Annual Project Report - 1999

THE IMPORTANCE OF CARBON BALANCE AND ROOT ACTIVITY IN CREEPING BENTGRASS TOLERANCE TO SUMMER STRESSES

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RATIONALE AND OBJECTIVE

Creeping bentgrass (Agrostis palustris) is the most widely used cool-season turfgrass on golf greens. Loss of bentgrass is observed on most golf courses nearly every year in the transition and warm climate regions during summer months when greens receive maximum use (Lucas, 1995; Carrow, 1996). Pavur (1993) reported that some courses have lost a majority of bentgrass to the decline syndrome. Attempts to extend use of bentgrass into warmer climatic regions further accentuates the problem.

To date, it is not clear what physiological factors cause summer bentgrass decline. Understanding the cause of the decline problem will not only help to treat bentgrass decline, but also provide guidelines for developing cultural practices to prevent decline. Identification of physiological factors that could be incorporated into new germplasm through genetic breeding approaches to develop cultivars tolerant to close mowing and high temperatures will reduce the overhead costs for intensive management of bentgrass greens during summer.

It was proposed that imbalanced photosynthesis and respiration process and carbohydrate depletion could be a major or primary physiological factor contributing to bentgrass quality decline under high temperature and close mowing conditions. The overall objective of the project was to test this hypothesis in creeping bentgrass cultivars grown under close mowing and high shoot/root-zone temperatures.

RESEARCH METHODOLOGY

To address the hypothesis, we initiated the two-year field study in 1999 to examine whether seasonal changes in turf quality or summer quality decline are related to changes in carbohydrate metabolism and partitioning patterns during the growing season (May, August and October) under changing temperature and close mowing conditions.

The study was conducted on an USGA-specification green at the Rocky Ford Turfgrass Research Center at Manhattan, KS. Crenshaw, Penncross, and L-93 were mowed at two mowing heights throughout the growing season: a) 5/32 inch (3.8 mm) and b) 1/8 inch (3.1 mm) height. Four replicates were used for each treatment.

Turf was measured weekly with a multispectral radiometer. The radiometer measures reflected light in the near infrared (800 to 1100 nm) and red (600 to 700 nm) regions which is a good indicator of plant canopy cover or leaf area index, and canopy color. Turf quality was visually rated. Plants from four plots in each treatment were destructively sampled monthly. Total nonstructural carbohydrate content in shoots and roots were measured. Carbon allocation pattern was determined using ^{14}C labeling technique. Nitrogen uptake capacity of roots were examined by applying stable isotope tracer ($Na^{15}NO_3$) at 5 cm soil depth.

PROGRESS

Turf and root growth

Turf quality was highest in May and declined to the lowest level in late July and early August, and recovered in late October (Fig. 1). This growth pattern was true for all three cultivars mowed at 1/8 inch or 5/32 inch. However, Grasses of all three cultivars mowed at 1/8 inch had lower turf quality than those mowed at 5/32 inch, especially during the summer months. Turf quality decline during summer was more severe for grasses mowed at 1/8 inch than those mowed at 5/32 inch. From June to early August, L-93 had the highest quality, Penncross the lowest, and Crenshaw was intermediate. From late August to October, severe dollar spots infected Crenshaw, which resulted in poor turf quality for Crenshaw, similar to Penncross.

Increases in electrolyte leakage in late July and mid-August demonstrated that heat damage to leaves occurred in the summer months (Fig. 2). Heat injury was more severe for Penncross and Crenshaw than L-93 and for grasses mowed at 1/8 inch than that mowed at 5/32 inch.

Seasonal changes in root dry weight and followed the similar pattern as turf quality for all three cultivars (Fig. 3). Root dry weight declined more dramatically for grasses mowed at 1/8 inch than those mowed at 5/32 inch for all three cultivars. L-93 had a big root system than Crenshaw and Penncross.

Root dehydrogenase activity deceased to the lowest level in late July and August, but increased in September for all three cultivars (Fig. 4). Mowing had no consistent effects on root activity during the entire growing season. Crenshaw roots had higher activity than Penncross.

