The Benefits of Consumable Water Management Technologies

James Spindler, Director of Agronomy, CPAg, CCA, CPSS

Ecologel Solutions, LLC, 4060 SE 45th Court, Ocala, FL 34480, jim@ecologel.com

Abstract. *Water conservation has become a major concern over the last decade or more. Influenced by rising costs, recurrent drought, use restrictions, politics and social pressures, turf and landscape managers are expected to do more with less. Beyond the advancements in irrigation hardware and software, there are a variety of consumable technologies and products designed to manage water in the soil and further maximize water use efficiencies. These products and technologies include hygroscopic humectants, surfactants and superabsorbent polymers as well as mulches, compost, antitranspirants, plant growth regulators, and hormones/biostimulants. Understanding each technology and soil/water interactions will help landscape and irrigation managers decided which strategy is best suited for their specific situation. The content will include how and why to use the various technologies, how to maintain healthy turfgrass and landscapes during periods of drought or watering restrictions and the economic benefits of using water management solutions as part of a regular program.*

Keywords. Hygroscopic humectants, wetting agents, surfactants, superabsorbent polymers, drought, watering efficiency, water conservation, consumable water management technologies, mulches, compost, ground covers, anti-transpirants, plant growth regulators, plant hormone, biostimulants, watering restrictions.

Water conservation has become a major factor affecting landscape and irrigation design over the last decade or more. Influenced by rising costs, recurrent drought, use restrictions, politics and social pressures, industry professionals are expected to do more with less. In many regions, landscape have become a political or social target for water conservation and movements to reduce irrigated acreage are growing in popularity nation-wide.

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 coupled with the threat of drought shaming have caused many property owners to reconsider landscape watering practices. Is money better spent on other budgetary items than on irrigation?

Beyond the advancements in irrigation design, hardware and software, there are a variety of consumable technologies and products designed to manage water in the soil and further maximize watering efficiencies. Combining the use of consumable technologies with modern irrigation technology provides a greater opportunity to sustain the industry without succumbing to sacrifices in landscape quality or quantities. Consumable products and technologies include hygroscopic humectants, surfactants and superabsorbent polymers as well as mulches, compost, antitranspirants, plant growth regulators, and hormones/biostimulants. Understanding each technology and soil/water interactions will help landscape and irrigation managers decided 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 landscape professionals as products that are very effective at reducing overall water requirements. With a history in golf and sports turf, these products are becoming more popular for municipalities as well as residential and commericial properties, particularly those in areas with recurrant drought, watering restrictions or high water costs.

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 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. Rootzone humidity cannot naturally be absorbed by plant roots. Hygroscopics convert this unavilable humidity into plant usable micro-droplets of water.

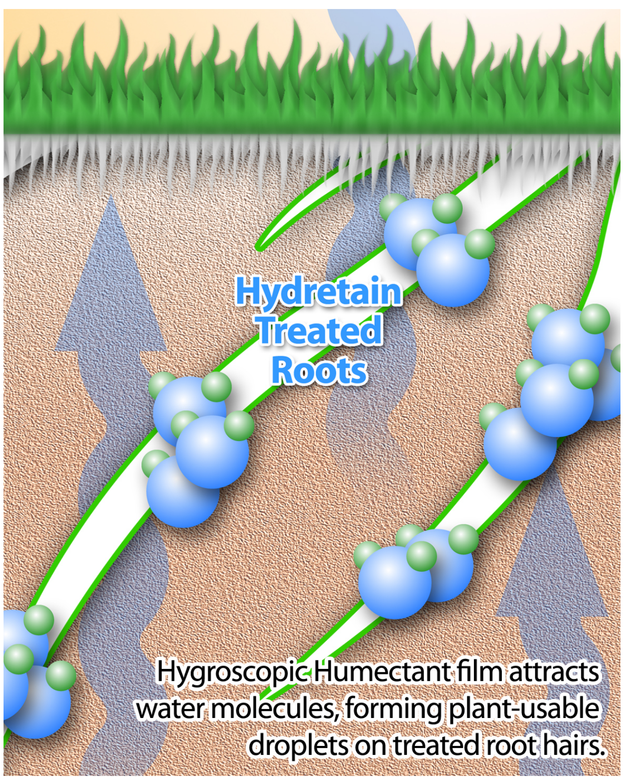

Figure 1. Diagram of the hygroscopic humectants on a soil particle. *(Courtesy of Ecologel Solutions, LLC)*

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. Not because they will burn, but to assure that the active ingredients will coat plant roots, soil particles and organic particles in the root zone. If hygroscopic humectants dry on the plant leaves or in the thatch or mulch, they will anchor themselves at that location permanently. The active incredients will perform its function at these locations, but there are no roots present to utilize the condensed water droplets, therfore the benefits will not be realized.

