limited rooting, the injection of gypsum and lime were included as additional treatments. Also, these soils have a high bulk density (i.e., soil strength), especially in the B horizon. Therefore, the Turf Conditioner was tested for its potential modification of both the physical and chemical properties of the soil.

All plots, except the non-compacted control, were compacted with a smooth power roller while at near soil saturation. The soil was a Cecil sandy clay loam with 55.1% sand, 17.6% silt, 27.3% clay and 2.14% organic matter content. A common bermudagrass mowed at 0.75 to 1.0 inch was used. Fertilization programs in both 1991 and 1992 were at 1.0 lb N/1000 ft^2 in mid-April (10-10-10), mid-June (33-0-0) and early August (33-0-0).

The Verti-Drain (2X) + Core Aeration combination caused the most rapid decrease in penetration resistance, with reductions from 43 to 45 percent throughout the surface 8 inches, compared to the compacted control. After the first year, elimination of the core aeration treatment in conjunction with the Verti-Drain (2X) produced similar penetration resistance results. The combination of the two cultivation techniques also produced the best root water extraction from deep within the soil root zone. The water extracted by roots from within 8 to 24 inches of soil was 33 to 71 percent greater than the compacted control.

The Verti-Drain (2X) + Core Aeration treatment reduced total root length and deep rooting; however, the remaining roots were more efficient and able to extract more water than roots in the compacted control. Thus, root data alone may not always correlate well to water uptake in cultivation studies. This treatment also enhanced overall water uptake as demonstrated by ET rates with values often 28 to 96 percent higher than the compacted control. Water infiltration and percolation, as measured by saturated hydraulic conductivity, was improved by Verti-Drain (2X) and Verti-Drain (1X) + Core Aeration treatments.

The Turf Conditioner + Lime was the most beneficial of the three treatments for this device in reducing penetration resistance (16 to 28 percent reduction compared to the compacted control). Better root water extraction and overall water uptake (ET) were greater than the compacted control for several measurements during the two year study.

Overall, the research indicated that a vigorous cultivation program (i.e., Verti-Drain + Core Aerification) greatly improved turfgrass water use efficiency by enhancing water uptake from deeper zones within a fine-textured soil profile prone to surface compaction. The Turf Conditioner cultivation method appeared to be suited for achieving physical and chemical modification, especially when lime is needed, for similar fine-textured soils.

Salt Screening

Texas A&M University - Dr. Garald L. Horst

Developing Salt, Drought and Heat Resistant Turfgrasses for Minimal Maintenance

The salt tolerance of turfgrass species has become more important as poor quality non-potable and effluent water use has increased on golf courses and other recreational turf. Dr. Horst ranked several of the major turfgrass species in order of their salt resistance (Table 14) and developed screening methods for salt resistance to evaluate selections from USGA/GCSAA sponsored buffalograss, zoysiagrass, and bentgrass breeding projects.

Some zoysiagrass selections from Dr. Engelke's breeding program appeared to have very good salt resistance. These selections could be useful in saline environments or as parents in future cultivar

Table 14. Relative salt resistance of several turfgrass species used in the United States.

Turfgrass Species[a,b]		
Cool-Season	Warm-Season	Relative Ranking[c]
Alkaligrass	Seashore paspalum	Excellent
	Zoysiagrass[d]	
	St. Augustine	
	Bermudagrass hybrids	Good
Bentgrass[d]	Bermudagrass	
Tall fescue	Bahiagrass	Fair
Perennial ryegrass	Centipedegrass	
Fine fescues	Carpetgrass	Poor
Kentucky bluegrass	Buffalograss[d]	

[a]Based on the most used cultivars of each species.
[b]Variable among cultivars within species.
[c]Ranked by Horst (1992).
[d]Species on which limited salt resistance screening was performed under USGA/GCSAA sponsored research.

improvement work. Bentgrass germplasm from the improvement program under the direction of Dr. Engelke (Texas A&M) and buffalograss germplasm from Dr. Riordan (University of Nebraska) also were screened using this technique to evaluate salt resistance. Promising bentgrass lines were identified, while less satisfactory results were reported for buffalograss.

University of Illinois - Dr. M.A.L. Smith

Whole Plant Microculture Selection System

A novel, highly uniform *in vivo* screening method for monitoring mature turfgrass plant response to increasing salinity levels over time was developed. Video image analysis was utilized to quantify and validate turfgrass responses, and permitted larger sample sizes and a more thorough screening of plants.

A strong linear relationship for shoot and osmotic adjustment occured between solution culture and whole plant microculture. Root growth, as measured by root length and area, was more variable in both solution and microculture. Whole plant microculture conferred additional advantages as a highly-controlled test system in terms of scale, timing, maintenance, and repeatability.

Salt tolerant lines were regenerated, adapted to the greenhouse, and reestablished in whole plant microculture. In whole plant microculture, the grass plants again were subjected to salinity stress, and the whole plant responses were non-evasively monitored over time using video image analysis. Approximately one third of the lines selected for salt tolerance at the cell level retained salt tolerance traits at the whole plant level.

Water Use

University of Georgia - Dr. Robert N. Carrow

Influence of Soil Moisture Level on Turfgrass Water Use and Growth

Reducing irrigation frequency is one means of conserving water. Of concern to the turfgrass manager is the quantity of water conserved and any adverse effects on turf quality. Evapotranspiration (ET) data obtained in arid regions is not necessarily valid for estimating turf water use in humid regions. A scale was developed to include ET and overall drought resistance criteria to rank grasses for water conservation in humid regions.

The ET ranges for 'Tifway' bermudagrass, 'Meyer' zoysiagrass, and common centipedegrass were determined under moderate stress irrigation in large field plots. The three warm-season grasses were irrigated under three irrigation regimes, i.e., well irrigated, moderate stress, and severe stress.

For the well watered irrigation regime, common for golf course tees or very high quality fairways, bermudagrass used the least water in summer and fall. Relative to Tifway bermudagrass, Meyer zoysiagrass used 10, 30, and 5% more water for July, August, and October, respectively. Common centipedegrass used 4, 23 and 13% more water than bermudagrass in July, August, and October, respectively.

In the moderate stress irrigation program, typical for many fairways, water use rates were 39 and 11% greater than bermudagrass in August for zoysiagrass and centipedegrass, respectively. Just prior to an irrigation, zoysiagrass showed slight wilt, while the other grasses did not.

Under severe moisture stress, such as for rough areas, water use rates in August were 4% lower and 43% higher than bermudagrass for zoysiagrass and centipedegrass, respectively. The zoysiagrass exhibited severe wilt and bermudagrass no symptoms. The semi-dormant state for zoysiagrass accounted for its lower water use. Zoysiagrass did not appear to develop many roots into the heavy B soil horizon and could not effectively use subsoil moisture.

A second means of reducing water use is to utilize atmospheric, soil or plant based criteria to schedule irrigation in contrast to guessing when to water. Comparative data on these methods were developed to allow turfgrass managers to select the best means of scheduling irrigation.

Entomology

Rutgers University - Dr. Peter R. Day and Dr. C. Reed Funk

Endophytes of Turfgrasses: New Tools and Approaches

The purpose of this project was to find naturally occurring endophytes within the *Poa* and *Agrostis* genera that would improve insect resistance. Endophytes are fungi which grow within the turf plant and produce chemical compounds, (i.e., Alkaloids) which make the plant less desirable to some insect pests. If naturally occurring endophytes could not be found within *Poa* and *Agrostis* species, particularly creeping bentgrass and