Effect of Temperature Stress on Poa Annua

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The actual temperature of a turfgrass plant or its individual parts is determined by the surrounding environment. Temperatures of the below ground portions of the plant are usually identical with the adjacent soil temperatures, while above ground plant parts tend to follow the surrounding air temperature. The greatest extremes in temperature commonly occur at the surface of the turf and are moderated with increasing distance above and below the surface. The air and soil temperatures will vary with (a) latitude, (b) altitude, (c) topography, (d) season of the year, and (e) time of day.

OPTIMUM TEMPERATURES

The temperature at which activity of a particular process occurs at the highest rate is referred to as the optimum temperature. The optimum temperature will vary depending upon the (a) age of the plant, (b) stage of development, (c) specific plant organ involved, (d) physiological condition of the plant, (e) duration of the temperature levels and (f) variation in other environmental factors. As a result, the temperature optimum is actually a range rather than a specific fixed temperature.

The optimum of temperature range for shoot growth of annual bluegrass is between 60 and 70 degrees Fahrenheit. In contrast the optimum temperature for root growth of annual bluegrass is between 55 and 65 degrees.

In general, it is more important to maintain an optimum temperature for root growth than for shoot growth. Turfgrasses can maintain growth at relatively high air temperatures so long as the soil temperature remains in a favorable range. Turfgrasses growing in the optimum temperature range will have increased nutrient and water requirements and will also require more frequent mowing.

As temperatures are increased or decreased from this optimum range the various metabolic processes within the plant are slowed. The net result is a general reduction in growth rate which continues until, at a certain point, growth actually ceases.

HIGH TEMPERATURE STRESS

Turfs are exposed to high temperature stress during summer periods when the degree of use is also the highest. This negative response where growth is slowly reduced and eventually ceases is termed indirect high temperature stress. Growth is impaired at superoptimum temperatures which are not necessarily fatal to the plant. Under these conditions the first visible effect of high temprature observed is a browning and die-back of the root system toward the soil surface. The roots will appear brown, spindly and weak.

High temperature stress actually causes increased maturation and death of the existing root system and also blocks the initiation of any new root system from the meristematic tissues. Loss of the root system is critical because it increases the susceptibility to injury from other adversities such as desiccation, diseases, insects, and nematodes.

The next significant effect of high temperature stress observed is a decline in shoot growth. Specifically, there is a reduction in leaf length, leaf width, leaf area, rate of new leaf appearance and succulence. Quite frequently the leaves will appear dark green to blue. The primary concern of the restricted shoot growth is that it limits the recuperative potential of the turf should injury from other adverse stresses occur.

The cause of high temperature stress is attributed to either (a) a destruction of certain heat sensitive enzymes involved in synthesis or (b) an imbalance between certain metabolic processes. Research at Michigan State University indicates that growth reduction is due to a blockage in either amino acid or protein synthesis.

Former MSU graduate student Tom Duff shows some paper chromotograms which are used to quantitatively analyze for the carbohydrates and amino acid levels of turfgrasses grown at optimum and superoptimum temperatures.

Evidence supporting this phyothesis includes a decline in protein level, an increase in free ammonia and a severe reduction in the amide level, especially glutamine. Michigan State University turfgrass researchers are attempting to describe the specific enzymes involved in high temperature growth stoppage. Once this is achieved it is hoped that the enzyme or enzymes involved can then be used as biochemical markers in a breeding program to select for heat tolerance. Such a technique would greatly accelerate the techniques of heat tolerance selection.

If temperatures are increased to quite high levels, direct high temperature injury may occur. This may be a more common problem than many individuals have previously thought. Direct high temperature kill involves denaturation of the proteins contained in the vital protoplasm of living cells. Studies at Michigan State University indicate that annual bluegrass can be killed at temperatures as low as 100 degrees. This is a surprisingly low temperature for kill to occur. Actually, temperatures of as high as 125 degrees have been measured at the surface of turfs.

Most turfgrasses have a built-in cooling system in the form of transpiration. During transpiration, energy is used to evaporate water from the leaf surface. In this process the leaf is actually cooled, therefore, so long as the leaf has open stomata which are actively transpiring, the temperature may not increase to a lethal level. However, should the stomata be closed due to a stress such as an internal plant water deficit, then transpiration will be impaired and lethal high temperatures may develop.

Detailed observations with annual bluegrass at Michigan State University show that the first signs of direct high temperature stress occur at the junction of the leaf sheaf and the leaf blade of the second and third youngest leaves. The lower portion of the crown, the youngest leaf and the apical stem were more heat tolerant than the older tissues.

TECHNIQUES FOR PROTECTION AGAINST STRESS

The question which is frequently asked by the professional turfman is "How may I protect my turf against high temperature stress?"

First of all, attempts should be made to maintain the plant tissues in a maximum state of hardiness. Specifically, heat hardiness is increased by decreasing the hydration level or water content of the tissue. In other words, judicious irrigation is important. A second factor is the nutrition level of the tissue. In general, excessive nitrogen fertilization should be avoided, because heat hardiness will be reduced, especially when the tissue is in a rapid state of growth.

The other aspect to consider when minimizing the chance of high temperature injury involves various means of cooling the turf or especially minimizing heat build-ups in the soil. Michigan State University research in this area has demonstrated the importance of good air movement in minimizing high temperature stress. Plantings, screens, or buildings which completely surround a turfgrass area and restrict air movement should be avoided. Investigations show that an air movement of only four miles per hour will cool a turf from 12-14 degrees during mid-day periods when air temperatures exceed 85 degrees.

The second factor to consider is the use of syringing as a technique to moderate peak mid-day temperatures. Although the light application of water may not necessarily lower the temperature, it will restrict heat accumulation for several hours during the mid-day period and, therefore, moderate the extreme soil temperatures which might have occurred had syringing not been practiced.

One further point to be made is that syringing should only be used as needed to avoid high temperature stress, and should not be considered a practice to be used day in and day out as a part of the routine maintenance program. This is particularly important on poorly drained turfgrass areas where overwatering can lead to saturated soil conditions, a low oxygen level, and, therefore, a restricted root system and a less vigorous turf.

An experimental arrangement for reproducing a 4 mph (left) and 0 mph (right) air movement over a bentgrass putting green turf.