Influences on water use rate of Penncross creeping bentgrass

Cultural and environmental factors influencing the stomatal density and water use rate of Penncross creeping bentgrass. R.C. Shearman. 1971. M.S. Thesis. Michigan State University. pp. 1-57. (from the Department of Crop and Soil Sciences, Michigan State University, East Lansing, Mich. 48823).

The objective of this study was to determine the relative importance of selected cultural and environmental factors on the water use rate of a Penncross creeping bentgrass turf. Correlations were also made with the stomatal density of the leaves when grown under various environmental and cultural conditions. The stomatal density counts were made from clear-nitrocellulose replications of the leaf blade surface.

The water use rates were determined in a specially devised wind tunnel. The environmental conditions maintained in the chamber included a temperature of 91 degrees F, 40 per cent relative humidity, a four mph constant wind velocity and a moderately low light intensity which kept the stomata open during the test period. This environmental stress condition was maintained for a 12-hour period after which the amount of moisture loss was determined by weighing. Six to 10 replications were made in each of the individual experiments depending on the variability anticipated.

The Penncross creeping bentgrass was established from seed in small half liter containers under greenhouse conditions. The standard cultural practices, except where varied by the specific treatments, were as follows: mowing weekly at two inches; the application of a complete nutrient solution twice a week to avoid nutritional deficiencies, and watering daily at midday.

The specific treatments utilized in the five experiments were as follows: experiment one included light intensity treatments of (a) 3,762 lux, (b) 25,800 lux and (c) full sunlight. The influence of the previous growing temperature was determined in experiment two. The treatments included (a) 50, (b) 68 and (c) 91 degree F soil temperatures for 2.5 months prior to determinations of the water use rate. In experiment three, there were three cutting heights: (a) 0.25, (b) 1 and (c) 5 inches applied on a weekly clipping schedule during the three-month growing period. In experiment four the water application rate effect was determined. The three treatments included: (a) 0.5, (b) 1 and (c) 4 inches of water applied weekly for three months prior to determination of the water use rate. In experiment five, three irrigation frequencies were evaluated. Included were (a) water applied only when visual wilt occurred, (b) watering three times a week to a saturated soil condition and (c) watering daily to a saturated soil condition. As in most of the previous studies, this experiment was conducted for a three-month period prior to placement in the wind tunnel for the evaluation of the water use rate as well as for the determination of the stomatal density.

An assessment of the stomatal density data indicated that there was a three-fold greater number of stomata on the upper surface of the Penncross creeping bentgrass leaf compared to the lower surface of the leaf blade. The actual stomatal density in this study ranged from 72 to 125 stomata per square millimeter.

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In experiment one the water use rate of Penncross creeping bentgrass increased as the light intensity was increased. There was also a corresponding increase in stomatal density with increased light intensities. Thus, the light conditions under which turfgrasses grow have a strong influence on the density of stomata formed on the leaf surface. This in turn affects the water use rate. Turfs growing in shade would have a lower water use rate compared to adjacent turfs of the same species growing in full sunlight.

In experiment two, it was found that suboptimal growing temperatures resulted in a reduction of both the water use rate and the stomatal density. A 30 per cent reduction in stomatal density occurred between 68 and 50 degrees F, while the water use rate declined by 20 per cent. There were no differences observed in the water use rate or stomatal density between the 68 and 91 degree F growing temperatures. In this regard, the soil temperature is more important than the air temperature. Turfs growing under cool conditions form a reduced number of stomata per unit area and therefore have a lower water use rate.

In experiment three the water use rate increased as the height of cut was raised. In raising the height of cut from 0.25 to one inch the water use rate increased 53 per cent. This results primarily from the greater leaf area exposed to the evaporative conditions of the atmosphere.

In experiment four the water use rate decreased as the water application rate was increased. In experiment five frequently irrigated turfs had an increased water use rate. The author concluded that, of the factors studied, the light intensity, cutting height and frequency of irrigation had the greatest influence on the water use rate.

Comments: The water use rate is defined as the total amount of water required for turfgrass growth plus the quantity lost by transpiration and evaporation from the soil and plant surfaces. The rate of water use of most turfgrasses under normal conditions usually ranges from 0.1 to 0.3 inch per day. Water use rates as high

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as 0.45 inch may occur under conditions of high evapotranspiration. This situation usually exists only in early to midsummer when peak water use rates are more common.

A knowledge of the water use rate of turfgrasses is important in designing and utilizing irrigation systems. It is also important to obtain information on the relative importance of various environmental and cultural factors on the water use rate. In this way it may be possible to modify certain environmental conditions or to alter certain turfgrass cultural practices so that the water use rate of a specific turf can be reduced. This probably will become more important as water availability becomes limited in the future.

The stomata are extremely important structures because they are the primary avenues or openings through which gas and water exchange with the external atmosphere. Although the stomata compose only 2 to 3 per cent of the turfgrass leaf area, they are responsible for as much as 90 per cent or more of the total water loss from the turfgrass plant to the atmosphere. Stomata may occur on the stem tissue but in a substantially reduced density compared to the leaf blades. The rate of water loss by stomatal transpiration is a function of the water vapor gradient between the leaf tissue and the external atmosphere. It increases with (a) a decrease in the atmospheric water vapor content adjacent to the leaf, (b) an increase in the wind velocity adjacent to the leaf, (c) a high leaf moisture content and (d) an increase in the leaf and atmospheric temperature.

As demonstrated in this paper, the density of stomata varies with the environmental and cultural conditions under which the stomata develop. The stomata density will also vary with the turfgrass species. The stomata on turfgrass leaves are usually arranged in longitudinal rows interspersed with other epidermal cells. The opening of stomata for water loss is stimulated by exposure to light. Generally, the stomata are closed during dark periods. Thus, the water loss by evapotranspiration is less at night.

Of the environmental factors investigated in this study, the light intensity during leaf growth was far more important than temperature in affecting the water use rate of the turf. Assuming adequate light is available, however, the rate of water use on any given day will increase as the temperature increases. In other words, we must distinguish between the effects of temperature during the growth period when the stomata are being formed on the leaf versus the actual temperature during the period when water loss is occurring. Thus, increased temperature, particularly above the optimum for turfgrass growth, results not only in a higher water use rate due to an increased stomata density, but also increases as the temperature is increased due to the higher rate of diffusion or movement of water molecules from the leaf to the external atmosphere.

Of the cultural practices investigated in this study the cutting height and frequency of irrigation were more important in moderating the water use rate than the total amount of water applied per week. In addition to these cultural factors the water use rate is increased if the turf is mowed with a dull, improperly adjusted mower. In this situation the leaf tissue is mutilated and injured to the extent that the water use rate is increased. From a nutritional standpoint, higher levels of nitrogen nutrition generally result in an increase in the total water use rate of turfgrasses. Other factors to consider include the effects of disease and traffic. Generally, water use rates increase on diseased turfs or those subjected to intense traffic.

In summary the more intensive cultural practices such as high levels of nitrogen nutrition and frequent irrigation result in an increased water use rate. Moderation in these practices can be achieved without seriously reducing the quality of the turf and, at the same time, also reduce the water use rate as well as the proneness to attack from turfgrass pests or to injury by heat, cold, drought or traffic stress.

This discussion is a relatively simplified version of some of the environmental and cultural factors influencing the water use rate. The processes involved in the absorption, translocation and transpirational loss of water from a turf are highly complex and interrelated. □