From the Director's Desk

TURF STRESS — WARM AND HOT CONDITIONS

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This discussion involves a few of the known factors of stress on cool season grasses during hot weather. We are all familiar with the various occurrences, but a review of them can help us to better understand them and thereby reduce the hazard to turf during the coming season.

It is well known that roots of cool season grasses become shallow during hot weather. Wilt is familiar to all — both under moist and dry conditions. Just what this relationship involves has prompted the research to be reviewed.

Brown's work in Missouri examined loss of roots in the summer. He reported that Kentucky bluegrass grew best north of the 60° Fahrenheit isotherm. It showed little vigor in July and August, whereas Canada bluegrass was less affected by heat.

Brown noted good Kentucky bluegrass regrowth after defoliation at a temperature of 60°F. At 80°F. regrowth was poorer and at 100°F. many plants died within six weeks. Other workers were quoted that little growth occurred when soil temperatures were below 42°F. Rapid growth occurred between 42° and 47° when adequate nitrogen was present. Above 47° good growth was seen regardless of the nitrogen level.

Carbohydrate storage is reduced as temperatures rise. This is due to continuation of respiration at temperatures too high for photosynthesis to take place. Brown found that the best temperature for top growth was between 80° and 90°F. The best rhizome development occurred at 60°F. Chlorophyll in leaves was lost between 40° and 50°F. After a week at 100°F., growth stopped. Roots made maximum growth at 60°, declining at lower and higher temperatures. But when air temperature was 100° and soil temperature was kept at 70°, the plants produced good top growth.

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Stuckey, working with Colonial bentgrass, made several references to various plants that made good growth at high air temperatures, provided the roots were kept cool. She reported that at high soil temperatures, roots matured more rapidly. Her conclusion was that at lower temperatures plant roots matured more slowly and hence remained more vigorous for a longer period of time. Plant death at high temperatures was due to maturity and death of the root system and the consequent stress on plant tops.

Brown reported also that maximum Kentucky bluegrass root growth occurred in April. In the fall, the most rapid growth began in September. After mid-June, few new roots formed and there was no appreciable growth of existing roots until October.

Without irrigation, bluegrass root growth reduction is soon followed by a reduction in top growth. Irrigation in mid-summer did not influence root growth but did accelerate decomposition of older roots. This seemed to exert a beneficial effect, since these plots produced more herbage — even during the spring and fall when moisture was abundant in all plots. Summer irrigation, naturally, produced more clover and weed growth than in the non-irrigated plots.

He states that where summer drought is short and not too severe, bluegrass plants were probably protected from excessive depletion of stored food reserves. Fall droughts were said to be altogether harmful, because they inhibited root and rhizome growth as well as food storage during periods otherwise favorable for such development. Stored carbohydrate was decreased when turf was irrigated during summer.

Mowing at reasonable height had little effect on carbohydrate storage. Storage of starch and sugar proceeded almost as rapidly during the autumn in the rhizomes of closely (1") mowed grass as in that which was not cut at all from May until November. He summarized that storage of organic food reserves in perennial grasses is essential to their normal functioning. Excessive carbohydrate production in the spring and fall is stored in the roots and rhizomes. During the late spring and summer there is a net loss of these reserves. Irrigation in the summer does not help prevent this loss. Reserves are also used during foliation in the spring.

Stuckey classified forage plants into annual and perennial root system groups. If the maximum production of roots occurred during the first year and they remained functional for more than one year, they were called perennial. If new root systems were formed every year, they were classed as annual.

Annual Root Systems	**Perennial Root Systems**
Timothy	Kentucky Bluegrass
Redtop	Canada Bluegrass
Meadow Fescue	Orchardgrass
Poa trivialis	Crested Wheatgrass
Perennial Ryegrass	
Colonial Bentgrass	

Beard's work reported in 1958 and 1960 showed similar root growth patterns in creeping bentgrass. He found satisfactory root growth at 80°F. but only half as much at 90°F. Clipping reduced growth to half that in uncut treatments.

60° — Best top growth and root growth.

70° — Most root branching.

