Wetting agents: What are they, and how do they work?

A better understanding of how wetting agents work will lead to their more effective use on the golf course.

Keith J. Karnok, Ph.D.; Kang Xia, Ph.D.; and Kevin A. Tucker

Without question, soil wetting agents have become an important management tool for superintendents. The senior author conducted a survey of more than 600 superintendents that showed 87% use wetting agents as part of their regular maintenance program while another 11% use them in certain situations. According to the survey, wetting agents are used for four primary purposes: relieving localized dry spots (42%), managing water (32%), improving drainage (11%) and improving pesticide movement into the soil (9%). In addition, superintendents use wetting agents for a variety of other reasons such as reducing dew and frost formation, improving seed germination, reducing fairy ring damage, reducing soil compaction, improving irrigation efficiency, reducing dust in golf car paths, improving firmness of bunker sand, etc. Little research supports the use of wetting agents in all these scenarios. However, when used in the right situation, a wetting agent can be can an effective management tool.

Although superintendents commonly use wetting agents, confusion about what wetting agents are and how they work is widespread. In this article we explain the characteristics of wetting agents and how they work in certain situations. Perhaps, through a better understanding of the chemical nature of wetting agents, superintendents will be able to determine whether a wetting agent will be effective in a given situation.

KEY points

More Info: www.gcsaa.org

- **Most of the soil wetting agents** used in turfgrass management are nonionic surfactants.
- **Wetting agents bond** both with water and with the organic coating on the soil or sand particle, thus allowing the soil or sand particle to become wet.
- **A wetting agent applied to a non-water-repellent soil** would most likely increase the downward movement of water out of the root zone and decrease the upward capillary movement of the water in the soil.
- **When a wetting agent is applied to an area** with excessive thatch or mat, that area dries more slowly than an untreated area at the same site.

Surfactants

Wetting agents fit into a class of chemical compounds called *surfactants*, which are chemicals that cause a physical change at the surface of liquids. Such changes occur at the interface between two liquids or between a liquid and a gas or a liquid and a solid. Because they cause changes at the surface, they are known as "SURFace ACTive AgeNTs." Surfactants are commonly used in herbicide formulations to enhance the desired properties of the formulation and the ultimate spray mixture.

Surfactants have many other uses depending on their specific chemical properties. For example, other types of surfactants include emulsifiers, dispersants, spreaders, penetrants, stickers and detergents. Each type of surfactant has one or more characteristics in common, but all possess the common feature of a water-soluble (hydrophilic) group attached to a long, oil-soluble (lipophilic) hydrocarbon chain (Figure 1). These two groups may be linked together or by an intervening group. Literally thousands of chemical combinations are possible.

Ionization

Small differences in the structure of surfactants can significantly affect their behavior. Depending on their ionization or charge, surfactants are commonly separated into four major groups: anionic, cationic, nonionic and amphoteric. Basically, anionic and cationic surfactants ionize when mixed with water. Their surface active properties are due to their negative charge (anion) and positive charge (cations), respectively. Nonionic surfactants do not ionize in aqueous or water solutions, whereas amphoteric surfactants can be either anionic or cationic depending on the acidity of the solution.

Anionic and cationic surfactants have the disadvantage of reacting with other ions in the solution, causing a precipitate or foam to form. Nonionic surfactants do not react with other ions so they are unaffected by hard water. In other words, they do not form insoluble salts with calcium, magnesium or ferric ions. They can also be used in strong acid solutions and tend to have relatively low toxicity to plants. Most of today's soil wetting agents used in turfgrass management are nonionic surfactants.

Soaps

Superintendents often ask, "What about soaps?" Soaps are a type of surfactant; can they be used as a soil wetting agent? Although soaps have both a polar end and a nonpolar end, they owe their surfactant properties to an anionic portion of the molecule. Therefore, soaps are actually anionic surfactants. They have the disadvantage of forming insoluble salts with magnesium, calcium and ferric ions in hard water. These salts will precipitate from solution and form a scum on the water. Therefore, soap would not be a good substitute for a nonionic surfactant or wetting agent.

Figure 1. A typical wetting agent molecule showing a hydrophilic water-attracting group and a long, oil-soluble (lipophilic) hydrocarbon chain.

Chemistry of water

Polarity

To understand how a surfactant or wetting agent works in a turfgrass situation, it is important to understand the properties of water. A water molecule consists of two hydrogen atoms and one oxygen atom. Water is a *dipolar* substance, which means it has both negative and positive polar ends (Figure 2). The unique properties of water are due to this polarity, which allows it to form bonds with a variety of polar molecules. However, water and other polar molecules will not bond with nonpolar molecules. In fact, water and other polar substances will be repelled by nonpolar molecules.