Nitrogen uptake capacity of roots was evaluated by ^{15}N tracing technique. About 200 shoot and root samples were collected and stored for ^{15}N analysis. The analysis is currently being conducted, but have not been completed.

Carbohydrate accumulation and allocation

The most interesting result is that the seasonal changes of carbohydrate accumulation in shoots and roots followed the same patterns as turf quality and root growth (Fig. 5 and 6). As discussed above, turf had the lowest quality and root biomass in late July and August. During the same periods, total nonstructural carbohydrate content in both shoots and roots also decreased to the lowest levels. When turf and root growth recovered in October, total nonstructural carbohydrate content also increased in both shoots and roots. In addition, similar to the effects of mowing on turf quality and root biomass, grasses mowed at 1/8 inch had lower carbohydrate content in both shoots and roots than those mowed at 5/32 inch, especially during summer months.

Seasonal changes in carbon allocation pattern was examined by radioactivity ^{14}C labeling technique. About 400 shoot and root samples were collected during the entire growing season. Samples have been grounded and stored for ^{14}C analysis. The analysis is underway.

PUBLICATIONS

Manuscripts submitted:

1. Xu, Q. and B. Huang. 1999. Growth and physiological responses of creeping bentgrass to root-zone temperature modification. Crop Sci. (in review).

2. Xu, Q. and B. Huang. 1999. Carbohydrate metabolism of creeping bentgrass in responses to high shoot and root temperatures. Crop Sci. (in review).

3. Xu, Q. and B. Huang. 1999. Root growth and nutrient status of creeping bentgrass cultivars differing in heat tolerance as influenced by supraoptimal shoot and root temperatures. Journal of Plant Nutrition. (In review).

WORK PLANNED FOR THE COMING YEAR

The field study will be repeated from mid-May to October in 2000. All parameters measured in 1998 will be evaluated.

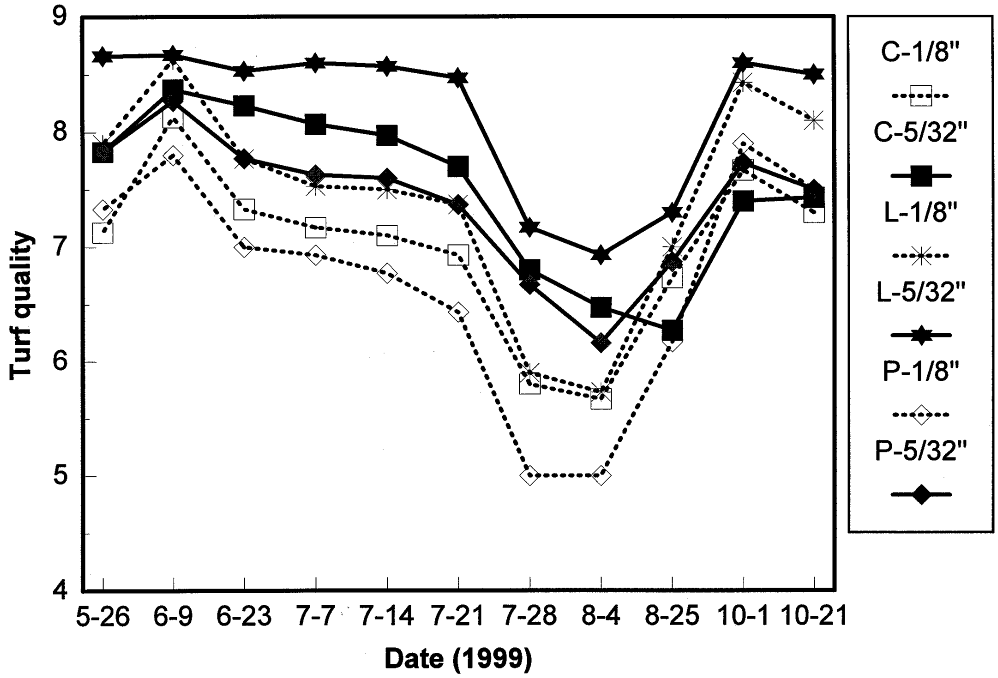

Figure 1. Seasonal changes in turf quality for Crenshaw (C), L-93 (L), and Penncross (P) mowed at 1/8 inch or 5/32 inch

