TURFGRASS WATER RELATIONS AND PHYSIOLOGY

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Water is the most important requirement for turfgrass growth and survival. Turfgrasses are composed of living containers (cells) of water within which all metabolic processes take place. Since the water content of actively growing turfgrasses approaches 90% of total mass, a small reduction in the moisture content of a plant can dramatically reduce growth and appearance, and even cause death.

The various functions of water in the plant include maintaining cell turgidity for structure and growth; transporting nutrients and organic compounds throughout the plant; comprising much of the living protoplasm in the plant cells; constituting a raw material for various chemical processes, including photosynthesis; and, through transpiration, buffering the plant against wide temperature fluctuations. This last function accounts for the greatest utilization of water by plants.

Transpiration

Transpiration involves the absorption, transport, and release of water to the atmosphere by plants. The evaporation of water films surrounding leaf cells requires heat energy (570 calories per gram of water); thus, transpiration is an important means of maintaining the plant within a tolerable temperature range. The exit of water vapor from the plant occurs primarily through the stomates, small openings distributed throughout the leaf epidermis. As it exits the plant, much of the water vapor surrounds the leaf to form a layer of moist air called the *boundary layer.* The thickness of the boundary layer is determined by numerous factors, including transpiration rate, relative humidity of the ambient air, and wind velocity.

With rapid transpiration, high relative humidity, and no wind, the boundary layer may reach up to 1 centimeter (cm) in thickness. As wind velocity increases, the moist air surrounding the leaf is mixed with dryer air to reduce the boundary layer to as little as a few millimeters (mm) in thickness. When the ambient air is at 40% relative humidity (RH) and 86°F, its vapor pressure is 12.74 mm of mercury (Hg), while that of the saturated boundary layer (100% RH) is 31.85 mm Hg. Thus, the large vapor pressure gradient of 19.11 mm Hg (31.85 – 12.74) results in rapid movement of water vapor away from the boundary layer and in the direction of lower vapor pressure. On a very humid day (80% RH) with the same air temperature, the vapor pressure of the ambient air would be 25.48 mm Hg and the vapor pressure gradient only 6.37 mm Hg; therefore, the tendency for water vapor to move away from the boundary layer would be considerably reduced. The boundary layer is important in that it reduces the vapor pressure gradient between the intercellular spaces within the leaf and the air immediately outside the leaf. The result is a much reduced rate of transpiration and, therefore, a smaller amount of water consumed by the plant.

Under some conditions, plants may lose water faster than it is absorbed by the roots. This creates an internal moisture deficit that may be favorable or highly unfavorable to the plant, depending on the magnitude and duration of the moisture imbalance. Carefully controlled moisture deficits can result in more extensive root growth and other morphological alterations that generally improve the tolerance of the turfgrass to environmental stresses. When severe moisture deficits are allowed to develop, however, the plants wilt and may eventually die or become dormant. The capacity of plants to survive periods of moisture stress is called *drought resistance.*

Drought Resistance

Drought-resistance mechanisms in plants are classified as escape, avoidance, and tolerance. *Drought escape* is of little practical importance to turfgrass species, but it is evident in some annual species that may invade the turfgrass community (i.e., weeds) and that respond to drought stress by producing large quantities of seed to ensure subsequent generations of the population. *Drought avoidance* mechanisms include those that function in maintaining high plant-water potentials under conditions in which moisture availability is low.

Maintenance of high plant-water potentials may be affected by reduced transpirational water loss through reductions in leaf area and increases in stomatal, cuticular, or canopy resistance. Increased root density and depth contribute to the plant's water-uptake capacity. *Drought tolerance* mechanisms include those that function in maintaining turgor pressure at low water potentials and others that contribute to the survival of dehydrated plants.

The role of fungal endophytes (*Neotyphodium* and *Epichloe* **spp.**) in drought tolerance and avoidance mechanisms in cool-season turfgrasses is not clear, but one likely explanation is the prevention of injury and associated water loss from parasitic nematodes, shoot-feeding insects, and some disease-inciting agents. Another possible explanation is an endophyte-induced alteration in the production of phytohormones that enhance cell wall extensibility and cell expansion rate. Biologically active alkaloids occurring in turfgrass-endophyte associations may favorably influence the physiology and growth of infected turfgrasses by encouraging the formation of larger, more competitive plants.

