BEATING SUMMER STRESS FOR COOL-SEASON SPORTS TURF

Cool-season turfgrasses, such as Kentucky bluegrass and perennial ryegrass are widely used species on sports fields in cool climatic regions. Managing cool-season grasses in sports fields that demand for high quality or playable turf can be challenging during summer months, primarily due to heat stress. The optimal temperatures are ranged from 65 to 75° F for shoot growth and 55° F and 65° F, but temperature often exceeds the upper levels of the optimal temperature ranges in many areas, including temperate climatic regions. In addition, cool-season grass species require as much as 2-3 inches of water per week to maintain active growth during summer months. However, evaporation demands increase with rising temperatures and water availability for irrigation or from rainfall may decline during summer months, which all together can lead to drought stress. It is not uncommon that drought and heat stress may occur simultaneously during summer months. Summer stress combining heat and drought can cause grasses, such as Kentucky bluegrass, undergo dormancy and severe decline in turf quality and field playability.

▼ **Illustration of turf performance** of Kentucky bluegrass under different deficit irrigation regimes.

KENTUCKY BLUEGRASS

100% ET irrigation

80% ET irrigation

60% ET irrigation

40% ET irrigation

The question is how to maintain high quality turf of cool-season turfgrasses in sport fields during summer months with increasing temperature and declining water availability? This article describes characteristics of heat and drought damages in cool-season turfgrass species, and discusses some cultural practices that can be taken during spring months to prevent turfgrasses from suffering summer stress and those can be used during summer months to suppress or alleviate summer stress damages.

CHARACTERISTICS AND SYMPTOMS OF HEAT AND DROUGHT STRESS

Root systems are essential for water and nutrient uptake, as well as production of some plant hormones regulating plant growth and development. Root growth is more sensitive to rising temperatures in the summer than shoot growth, due to its lower optimal temperature requirements. Root growth decline or root dieback, therefore, typically precede turf quality decline. Turf quality decline caused by heat stress is characterized by leaf senescence or yellowing of leaves due to loss of chlorophyll (a green pigment for light absorption in photosynthesis). Without adequate chlorophyll pigments in leaves, plants cannot properly photosynthesize for carbohydrate production. Whole-plant tolerance of turfgrasses to heat stress or turf quality is highly correlated to the amount of green leaves or chlorophyll content in leaves. When leaf yellowing as the most visible symptom of heat damages appears, root damages may have already occurred. Restricted root growth or accelerated root dieback by heat stress inhibits rooting ability for water and nutrient uptake, and the synthesis of hormones, such as cytokinins that control leaf senescence.

Drought injury in turfgrass is characterized by leaf wilting or desiccation and reduction in cell enlargement and growth due to water deficit, although many physiological and morphological changes are induced. Under drought stress, water loss from stomatal pores on leaf surface (transpiration) increases while root growth and water uptake from the soil are limited. This results in water deficit and loss of cell turgor. Leaf wilting or rolling is a typical symptom of drought stress. Turf experience drought stress initially becomes bluish, dull green color and then turns to brown color as chlorophyll content decreases with stress progression.

Another symptom of summer stress in cool-season turfgrasses is dormancy, in which case turfgrass leaves turn brown in response to drought stress alone or in combination with heat stress, but the meristematic crowns and stem or rhizome nodes remain alive. Dormancy is a mechanism of turfgrass escape from drought stress such that dormant plants survive (without growth) for extended periods of drought stress and resume growth when soil moisture becomes available. In general, dormant turfgrasses, especially those with rhizomes (underground stems) such as Kentucky bluegrass, can survive without water for several weeks with limited damage at temperature near or below normal levels, but may survive in dormant conditions for a shorter period of time during the summer when temperature is elevated. Depending on the duration of dormancy, grasses may recovery to a certain extent or fully recovery when temperature drops to normal levels and rainfall or irrigation becomes available. Allowing turfgrasses to go dormant may lose the field playability, although it can result in significant water savings without loss of turfgrass. Kentucky bluegrass can withstand extended period of dormancy and recover, as it has extensive rhizomes that generate new roots and shoots once soil moisture is replenished. However, bunch-type turfgrasses such as perennial ryegrass, once the turf canopy becomes desiccated and thinned under non-irrigated conditions, are slow to recover to their full canopy upon rewatering.

Any cultural practices that can promote root growth or minimize root damages and that can alleviate leaf senescence or increasing photosynthesis capacity and carbohydrate accumulation during hot summer months would help to maintain healthy, green turf during hot summer. In addition, it is important to take measures to promote turfgrasses quickly recover from dormancy once temperature drops and water becomes available. Proper routine management practices, such as mowing, fertilization, irrigation, and soil cultivation, as well as selection of stress tolerance turfgrass species or cultivars are important for maintaining actively-growing turf and improving turfgrass tolerance to summer stress. In the following sections we will focus on the discussion of practicing infrequent or deficit irrigation and use of plant growth regulators (PGRs) and biostimulants to prevent or control summer stress damages in cool-season turfgrass species, as well as cultural practices to promote turfgrass recovery from summer dormancy.

PRE-CONDITIONING TURF WITH INFREQUENT OR DEFICIT IRRIGATION

Irrigation practices performed in the spring, when maximum growth of shoots and roots occurs for cool-season turfgrasses, may well dictate how well turf will perform in the summer. Irrigation frequency and quantity can affect root growth, shoot growth and the balance of roots to shoots, as well as other physiological processes, such as carbohydrate availability, thereby affecting plant tolerance to summer stress.