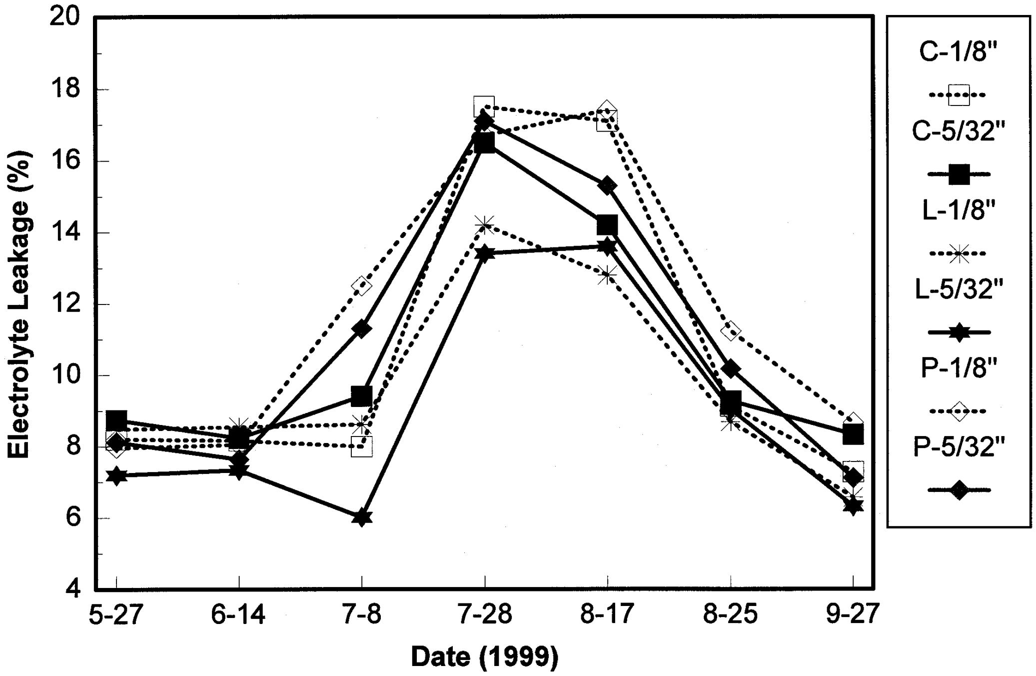

Figure 2. Seasonal changes in cell membrane stability expressed as electrolyte leakage for Crenshaw (C), L-93 (L), and Penncross (P) mowed mowed at 1/8 inch or 5/32 inch.

