WATER USE BY TURFGRASS PLANTS

Three California researchers discuss why turfgrass needs that water you're giving it, and what happens when it gets too much or too little.

By Matt Leonard, Steve Cockerham and Vic Gibeault

This automatic weather station reports local evapotranspiration information as part of a statewide system in California.

Increasing leisure time and a greater awareness of the health benefits of physical exercise have led more people of all ages to become active participants in a wide range of sports and recreational pursuits. As a result, turfgrass acreage in the United States is continuing to grow.

Still, the most persistent force behind the increasing use of turf is population growth. More people translates into more homes, schools, parks and commercial centers, all of which means more turf. As the area under turf increases, there is an increased demand on available water resources. Since it has been demonstrated that turfgrass irrigation is not a high priority when water is allocated, turf managers must become aware of available water-saving options.

The cost of water for irrigation is having an even greater impact on conservation than local supply problems. Fundamental to the water conservation effort is an understanding of how the turfgrass plant uses water.

Water in grass

Water entering the root from the soil contains plant nutrients as dissolved mineral salts. As water moves up through the root to the stem and leaves, these mineral nutrients are carried along, available for absorption by cells that need them. Water enters the roots and moves through the plant along a continuum of potential gradients. This is the process of moving from a high concentration of water toward a lower concentration. Where water concentration is high, dissolved salt concentration is low and vice versa. This is an important principle as it explains how water moves and carries nutrients throughout a plant, even to the top of the tallest trees.

Light and water

Water is also used in photosynthesis, which is the process of using light en

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ergy to make carbohydrates from water, nutrient salts and carbon dioxide. Carbon dioxide is obtained from the atmosphere when it diffuses into the interior of the leaf through pores in the leaf surface.

Pores in the leaf, stomates, are formed by pairs of elongated cells which lie side-by-side attached at each end. An increase in internal water pressure (turgor) within these guard cells swells them, causing the stomates to open. The loss of turgor in the guard cells results in closing the stomates.

Stomates not only allow carbon dioxide to enter, but also permit water to evaporate from the plant into the atmosphere. This water loss is called transpiration. The fate of most of the water taken up by the plant is to be lost to the atmosphere through transpiration, leaving the dissolved nutrient salts behind.

Transpiration's primary function is to dissipate heat from leaves exposed to sunlight. In this process, accumulated heat converts water to vapor, which then diffuses out of the leaf through the stomates. Heat and water vapor are lost. As temperatures rise, so does the rate of transpirational water loss. If transpiration exceeds the rate of water uptake by the roots, the plant experiences water stress. This can result in wilting and, if prolonged, permanent disruption of physiological processes.

Transpiration also pulls water through the plant by maintaining a low concentration of water at the stomates, thus beginning a sort of chain reaction to move water to the leaves from the roots.

Light provides the energy for photosynthesis, and stimulates the opening of the stomates. Stomates are typically open during the day and closed at night, permitting carbon dioxide to enter the plant when the light energy required for photosynthesis is available. It also minimizes water loss from the plant at night.

Moisture stress

Grass plants experience water stress almost daily, usually during mid-afternoon when temperatures peak. As water-stressed plants lose turgor, the stomates close. This prevents further water loss while continued root uptake replenishes the plant and turgor is restored. Increase in turgor reopens the stomates and transpiration resumes. Daytime temperatures are generally lower by the time turgor again builds up and root uptake of water can keep pace with transpiration.

Climatic factors can also influence transpiration rate. Wind quickly moves water vapor away from the leaf surface. This increases the difference in the water vapor concentration between the inside and the outside of the leaf, increasing the transpiration rate. When there is not wind, a layer of still air envelopes the leaf surface, allowing the water vapor concentration outside the leaf to rise, decreasing transpiration. This, again, is due to the principle of water moving from high concentration outside to low concentration. Since the water concentration outside the leaf increases, closer to that of the inside of the leaf, water movement out slows down, which slows water movement throughout the plant.

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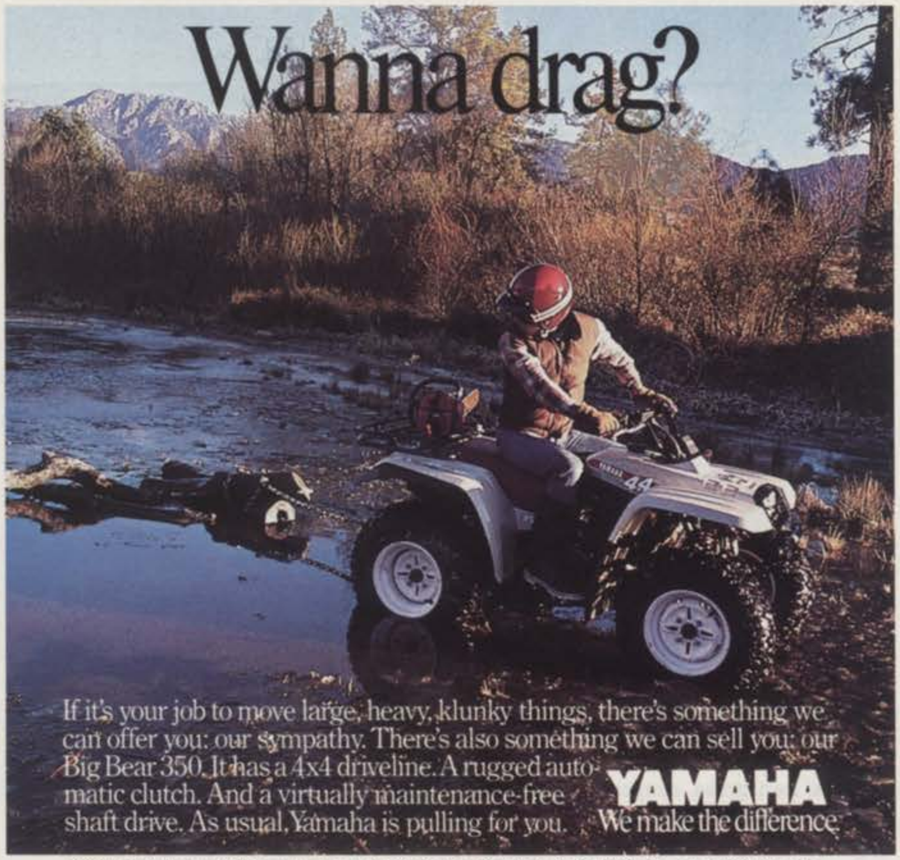
Humidity influences transpiration in a similar fashion. As atmospheric humidity increases, the water vapor gradient across the leaf surface decreases (concentration decreases) and the transpiration rate increases. Low humidity combined with high winds cause a tremendous rise in transpiration rates and quickly lead to water stress.

