shoot/root (20/20 C; control), low shoot/high root (20/35 C), high shoot/low root (35/20 C), or high shoot/root (35/35 C) conditions. Grasses were mowed at a 3 to 4 mm height daily or on alternate days.

It was found that turf quality and root activity were much lower at high root (20/35 C) or high shoot/root (35/35 C) temperatures than those of their respective controls for all four cultivars. Reducing root temperature to 20 C while maintaining shoots at 35 C improved turf quality and root growth to levels similar to those of the control treatment. High shoot/root temperatures reduced canopy photosynthetic rate and caused an imbalance between photosynthesis and respiration (carbon deficit) whereas reducing root temperatures reversed, to some extent, the adverse effects of high shoot/root temperature on carbon balance. The decline in turf quality was more severe for *PENNCROSS* than *CRENSHAW*, *L-93* and *PENN A-4* under high root or shoot/root temperatures. Similarly, daily carbon consumption to production ratio was higher for *PENNCROSS* than other cultivars under high root or shoot/root temperatures when grasses were closely mowed daily. Extending mowing frequency from daily to every other day improved turf quality and root growth, especially under high root or shoot/root temperatures, which was accompanied by enhanced photosynthetic rate and reduced carbon consumption to production ratio.

The second study examined whether declines in shoot and root growth with increasing temperatures (20, 24, 30, 34, and 38 C) were related to changes in carbohydrate metabolisms in *PENNCROSS* under close mowing conditions. Turf quality, root growth and viability of *PENNCROSS* declined significantly with increasing temperature to 30 C and higher. The imbalance between photosynthesis and respiration, carbon deficit, and reduced carbohydrate availability occurred as temperatures exceeded 30 C.

Results from both studies clearly demonstrated that first, carbohydrate depletion was a major physiological cause of summer bentgrass decline under high temperatures and close mowing. This was related to the imbalance between photosynthesis and respiration, which was caused by severe decline in photosynthesis capacity under high temperatures and low mowing. Second, roots played an important role in the regulation of creeping bentgrass tolerance to high temperature stress. Therefore, reducing root-zone temperature improved turf quality.

Two manuscripts describing the results of the project are currently being prepared for submission to Crop Science by the end of 1998.

The Basic Biology and Etiology of Sclerotinia Homoeocarpa, The Causal Agent of Dollar Spot

Cornell University

Gary E. Harman

Start Date: 1998
Number of Years: 3
Total Funding: $75,000

Objectives:

1. *Examine the development, including possible apothetical production, of the pathogen in creeping bentgrass greens and fairways when present in leaf tissue, in root tissue or as isolated stroma and to determine the length of survival of the pathogen in infected tissue or as stroma.*
2. *Measure the genotypic variation of the pathogen from similar and diverse geographical locations using RAPD analysis and anastomosis groupings.*

A summary of observations and tentative conclusions from the first field season are provided below together with action plans for the upcoming months.

1. Small (2 x 4 cm) porous nylon bags were prepared, inoculum of *S. homoeocarpa*, in the form of infected grass or grown on sterile wheat, was placed in the bags, the bags were heat-sealed and they were buried vertically in bentgrass greens. The upper edge of the bags was even with soil line.
2. The bags containing the wheat-based inoculum caused low levels of disease shortly after burial. Conversely, the bags with the turf-based inoculum rarely, if ever, caused disease. Disease was attributed to the bags since the natural epiphytotic had not occurred yet in this area.
3. At the time of the natural epiphytotic in August and September, no disease from the bags occurred from either inoculum type.
4. Re-isolation of *S. homoeocarpa* from the internal region of the bags resulted in slow-growing colonies that were almost overlooked due to the great difference in the growth patterns and morphologies of the laboratory culture.
5. *S. homoeocarpa's* normal growth type is rapid and floccose. This morphotype occurs in laboratory-adapted cultures and is obtained if the pathogen is isolated from infected turf. The slow-growing phase of the organism and the rapid-growing phase are very different.
6. After a week of incubation, the slow-growing, *S. homoeocarpa* colonies from the buried inoculum suddenly began to grow rapidly and become indistinguishable from the rapid-growing phase. The sudden explosive development is the only way that we could recognize the pathogen on the plates. We are still attempting to isolate

the pathogen from the dark stromal area on the surface of the bags.