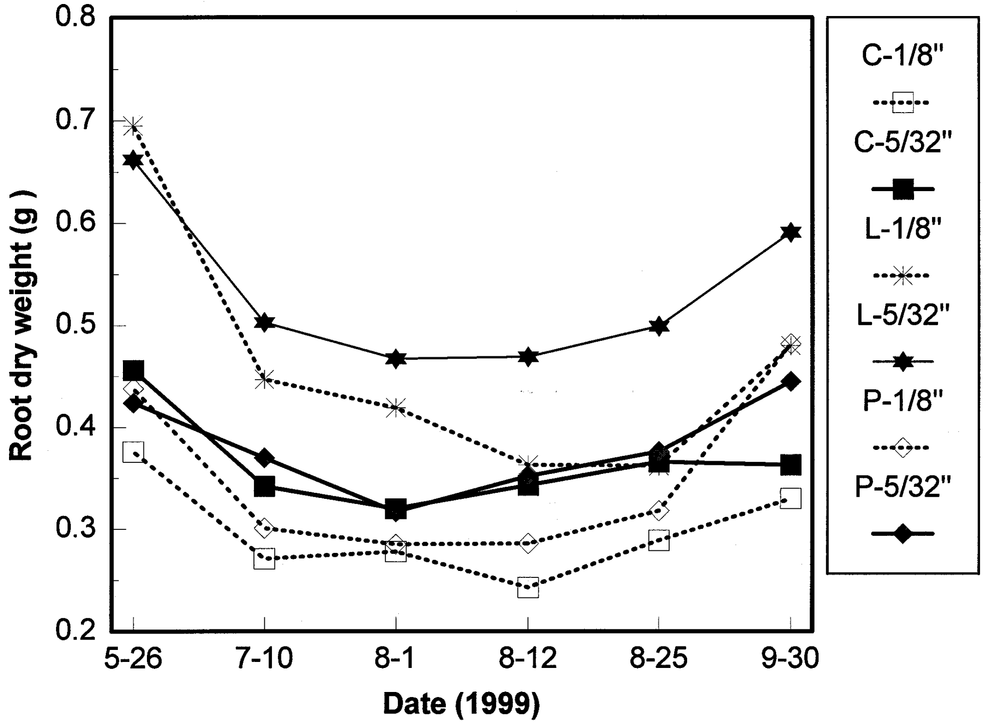

Figure 3. Seasonal changes in dry weight of roots in 0-20 cm soil layer for Crenshaw (C), L-93 (L), and Penncross (P) mowed at 1/8 inch or 5/32 inch.

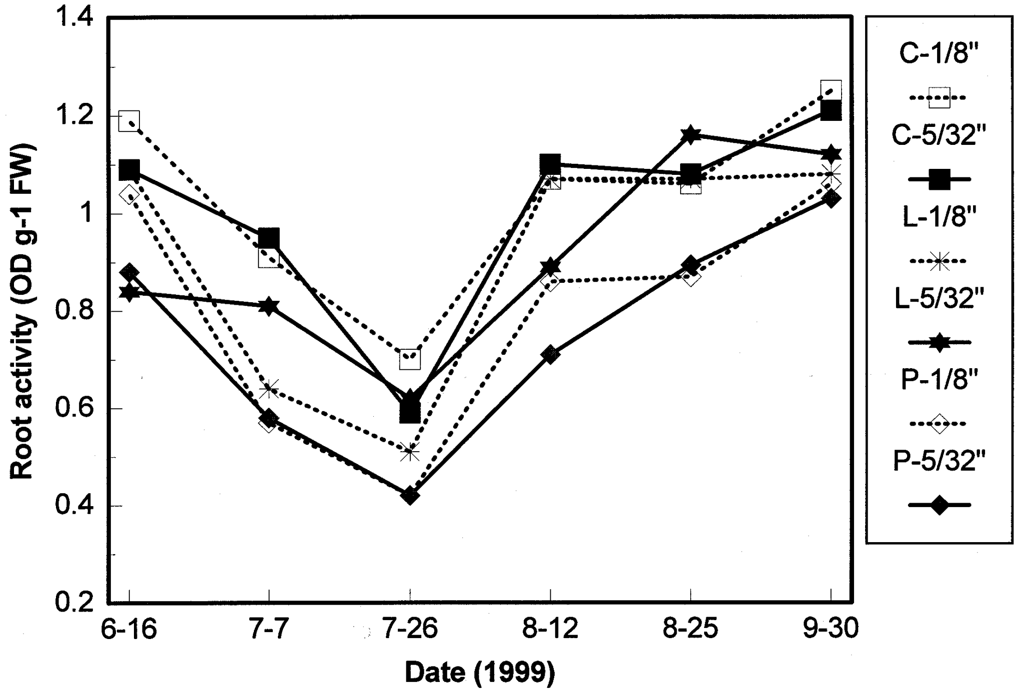

Figure 4. Seasonal changes in root dehydrogenase activity in 0-20 cm soil for Crenshaw (C), L-93 (L), and Penncross (P) mowed at 1/8 inch or 5/32 inch.