Forms of Atmospheric Moisture

The oceans covering approximately three-fourths of the earth's surface are the basic sources of atmospheric moisture. Water evaporates from bodies of water and, as water vapor, becomes a component of the atmosphere. When the air is cooled, water vapor condenses around small particles (condensation nuclei) to form clouds. Precipitation from clouds transfers moisture to terrestrial areas, where it supports life. Subsequent return of moisture to the atmosphere or to bodies of water completes the hydrologic cycle.

Forms of moisture that are important in turfgrass culture include precipitation, irrigation, water vapor, and dew. The distribution of precipitation over land masses greatly affects the quantity and type of vegetation that can be sustained. In some areas even the most drought-hardy turfgrasses may not persist without supplemental irrigation. Under different climatic conditions, turfgrasses may thrive strictly from naturally occurring precipitation.

Water vapor is a relatively small component of air, but it is an extremely important factor in the turfgrass environment. Precipitation, transpiration, and temperature are influenced by atmospheric water vapor. These, in turn, control the distribution and growth of turfgrasses and other plant species. The water vapor content, or relative humidity, of the air surrounding turfgrass shoots influences the incidence of disease through its effect on the growth and survival of pathogenic organisms. The amount of water vapor that can be held by air is directly proportional to the temperature of the air. Increasing the air temperature from 62° to 87°F allows for a doubling of the water vapor content of saturated air. Conversely, a substantial drop in the temperature of moist air can result in condensation of moisture around particles or on plant surfaces.

Dew is the accumulation of visible moisture on plant leaf surfaces observed in the early morning hours. It is the result of several processes occurring independently or together. One process, called *guttation,* involves the diffusion of plant moisture through openings (hydathodes) at the ends of uncut leaves. Guttation occurs when water pressure builds up in the roots during periods of minimal transpiration and rapid water absorption. When leaves are cut, resulting in the removal of hydathodes, plant moisture may still diffuse through openings at the wound sites. This is called *exudation.* Guttation and exudation fluids contain various minerals and simple organic compounds collected from within the plant. As droplets of these fluids form on the leaves, these dissolved materials accumulate on the leaf surfaces and may significantly enhance the growth of fungal pathogens and increase disease incidence. Some burning of the leaf tips may also result as the fluids evaporate and leave high concentrations of salts on the leaves.

Condensation, another dew-forming process, may occur on leaf surfaces when radiation cooling of the leaves reduces leaf temperature to below that of the surrounding air. The moist air immediately adjacent to the leaf is cooled to its dew-point temperature (temperature at which air is saturated) and, with further cooling, water vapor condenses on the leaves. Condensation is the opposite of evaporation; latent heat is converted to sensible heat during condensation, and the drop in leaf temperature from radiation cooling is reduced. Dew formation typically occurs during the evening hours, especially on clear nights when radiation cooling is proceeding rapidly. Under favorable conditions, so much dew may form that water drips from the leaves onto the soil. The amount of moisture gained from these processes, however, is usually not very substantial.

During cold seasons when night temperatures drop to below freezing, frost is formed in place of dew. Traffic should be avoided on frosted turfs until the frost has disappeared; otherwise, damage to the leaf tissue may occur and be evident until sufficient new growth has taken place.

Dew may be of some benefit to the turfgrass community. It delays the onset of transpiration during the early morning hours so that soil moisture is conserved. In summer, the rise in leaf temperature is retarded until later in the day when the dew has evaporated. The application of various pesticides is facilitated by the presence of dew. Sprayer operators are less likely to miss strips of turf where dew clearly marks the unsprayed areas.

An undesirable effect of dew is the enhanced disease development that results, especially on greens and some other closely mowed turfs. A traditional disease control practice has been to remove dew by poling, dragging, or syringing with water during the early morning hours.

During winter months, snow and ice may accumulate on turf and remain for extended periods. Snow cover protects the turf from winter desiccation and traffic-induced injury; however, several winter disease problems may be favored in snow-covered turfs and, for this reason, greens are usually treated with preventive fungicides prior to snowfall. Freezing rain may quickly form ice layers over a turf during winter. There is little evidence to suggest that temporary ice cover can directly result in serious injury to turf; however, when the ice thaws on sites with poor surface drainage, submerged turfgrass crowns may absorb enough water to reduce their cold-hardiness. A rapid freeze could then result in some direct low-temperature injury. Partial removal of a thick ice cover may be advisable on greens to reduce the potential for this type of injury.