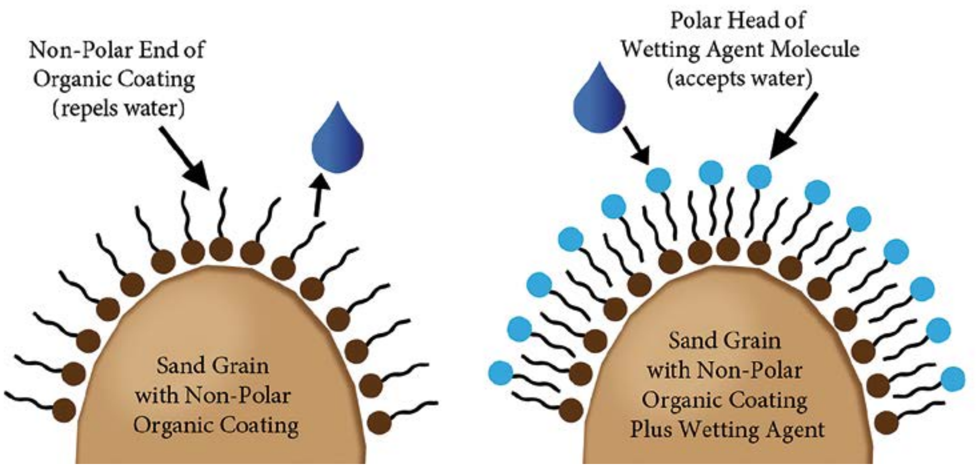
Surfactants/wetting agents have been demonstrated to possess many functions in the management of water in and around turfgrass and other plant systems. When discussing the maximization of water use efficiencies, these products tackle the barriers (non-polar coatings in the soil) that prevent water from moving into and distributing throughout the soil. Research has shown that surfactants/wetting agents can significantly improve soil moisture content and reduce variability in soil water content, improving soil moisture uniformity. In addition, they have been shown to "reduce localized dry spot incidence, allow for longer periods between irrigation events, and reduce hand watering in isolated areas" (*Karchner & Richardson, 2014*).

Surfactants/wetting agents are available in liquid and granular forms. The amount of water conserved, longevity of the product and cost may vary based on product type and local conditions.

Conclusions

There is a wide variety of technologies available to help manage and conserve water. The key to success is to identify the cause(s) of water challenges. If salts or bicarbonates are a problem, there are calcium- and acid-based treatments. If hydrophobic soils are the challenge, there are a variety of surfactant/wetting agent solutions for this condition. If poor water holding capacity is the issue, polymers can be used to store water and hygroscopic humectants can be used to convert soil humidity into plant-usable water droplets. If drought, water availability or high water cost are creating the need to reduce overall water requirements, hygroscopic humectants are the right tool to maximize water conservation.

As a final note, it is adviseable to remember to not think linearly. Often, there is not one single issue with one single solution. The best solution for the management and conservation of water may be to combine technologies. A very common



Diagrams illustrating wetting agent activity example of this is the combination of hygroscopic humectants with surfactants technologies. In this situation, the surfactant will allow water with the hygroscopic humectant to enter and disperse throughout the soil where hydrophobic non-polar organic coatings exist. Water can uniformly disperse throughout the root zone. Then, the hygroscopic humectant can reduce evaporative loss for maximum plant water use.

Thinking outside the box and using all tools available gives turf and landscape managers the ability to maximize water use efficiency and optimize turf and plant performance.

**Products brands Hydretain® and LESCO Moisture Manager™ have been certified to contain 93% biobased contents by the USDA BioPreferred® Program.*

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