Once the hygroscopic humectant molecules arrive in the rootzone they 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 USDA BioPreferred Certified for biobased content*). Therefore, they are eventually broken down by soil microbial activity. Research and users have demonstrated that the most effective hygroscopic humectants products have been able to reduce water use by up to 50 percent or more 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.

Figure 2. Sports field under water restrictions. Plot treated with a hygroscopec humectant compared to adjacent untreated plot in the foreground. (Courtesy of Hydretain)

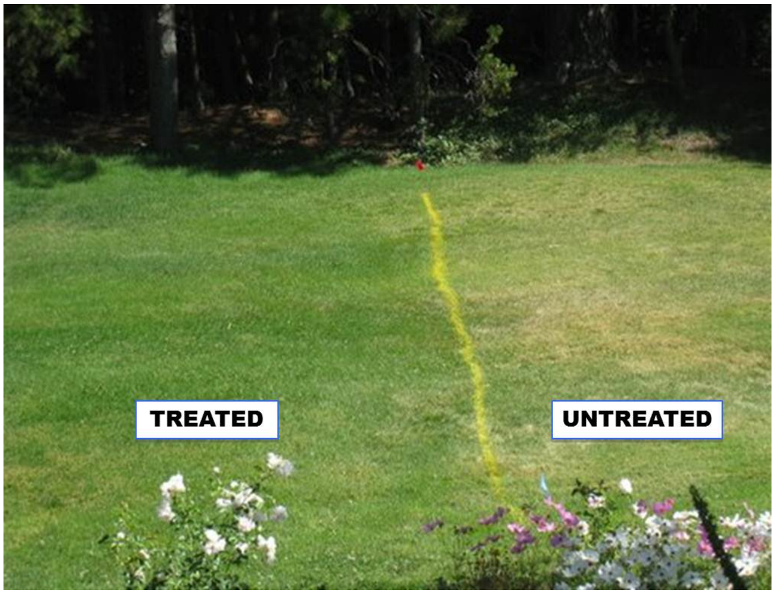

Figure 3. Golf course slope treated with hygroscopic humectant under water restrictions. (Courtesy of Lesco Moisture Manager)

Superabsorbant Polymers

Superabsorbant 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 pore 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 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). The lifespan of polymers is thought to range from 2 to 10 years, depending on the type of polymer and soil conditions (Polhemus, 1992).

Figure 4. Comparison of dry vs. hydrated superabsorbent polymer crystals

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 reduce water use 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 manager will aerate the turf and drag the crystal into the holes. In addition to this practice, there are now machines that will inject the polymer crystals into the soil.

Surfactants/Wetting Agents

Surfactants or wetting agents are probably the most commonly known 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, assisting the efficiency of various pesticides, reduced dew and frost accumulation, improved seed germination, reduced fairy ring damage, alliviation of soil compaction, improved irrigation efficiency, and more (Karnock, Xia, & Tucker, 2004).

Surfactants stand for **SURF**ace **ACT**ive **A**ge**NTS (SURFACTANTS)**. These are agents that affect the surface of a liquid or solid. Understanding the nature of water is critical to understanding the function of surfactants. Water molecules are naturally polarized: the two hydrogen atoms are attached to one side of the oxygen atom causing each end to have a slight charge. Just as opposite charges of magnets attract to each other, the positive end of the water molecule is attracted to the negative end of another water molecule. This is called cohesion and is why we see a drop of water bead up when placed on wax paper. The waxy surface of the paper has no charge or is non-polar; therefore, the only place for the water molecules to be attracted is to each other. In soils, waxy coatings are the result of the decay of organic materials and certain species of fungi that exude waxy substances. The formation of waxy, non-polar coatings on soil particles is the primary cause of hydrophobic conditions. The non-polar soil particle surface will not attract, and may actually repel, the polar water molecule. This prevents irrigation water or rainfall from infiltrating into soils to hydrate plants.

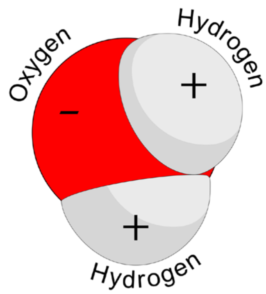

Figure 5. Graphic rendering depicts the polar nature of water molecules.

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).