These observations have permitted us to develop some concepts regarding how *S. homoeocarpa* may survive and cause epiphytotics. These are provided below.

1. Data suggest that *Sclerotinia homoeocarpa* in soil have a slow-growing near-dormant phase that may not be infective. The lack of infection is suggested by the fact that the pathogen in our buried bags, which was in the slow-growing phase, did not cause disease during the time when natural epiphytotics were occurring. It is very difficult to isolate the fungus in this phase; this difficulty has no doubt interfered with research on the presence, etiology and epidemiology of this disease.

2. It may well be that *Sclerotinia homoeocarpa* has two phases - a near dormant, heretofore undescribed, phase and the expected rapidly growing phase described by other researchers. It is tempting to speculate that the slow-growing (near-dormant) phase may be a survival mechanism and that the rapid-growing phase is the infective one. If so, then the mechanisms that cause the shift between the two phases could be the trigger for the onset of epiphytotics that are typical of the disease.

Upcoming Work

Turf Bags. Some of the bags buried in 1998 will be allowed to overwinter and will be recovered in the spring. We will examine the effects of overwintering and determine what, if any, dormancy structures are present in the bags and the surrounding turf. This fall, more bags containing inoculum from our strain, as well as bags containing small cores of naturally diseased turf will be placed in the field similar to last year. Some bags will be recovered in 1999 and some will be left to overwinter to 2000.

Genetic Diversity. - Genetic assays will be performed during the winter on the isolates on various turf species were obtained from Massachusetts, Michigan, Nebraska, New Jersey, New York, Pennsylvania, and Canada. Assays will include RAPDs (Randomly Amplified Polymorphic DNA) and anastomosis groupings, as well as any new techniques that are applicable. We will compare the similarities and differences between isolates from the same area and host species relative to ones from different geographical areas or hosts.

Greenhouse Assays. Flats of creeping bentgrass and possibly other species of turfgrass will be grown in the greenhouse and inoculated with the isolates of *S. homoeocarpa* to assess pathogenicity of the isolates. Dead or infected turf will be inspected for structures related to infection by means of microscopic examination following clearing and trypan blue staining. We will observe how different strains might behave differently.

Selective Medium for *S. homoeocarpa*. We will continue to investigate new methods for recovering and enumerating the dollar spot pathogen. Due to competition from *Trichoderma*, *Gliocladium* and *Penicillium* spp., the dollar spot pathogen rarely shows up even when we know it is present. Therefore, we need to eliminate these faster growing species in order to recover and enumerate *S. homoeocarpa*. This may be useful, perhaps, for predicting epiphytotics.

The Impact of Golf Courses on Soil Quality

Kansas State University

Steve J. Thien

Start Date: 1998
Number of Years: 5
Total Funding: $50,000

Objectives:

1. *Study the construction of a golf course in a grassland ecosystem.*
2. *Quantify indicators of soil quality and follow their change during the construction and establishment of a golf course on a natural grassland site.*
3. *Changes to soil quality indicators will be described, quantified, and used to predict areas where future golf construction and/or management actions may require special attention to minimize their negative environmental impact.*

This project is monitoring some soil quality criteria needed to assess the long-term impact and sustainability of golf courses on the environment. The research was initiated on native grassland destined to become Colbert Hills Golf Course, near Kansas State University in Manhattan, Kansas. Colbert Hills has been designated as a *living laboratory* by KSU to highlight its utility for research in environmental resources and turf management. This situation presents a unique opportunity to characterize site resources prior to construction and follow the long-term impacts and changes brought on by constsuction, use, and management of the facility. The golf industry needs this information to realistically understand its environmental impact, to formulate knowledgeable responses to public inquiries, to establish management strategies for new courses, and to provide knowledge for future planning and growth.

Relevance of Soil Quality to Golf Courses. Golf courses are only as sustainable as their weakest natural component, which can often be soil quality. The inherent sustainability of managed areas can be viewed as inversely proportional to the level of management needed to maintain it. Golf courses that diverge the most from their natural surroundings require the highest levels of management inputs to remain sustainable.

Soils play a central role in determining the sustainable land use potential of golf courses. Soil influences such critical properties as; leaching, aeration, fertility, water relations,