When stomates close as a result of water stress, the plant is subjected to additional stresses. Heat is no longer dissipated by transpiration. This can injure or possibly kill the plant by disrupting metabolic activities if drought conditions are prolonged. Turf is especially sensitive to mechanical injury during these periods.

Photosynthesis is also inhibited when stomates close. This is because carbon dioxide, an essential ingredient in the photosynthetic reaction, is excluded from the leaf. Without a supply of carbon dioxide, the plant cannot manufacture carbohydrates for building new plant structure. In other words, when the stomates close, growth slows down. Extended water stress can, therefore, adversely affect shoot density and the ability of the plant to recover from injury or disease activity.

Types of turfgrasses

Turfgrasses are typically categorized as being either cool-season or warm-



Cans set out in a grid pattern on a golf green help evaluate the distribution uniformity of the irrigation system.

season species. Cool-season species, as the term implies, are adapted to temperate, northern climates. Bluegrass, bentgrass, ryegrass and fescues are included in this group.

Warm-season species, including Bermudagrass, zoysiagrass, St. Augustine and seashore *paspalum* are adapted to hot, tropical and sub-tropical climates. The differences between warm- and cool-season grasses are much more fundamental than geographic distribution.

Warm-season grasses use significantly less water than cool-season species. This difference in water use derives from changes in the photosynthetic process that occurred in grasses evolving under hot, dry conditions. These changes, which include modifications to biochemical reactions and internal leaf anatomy, greatly enhance the photosynthetic efficiency of warm-season species and help reduce transpiration. Increased photosynthetic efficiency means that plants can maintain high levels of carbohydrate production and continue to grow even when stomates are partially closed. This partial closure of the stomates slows the plant's transpirational water loss.

Cool-season grasses, with a less efficient photosynthetic process, cannot maintain enough carbohydrate production to maintain growth unless their stomates are nearly wide open. Thus, when water is limited, transpiration rates of cool-season grasses are generally higher than those of warm-season grasses.

Root depth density

Important characteristics influencing the ability of plants to avoid water stress are the depth and density of rooting. Grasses with deep root systems have the ability to draw water from a much greater volume of soil. Plus, there is less chance that water will percolate down beyond the reach of the root system. This is a distinct possibility with shallow-rooted species such as Kentucky bluegrass and perennial ryegrass. With these species, soil water beyond a depth of two feet is essentially unavailable. This water would still be within reach of Bermudagrass or tall fescue.

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Greater soil penetration by a large number of roots significantly increases the volume of water upon which a plant can draw. Bermudagrass and seashore *paspalum* both send roots down more than five feet, though Bermudagrass has better drought resistance due to a somewhat deeper and better distributed root system.

The fescues commonly exhibit leaf rolling when subjected to water stress. By enclosing the upper leaf surface, where most of the stomates are located, a high level of humidity is maintained within the rolled leaf and transpiration is reduced.

Water used by plants is thought of as the amount lost to transpiration. When considering irrigation of turf, evaporation becomes important as a part of the water use, or rather, the water loss. A practical means of calculating turf water use is to determine the transpiration rate plus the rate of evaporation, referred to as evapotranspiration (ET). ET is the total water lost by turf.

Many states, through water agencies and districts, provide local ET information for agricultural growers and landscape managers. The irrigation industry has been very active in developing ET guidelines for the turf industry.

Irrigation systems

Though substantial water savings can be realized through proper species selection, those same savings can be just as quickly dissipated by a sprinkler irrigation system with poor distribution uniformity.

The quickest and most effective way to evaluate the distribution uniformity is to perform a can test. This is done by setting out a number of uniform, open-topped containers (motor oil cans, plastic cups, etc.) in a grid pattern over the area to be tested. Distance between containers is up to the user, but should be close enough to be meaningful (10 or 20 feet are often used). The accuracy of the test increases as the number of containers increases. Spacing between containers should be equal.

The sprinkler system should be turned on for about 15 minutes. If the user does not wish to record data, simply looking into and comparing the containers will indicate whether the system is nearly uniform or not. If recorded data would be useful, e.g. to make a point with administrators, measure the amount of water collected in each container.

Measurements are made into a measuring cup or graduated cylinder, being careful to note the grid location of the measurement. Ideally, all measurements would be equal. In reality, the values will vary somewhat. If major discrepencies are evident in values from container to container or from one part of the test area to another, the uniformity of water distribution needs to be improved. Unless the problem is obvious, like a malfunctioning sprinkler head, the system should be evaluated by an irrigation consultant. The resultant savings in both water and money can be significant.

Efficient water use and conservation opportunities are based on selection of grasses, their culture and the efficiency of the irrigation system. All of this is site-specific so the manager must become involved in the use of this vital natural resource. **LM**