An example would be trying to mix water with oil or grease. Chemical bonds cannot be formed between water and oil. However, if a surfactant, which has both polar and nonpolar portions, is added to water, the water is no longer repelled. The nonpolar portion of the wetting agent bonds with the nonpolar oil, and the polar portion bonds with the water, apparently allowing the two to mix.

Figure 2. Water is a dipolar substance that consists of two hydrogen atoms (positive charge) and one oxygen atom (negative charge).

Surface tension

Another significant trait of water is surface tension. *Surface tension* is the tendency of the surface molecules of a liquid to be attracted toward the center of the liquid body. Surface tension is why a single water droplet on wax paper appears as though it has a tense, elastic membrane surrounding it. Few liquids have a higher surface tension than water. For example, a small sewing needle will float on the surface of pure water because the needle isn't heavy enough to break the surface tension of the water. However, if a wetting agent is added to the water, the surface tension (that is, the attraction of water molecules to each other) is reduced, and the needle will sink.

Wetting agents and water-repellent soils

It has been well documented that soil water repellency resulting in localized dry spots is the result of an organic (nonpolar) coating that adheres to the individual soil or — in most cases — sand particle (Figure 3). This organic material is the end product of organic matter decomposition. The authors have written about this phenomenon in several articles in *Golf Course Management* (see references list). The important point to

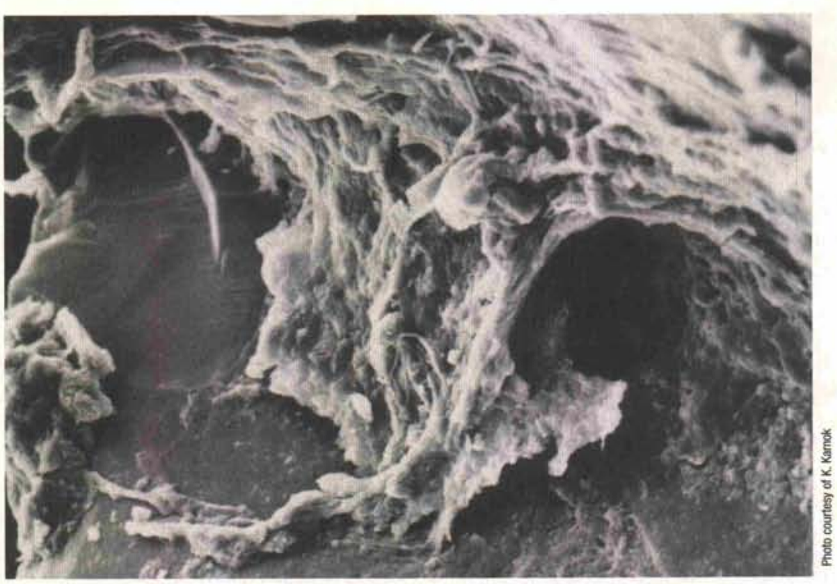

Figure 3. A scanning electron micrograph showing a sand particle with a water-repellent organic coating.

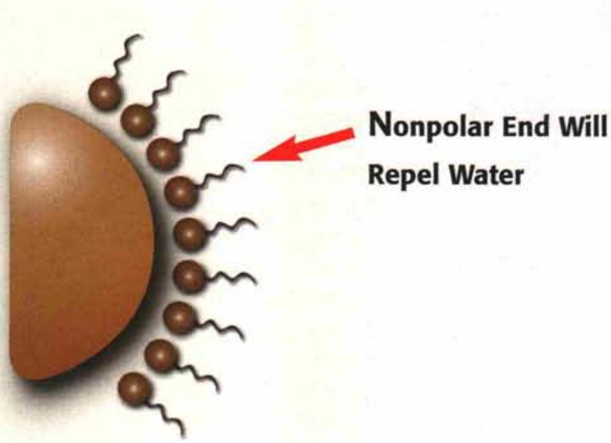

Figure 4. Diagram of a sand particle with a water-repellent organic coating.

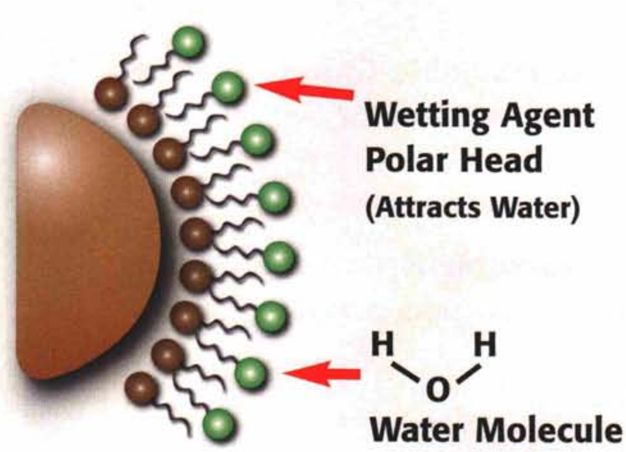

Figure 5. Diagram of a sand particle with a water-repellent organic coating after treatment with a wetting agent.

understand is when this organic coating covers a significant amount of a soil or sand particle, the particle will repel water (Figure 4).