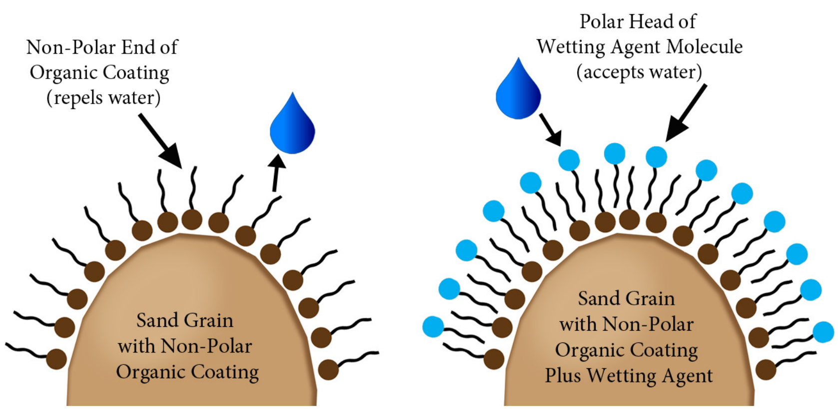

Figure 6. Diagrams illustrating wetting agent activity

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—Does 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 catetories 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.

Soil Barriers and Composts

Soil barriers such as mulches, pine straw, plastics, landscape fabrics, and gravel have long been used to conserve water in landscape beds. These products retain soil mositure by acting as a physical barrier to moisture loss through evaporation. They act to insulate the soil from the excessive warming drying effects of direct sun exposure. They also help reduce soil erosion and compaction, which can negatively affect water use efficiency. Furthermore, they reduce weeds, which steal water resources from desired plant materials.

Compost incorporation is also used to increase water use efficiency. Similar to the use of superabsorbent polymers, composts are known to increase soil water holding capacity. Amended soils are estimated to require up to 60% less water depending on the quality of the compost and quantity incorporated into the soil.

Antitranspirants

Antitranspirants are substances sprayed on the leaves of plants to reduce the rate of transpiration. Antitranspirants function utilizing three known modes of action. First, they reflect radiant energy way from the plant resulting in lower temperatures and transpiration rates. Second, emulsions of wax latex or other film are used to prevent the escape of moisture from the plant. Third, they prevent the stomata from opening fully and decrease the loss of water vapor from leaves. While not all experts are in agreement on the benefits of anti-transpirants, studies have shown that they can conserve water and minimize wilt and drought stress.

Growth Regulators and Biostimulants

Growth regulators and hormone biostimulants represent another class of chemistries that can be used to reduce plant water requirements. Plant growth regulators (PGRs) are designed to reduce excess vertical plant growth. While the intended benefit of these products is lower trimming and mowing maintance, slow growth has also proven to reduce plant water requirements.

Hormone biostimulants containing cytokinins have proven to increase root mass and depth. By encouraging root development, biostimulants improve water efficiency by helping plants source more water from soil. They have also provent to increase plant tolerance to a number of stresses, including drought.

Conclusions

There are a wide variety of consumable products and technologies available to help manage and conserve water. Using these technologies in conjunction with modern advancements in irrigation hardware will offer greater opportunities to maximize water use efficiency. The key to success is to recognize the value of consumables and learn which product(s) are the best fit for each specific situation. 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 consumable technologies. A very common 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 rootzone. Then, the hygroscopic humectant can reduce evaporative loss for maximum plant water use.

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

*Products brands Hydretain®, LESCO Moisture Manager™, and BioPro H3O™ have been certified to contain 93% biobased contents by the USDA BioPreferred® Program.

References

Karchner, D., & Richardson, M. (2014, December). Wetting Agents Improve Root-Zone Moisture Distribution. *Golf Course Management*, pp. 80-83.

Karnock, K. J., Xia, K., & Tucker, K. A. (2004, June). Wetting agents: What are they, and how do they work? *Golf Course Management*, pp. 84-86.

Messina, F. (1991, March 18). Absorbing Issue: Polymers are Saving Grace for Large Water Unsers, but Some Question Long-Term Effects. *Los Angeles Times*, p. Internet.

Orzolek, M. (1993, January/March). Use of Hydrophylic Polymers in Horticulture. *HortTechnology*, pp. 41-44.

Polhemus, D. (1992, June). Soil Polymers for Turf Areas: A Technical Review. *Sports Turf*, pp. 14-17.Zonteck, S. J., & Kostka, S. J. (2012, July). Understanding the Different Wetting Agent Chemistries. *USGA Green Section Record, Volume 50 (15)*, pp. 1-6.