Figure 1. Heat bench to create high soil temperatures, a facility developed to screen large populations of plants for survival under high soil temperature.

Quality Turf in the Natural Environment — Enhanced Through Genetic Improvement

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THERE ARE those who believe water will become a major limiting factor in the production and maintenance of quality turf. Water availability has already been reduced throughout many regions of the United States because of the dry cycle in our weather pattern. Greater demands on water supplies have also resulted from increased agricultural production, industrialization, and urbanization.

Restrictions in water use are felt throughout the nation, but they are further complicated by recent population shifts to more arid regions. Urbanization has placed excessive demands on municipal water districts, and the construction of water treatment plants and distribution systems falls far short of projected requirements. Because statistics for Texas in 1982 indicate that over 50 percent of the municipal water supply was applied to the landscape, it is easy to understand why, when they come, the first restrictions are applied to turf. If they are imposed for prolonged periods of time these restrictions can cause permanent damage and create a much broader environmental impact, including erosion control, air quality, energy consumption, health problems, and recreational activities. The effect would be a decline in the general quality of life.

National policy makers concerned with water use and availability predict that water demands will increase 35 percent within the next 15 years. These predictions suggest that restrictions on the use of our water, especially potable water, will increase greatly and may result in the exclusion of potable water for turfgrasses and ornamentals regardless of their purpose. Turf managers are already faced with increasing costs for pumping and purchasing potable water.

Brackish and effluent water offer an alternative. Effluent water is now used in increasing quantities to supplement existing supplies for golf courses, park and recreational areas, and for sod and seed production throughout the southern and western United States. Generally, the quality of non-potable water is less than desirable. It often contains high salt concentrations, toxic compounds, undesirable microbes, and heavy metals. The quality is often unpredictable and therefore difficult to manage. Continued use of such water may result in an accumulation of salt and heavy metals within the root zones of the turf which can create additional stress problems, with eventual loss of stand.

Few turfgrass cultivars can persist without supplemental water; they are not adapted to natural environmental conditions. The environment is defined as any and all external forces and substances which influence the growth, structure, and reproduction of the plant. The only elements of the environment that cause us concern are those that produce a negative performance in the plant. When such negative forces occur, this is considered a stress situation. Specifically, such forces may include: biotic factors (diseases, insects, nutrient deficiencies, excessive traffic); edaphic factors (soil compaction, soil salinity, pH shifts); or climatic factors (temperature extremes, moisture deficiencies, light, and wind).

The performance of turf in terms of quality, persistence and playability is determined by the genetic composition of the plant and by the environment in which the plant grows. A change in any of the components of the environment will result in a change in turf performance.

A PLANT can survive moderate levels of stress so long as the critical levels of its biological system are not exceeded for a prolonged time. These biological limits are under genetic control, and they influence the physiological state of the plant, which changes in response to environmental changes. Since many of our cultural practices alter the environment, the intensity and duration of these external forces can often be reduced or even eliminated. Such practices result in a more favorable environment for the growth and performance of the plant. Unfortunately, many of the commercially available turfgrass cultivars were designed for moderate to optimal environmental conditions. Full utility of these cultivars often requires that the turf manager modify the environment with frequent fertilization, irrigation, and pest control in order to compensate for the plants' biological deficiencies. Once the turf is established, the performance of the grass is directly dependent on the environment and the cultural practices. If supplemental irrigation or the use of good quality water is restricted, as anticipated, then the plants' performance will be less than acceptable.

The question remains, can we have quality turfgrass with minimal supplemental irrigation? If our cultural practices are impractical, then it becomes imperative to change the turfgrass plant to be more compatible with the environment, rather than trying to modify the environment to fit the plant. A change in the plant can be accomplished by identifying, selecting, and combining characteristics that perform well under stressed or natural environmental conditions *(Figure 2)*. These characteristics or biological limitations are under genetic control and can be manipulated to improve performance in the desired environment. We must recognize that each species has a region within which it is adaptable. To place the plant outside this region may not be practical or even possible. Many species today are marginally adapted to their environment and they require intense culture to survive. It should be possible, however, to select individual plants within these marginally adapted species that will survive without intense culture.

For example, bentgrasses have been used for more than 40 years in the southern United States for overseeding warm season grasses and provide a playable surface during the winter. In more recent times, permanent bentgrass greens have been established. During this time, natural selection has occurred, as is evidenced by numerous local ecotypes of bentgrasses that survive within or adjacent to old bermudagrass greens. This is particularly true where seaside and the old German bentgrasses have been used. Many of these adaped plants have the genetic and biological mechanisms to cope with the natural environmental stress. These natural environmental conditions often include prolonged periods of high temperatures and drought.

The bentgrass cultivars most frequently used for greens in the southern United States include "Penncross," "Penneagle," and "Seaside." In general, they all lack sufficient heat tolerance and drought resistance and require special culture to maintain acceptable quality turf. Syringing bentgrass greens during the heat of the day enhances a biological process known as transpirational cooling and reduces the heat load on the tissue of the plant. Syringing causes an increase in the humidity of the turf microclimate and, in conjunction with high temperatures, creates a favorable environment for disease. To complement the syringe program, the superintendent includes a routine fungicide program against disease attack. Although these practices appear to be effective, they add considerable cost to the general management and operation of the course.

THE BENTGRASS breeding program at the Texas Agricultural Experiment Station - Dallas, in cooperation with the United States Golf Association Green Section and Bentgrass Research Inc. -

By combining deep, vigorous, perennial rooting characteristics with plants that can survive and continue to grow under high soil temperatures, we should be able to develop cultivars better able to survive the intense summer heat of the southern United States, plants able to use a larger soil moisture reservoir for transpirational cooling, which should reduce or eliminate the need for syringing. This in turn will reduce the humidity within the turf canopy. Lower humidity is less favorable for disease development and should therefore create a healthier plant.

Similar objectives related to heat stress, water use requirements and water quality are simultaneously being pursued in zoysiagrass, buffalograss, St. Augustinegrass, and tall fescue. Considerable genetic diversity exists within each of these species. It is the intent of this breeding program to identify, select, and concentrate those characteristics into a germ plasm resource pool with traits compatible with the natural environment. Through hybridization, individual plants will be created and identified that have the characteristics necessary to cope with the natural environmental stresses. These plants will have a broader biological region of adaptation, and they should experience less stress and provide a higher quality, healthier turf with fewer cultural requirements.

Figure 2. (Opposite page) Drought tolerant zoysiagrass growing on the banks of a king's tomb in South Korea.

Figure 3. (Below) Root observation tubes, a technique developed to observe the rate, distribution and depth of rooting in individual plants.

Dallas, has identified its major objective as the need to develop bentgrass cultivars with superior heat tolerance for both high soil and high ambient temperatures. Most bentgrasses exhibit a definite degeneration of root tissue and shortening of roots under high soil temperatures, close frequent mowing, and heavy traffic. These conditions impair the transpirational cooling process. Therefore, selection and development of plant materials whose improved biological characteristics cope with these environmental stresses are of primary consideration.

Research in turfgrasses and other plant species supports the concept that root distribution, rate of root development, and total root mass differ significantly among individual plants and is under genetic control. Special greenhouse and laboratory procedures permit close observation of plant growth with respect to root development. Of special interest is identification of individual plants that produce more roots faster and deeper in the soil profile *(Figure 3)* and can maintain active root systems under high soil temperatures *(Figure 1)*.