Allowing surface soil drying between irrigation or infrequent irrigation typically reduces water loss due to slower vertical shoot growth and stimulates root penetration into deeper soil profiles by promoting carbon allocation into roots and reducing carbohydrate consumption of the shoots. In contrast, frequently irrigated turfgrasses (soils that are kept wet constantly) use more water than turfgrasses that receive less frequent irrigation and also promotes shallow root systems, which limits water uptake from deeper soil profiles where water may be available. Deficit irrigation is applying water at the quantity lower than the maximum amount of water evapotranspired from the turf (often measured at ET rate) with little or no loss of aesthetic turfgrass quality or field playability. Deficit irrigation has been associated with increases in water use efficiency. The level of deficit irrigation, however, varies with turfgrass species, soil types, and climatic conditions. For example, some cultivars of Kentucky bluegrass were able to maintain acceptable turf quality with 80% ET irrigation while 60-80% ET irrigation was adequate for tall fescue during June-September in loamy soils in Manhattan, KS.

Either infrequent or deficit irrigation may induce mild water deficit, leading to pre-conditioning or enhancement of physiological hardiness of plants. Infrequent or deficit irrigation promotes deep rooting, facilitates water retention (osmotic adjustment) mechanisms, and activates antioxidant stress-defense systems. Such mechanisms have been found in various plant species, including Kentucky bluegrass. Therefore, infrequent or deficit irrigation may be practices in spring for effectively promoting summer stress tolerance of cool-season turfgrasses. Spring is the best time to pre-condition plants for combating summer stress.

USE OF PLANT GROWTH REGULATORS AND BIOSTIMULANTS

Plant growth regulators are synthetic hormone-synthesizing inhibitors or other synthetic compounds that regulate plants growth and development at very low concentrations. Biostimulants contain various organic solutes, such as amino acids, sugars, antioxidants, and hormones, and many biostimulant products are extracts from seaweeds or kelps. Recently, PGRs and biostimulants have received increasing attention, and have been incorporated into the management programs in promoting turfgrass tolerance to stresses. However, most research information was obtained in golf turf management whereas field research on sports turf is limited in the study of using PGRs and biostimulants in stress management.

Among PGRs, trinexapac-ethyl (TE) is one of the most widely-used products as a foliar spay for suppressing vertical growth of shoots in turfgrasses, as it inhibits the synthesis of gibberellic acid that control cell elongation. Due to the growth inhibition effects, water demand of shoots is reduced; in addition, TE application has also been found to increase chlorophyll concentration and tiller density in warm-season and cool-season turfgrasses, including Kentucky bluegrass. The research information on TE regulation of root growth is inconsistent with no effects reported in perennial ryegrass and a reduction in root growth found in Kentucky bluegrass. As the consequences of growth and physiological regulation of shoot growth, TE is also effective in reducing water consumption and delaying drought stress or suppressing heat injury in various turfgrass species, including perennial ryegrass and Kentucky bluegrass. Ervin and Koski reported that application of TE (0.27 kg a.i. ha-1) three times per year at 6-week intervals reduced weekly evapotranspiration rate in Kentucky bluegrass in 5 out of a total of 34 weeks. Pre-stress conditioning of turf with TE seems to be more effective than applying TE at the onset or during drought stress. TE may be applied to turf at reduced rates more frequently before a dry period is anticipated or prior to reducing irrigation. How TE application may alleviate heat stress damages in cool-season sport turf are not well documented and the effective frequency and rates for improving turf performance during heat stress have yet to be determined. Further investigation is required before TE is adopted in the summer management program.

Biostimulant products contain a remarkable variety of ingredients. The effectiveness of those products can vary, depending on the mode of actions of the active ingredients. Seaweed-based biostimulants are most studied, which has been found to be effective for improving drought and heat tolerance in several cool-season turfgrasses, including Kentucky bluegrass. The positive effects of seaweed-based biostimulants are mainly due to the antioxidant activities of some compounds in the biostimulants that protect plant cells from oxidative damages induced by drought or heat stress. Proper dose and frequency are critical to the efficacy of the products. Multiple applications are often necessary to increase the effectiveness of the products in alleviating summer stress.

MANAGEMENT PRACTICE TO SUSTAIN SURVIVAL AND PROMOTE RECOVERY

Extended period of dormancy in cool-season turfgrasses, particularly bunch-type perennial ryegrass without watering can cause the plants to die. Light, frequent irrigation during summer may sustain the survival and prevent death of dormant plants. Small amount of irrigation just sufficient to moist the canopy will not be able to break the dormancy, but provides enough moisture to keep the meristems of crowns alive until weather becomes cooler and more water becomes available.

It is critical for dormant turf to quickly regenerate new shoots and roots when temperatures cool down in the fall. However, limited research information is available in management practices promoting recovery from summer dormancy. Applying irrigation to soak the crown and rhizomes, as well as the root zone will help to weaken the meristematic tissues for the regeneration of new shoots and roots. Quick-released or soluble fertilizers, including phosphorus and nitrogen may be incorporated in the fall recovery program, as P provides respiratory energy for the regeneration of new tissues and N promotes growth of newly-formed tissues. In addition, some growth promoting hormones, such as gibberellic acid, may be applied for promoting recovery from summer dormancy. In our studies, we found foliar application of GA was effective in promoting shoot regrowth and turf quality recovery in creeping bentgrass following summer stress. However, gibberellic acid effects on sports turf recovery, such as Kentucky bluegrass and perennial ryegrass are yet to be determined. The doses and application frequency can vary with turfgrass species and severity of summer dormancy. ■

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