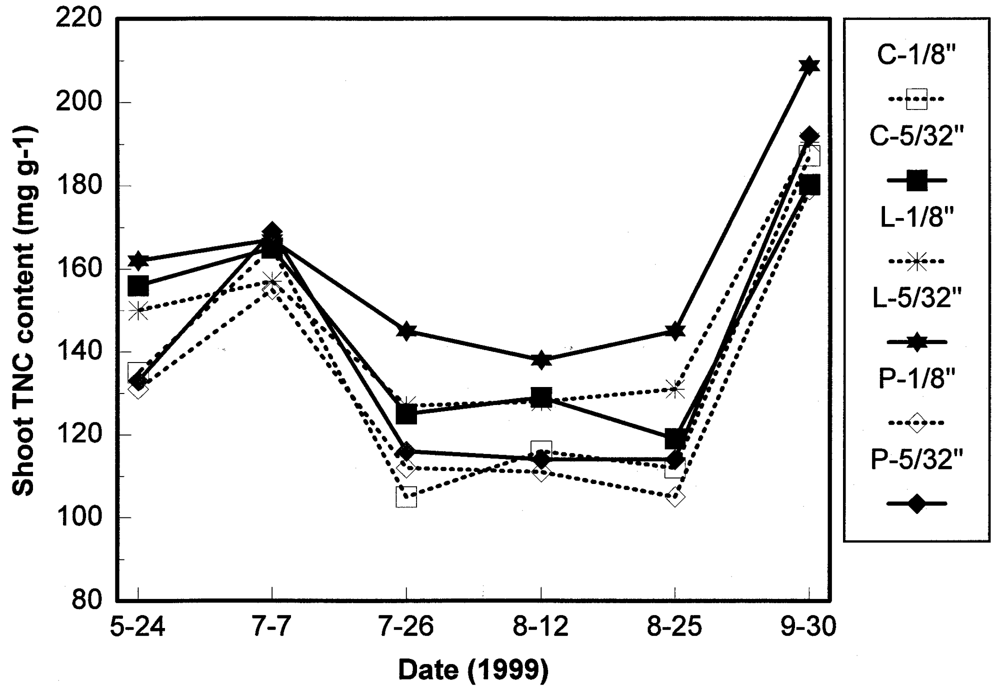

Figure 5. Seasonal changes in total nonstructural carbohydrate in shoots for Crenshaw (C), L-93 (L), and Penncross (P) mowed at 1/8 inch or 5/32 inch.

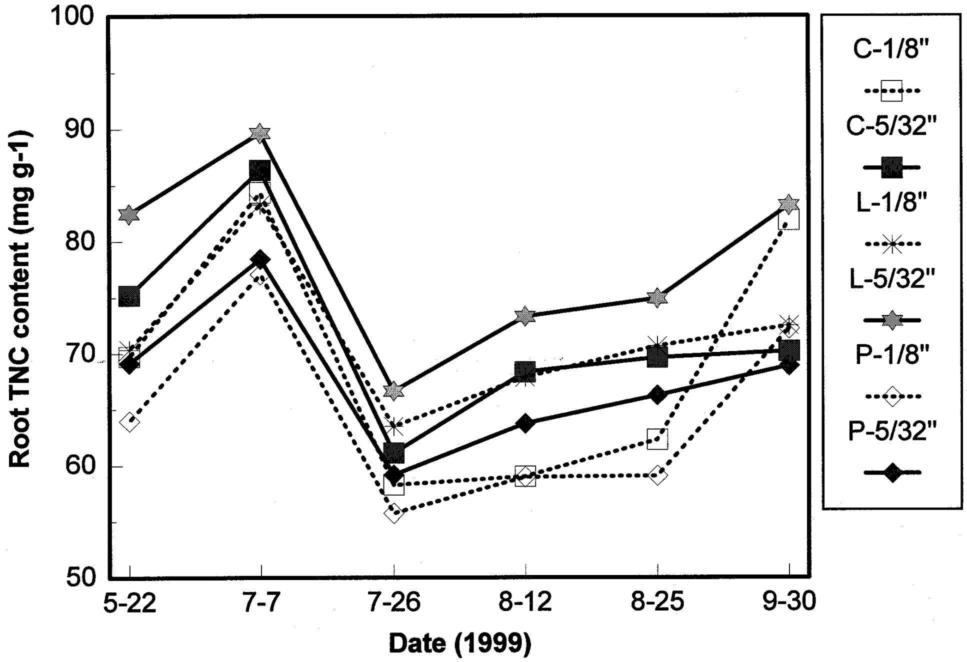

Figure 6. Seasonal changes in total nonstructural carbohydrate in roots in 0-20 cm soil for Crenshaw (C), L-93 (L), and Penncross (P) mowed at 1/8 inch or 5/32 inch.