When a wetting agent is added to the water, the polar portion of the wetting agent bonds with the water while the nonpolar portion bonds with the nonpolar organic coating, thus allowing the soil or sand particle to wet (Figure 5). As long as there is sufficient wetting agent bonding with the organic coating, the soil or sand particle will not be water-repellent. However, it should be kept in mind that this alleviation of soil hydrophobicity is only temporary. As long as the coating remains on the soil or sand particle, water repellency will return when the use of a wetting agent is discontinued.

Wetting agents and thatch or mat

Because wetting agents are designed to have an affinity for nonpolar as well as polar substances, then it stands to reason that excessive thatch or mat accumulation will affect wetting agent performance. In other words, a wetting agent will potentially bond with the thatch or mat as readily as it bonds with water-repellent soil particles. Research at the University of Georgia has demonstrated this fact. In a turfgrass site with an excessive accumulation of thatch, an area that has been treated with a wetting agent will dry significantly more slowly than an untreated area at the same site.

This in part explains the observation some superintendents have made that certain wetting agents apparently hold moisture at the soil surface. Although this phenomenon could be related to the chemistry of certain wetting agents, our research suggests that the amount — and possibly even the nature — of the thatch or mat is at least as important or perhaps a more important factor. At this point, we are unsure as to how much thatch or mat is too much. Research is under way to better understand the relationships among thatch or mat, organic matter and the performance of specific wetting agents.

Wetting agents and non-water-repellent soils

Superintendents often ask, "What happens when a wetting agent is applied to a non-water-repellent soil or sand?" In agreement with the reasoning discussed above, on a site with little or no thatch or mat and the absence of water-repellent soil, a wetting agent would have little effect on the soil itself. However, a wetting agent would reduce the surface tension and attraction of water molecules to each other, making water "wetter." This effect would most likely increase the downward movement of water out of the root zone (providing there was subsurface drainage) while decreasing the upward capillary movement of the water in the soil.

Conclusions

Many questions pertaining to wetting agents remain unanswered, including how, when and under what conditions they should be used on the golf course. We have several studies currently under way to answer many of these questions.

References

1. Carrow, R.N. 1989. Understanding wetting agents. *Golf Course Management* 57(6):18-26.
2. Fainerman, V.B., D. Mobius and R. Miller (eds.). 2001. Surfactants: Chemistry, interfacial properties, applications. Elsevier, New York.
3. Karnok, K.J., E.J. Rowland and K.H. Tan. 1993. High pH treatments and the alleviation of soil hydrophobicity on golf greens. *Agronomy Journal* 85:983-986.
4. Karnok, K., and M. Beall. 1995. Localized dry spots caused by hydrophobic soil: What have we learned? *Golf Course Management* 63(8):57-59.
5. Karnok, K.J., and K.A. Tucker. 1999. Dry spots return with summer. *Golf Course Management* 67(5):49-52.
6. Karnok, K.J., and K.A. Tucker. 2000. FAQ about LDS. *Golf Course Management* 68(6):75-78.
7. Karnok, K.J., and K.A. Tucker. 2001. Fight localized dry spots through the roots. *Golf Course Management* 69(7):58-60.
8. Karnok, K.J., and K.A. Tucker. 2001. Effects of flutolanil fungicide and Primer wetting agent on water repellent soil. *HortTechnology* 11(3):437-440.
9. Karnok, K., and K. Tucker. 2002. Water-repellent soils, Part I. Where are we now? *Golf Course Management* 70(6):59-62.
10. Karnok, K., and K. Tucker. 2002. Water-repellent soils, Part II. More questions and answers. *Golf Course Management* 70(7):49-52.
11. Karnok, K.J., and K.A. Tucker. 2003. Turfgrass stress, water-repellent soils and LDS. *Golf Course Management* 71(6):97-98.
12. Tucker, K.A., K.J. Karnok, D.E. Radcliffe, G. Landry Jr., R.W. Roncadori and K.H. Tan. 1990. Localized dry spots as caused by hydrophobic sand on bentgrass greens. *Agronomy Journal* 82:549-555.
13. Wilkinson, J.F., and R.H. Miller. 1978. Investigation and treatment of localized dry spots on sand golf greens. *Agronomy Journal* 70:299-304.

Keith Karnok, Ph.D. (kkarnok@uga.edu), is a professor of turfgrass science and Kang Xia, Ph.D., is an assistant professor of environmental soil science in the department of crop and soil sciences at the University of Georgia. Kevin A. Tucker is a research associate in the department. Karnok will be an instructor at GCSAA education seminars in Orlando.