80° — Fastest initial root growth.

90° — Very slow root growth. Growth was temporarily stopped if tops were severely cut back.

He suggested that soil temperature at a 6" depth was a major factor in predicting variation in root numbers. This indicates that soil temperature is probably the major factor in root development or loss. It is the most consistent environmental factor controlling root growth. Light was secondary, but measurement facility was questioned. Soil moisture was of poor correlation since putting green plots were kept near field capacity at all times.

Jordan, reporting his work in 1958 and 1959 showed that temperature was a primary influence in plant sugar production.

If high temperature is a factor in reducing a root system, what happens when other parts of the plant are subjected to demands for water? Since this is due to transpiration, we should consider what affects the transpiration of water from plants. Solar radiation, humidity, temperature, wind movement, soil conditions influencing water availability, and atmospheric pressure all play a part in the amount of water given off by a plant.

Solar radiation caused plant pores or stomata to open. Most moisture is lost through these openings. They do not open at night. Humidity affects the diffusion of water vapor out of the pores. It is thought that the higher the humidity the slower a plant will transpire. Temperature reaction is direct when in sunlight.

Wind effects are far from simple. We assume that wind movement increases evaporation. This is true if, in a still atmosphere, vapor given off by a leaf remains in the surrounding air and slows transpiration by increasing humidity. In nature, however, the air is seldom perfectly still. Another effect of wind movement is its twisting and bending effect on leaves. This movement constricts and squeezes leaf cells and forces the vapor from the leaf. A gentle wind is more efficient, because high winds are thought to close stomata. The cooling effect of wind also tends to slow transpiration.

Soil conditions influencing transpiration are water availability, soil temperature, aeration and the solute concentration in the soil water. These may be direct or indirect, and as we have seen, may be due to their effect on the root system.

Atmospheric pressure has a minor role but could influence the rate of evaporation. Under reduced pressure, plants can be expected to give up their water more readily.

Wilting occurs when plants lose their turgidity. This may happen in either wet or dry soils, as a result of higher transpiration than water imbition. The total volume of water in the plant shrinks, although not equal in all tissues. The greatest loss is in the leaf cells.

There are several states of wilting. On some days visible wilting does not occur at all, but incipient wilting is frequent. This corresponds to only partial loss of turgor by leaf cells. It is during such periods of incipient wilt that damage can be done by spray applications of even faintly caustic materials.

Irrigation practices based directly on transpiration are syringing to cool the surface during hot weather and irrigating in the early spring when soils are still cold but air temperatures are high.

Oversucculence and weakened plant cells are ripe for attack by many disease organisms. It is during summer periods that **Pythium**, brown patch and leaf spot disease are most prevalent.

Traffic damage during the summer may not be a primary problem but secondary. Both traffic and disease problems are more severe when the plants are weakened than during periods of active growth.

Since we can do nothing (yet) about the primary cause of weakness due to reduced root systems, we can do many things to reduce damage from other causes:

1. Develop the best possible root systems during periods of maximum growth — spring and fall. Aeration, adequate fertilization and proper mowing heights are most important.
2. Keep moisture additions to a minimum on bluegrass during hot weather. It may be best to wait for signs of wilt before irrigation. Merion bluegrass and Penncross bent tees perform beautifully as long as moisture is not oversupplied.
3. Manage hot weather fertilization to prevent overavailability of nitrogen. Nothing should be left to the vagaries of nature, or theoretical formulations. Adequate applications of fertilizers should be used in the spring and fall, but excess residual should be avoided. Periodic, light applications should be used to allow the turf manager to remain in control of growth during the stress period.
4. Maintain adequate, but not excessive levels of all other plant nutrients.
5. Assure good air movement across turf areas, especially putting greens.
6. Provide adequate sunlight, especially in the morning, to promote optimum growth of the grasses.

By making the most of the optimum growing periods, the plants will be better able to withstand stress during hot summer weather. A capable turf manager will consider all facets of plant growth and not simply react to a specific condition that crops up during a particular phase of growth. In so doing he is making his job easier and removing some of the stress on himself.

References

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