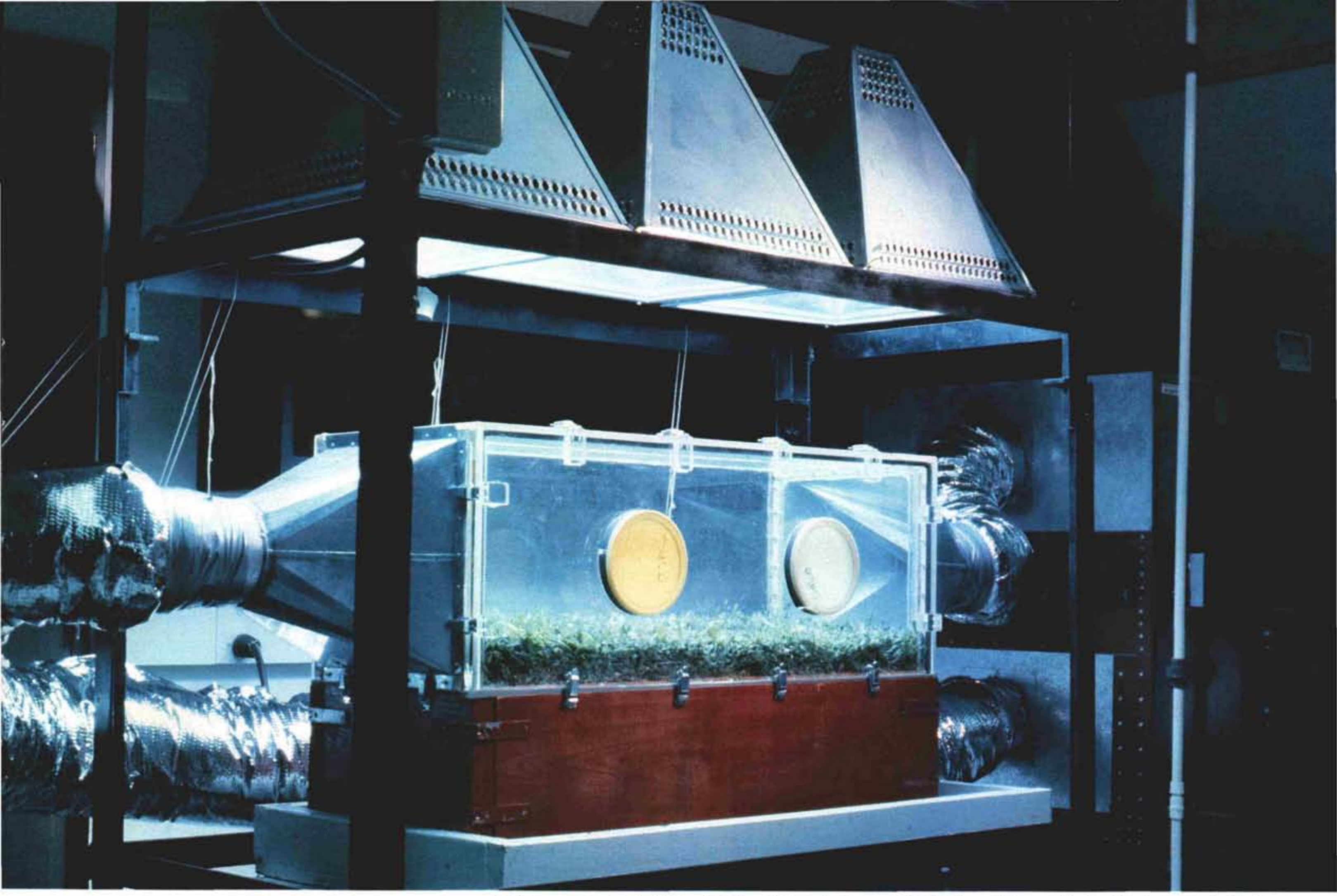

Water stress simulation chamber for water use rate, heat and drought studies in a controlled environment.

Quality Playing Conditions – The Role of Research

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AN EARLY BENCHMARK was the invention of the first mechanical lawn mower by Edwin Budding in 1830, making 1980 the 150th anniversary of this major event in the evolution of turf culture. This first mower was a reel design that included a catcher. The first prototype was constructed in a shed and tested at night on a nearby grassy area in order to maintain secrecy before Budding applied for a patent. This pioneering research resulted in 1,000 units being marketed over the next 20 years by Ransomes Manufacturing Company. The next benchmark was 50 years later when the first powered mower was developed. It cut a very narrow swath and was steam driven. Unfortunately, it weighed a ton-and-a-half. Then, in 1900, the internal combustion engine was introduced in a powered mower. The electric mower was developed in 1925.

During this period of evolution in mowing equipment, the allied turfgrass cultural techniques evolved through trial and error by the practicing turf manager. Greens and fairways were relatively rough by today's standards, and research had not developed the techniques, chemicals, and equipment needed for quality turf culture as we know it today.

The art of golf course turf culture remains as a significant dimension in golf course maintenance. However, it is becoming less and less significant as the basic pool of knowledge concerning the science of growing turfgrasses enlarges

and as this information is conveyed to the practicing professional turf manager. Research has played, and continues to play, an important role in generating the information needed to support these advances in turfgrass science. This transition from sole reliance on the art of turf culture was necessary because such an approach failed to provide the fundamental answers as to "why," so that the turf manager could interpret the specific cause of a particular problem and then make adjustments in the cultural program to best avoid that problem in the future.

Early 1900s

By the early 1900s, the intensity of play on golf courses was increasing. Further, golf courses were being constructed on more adverse soil and under less appealing climatic conditions across North America. When these two major factors were combined with increased costs of labor, it became apparent that the problems of maintaining turfs on golf courses were becoming increasingly complex and the art of turf culture was just not providing the answers. A significant research effort was begun.

At this time the USGA Green Section was formed. One of its primary objectives was to initiate turf research concerning the problems of maintaining intensively managed turfs. A significant research effort was initiated not only at the research facility in Arlington, Virginia, in joint cooperation with the U.S. Department of Agriculture, but also at a number of key land grant universities. This concerted research program was initiated primarily through the efforts of the USGA and its Green Section. It provided the major impetus in the 1920s for the development of a concentrated research program to generate sound principles of turfgrass culture. Significant landmarks during this period included the development of a number of improved creeping bentgrass cultivars, identification of improved fertilization programs for golf course turfs, improved techniques for turfgrass establishment, and initial identification and control of certain major turfgrass diseases such as dollar spot and brown patch.

After this initial thrust of pioneering research, the Great Depression of the 1930s, followed by World War II, unfortunately caused a change of national priorities, which severely limited turfgrass research.

Modern Turfgrass Science

Our greatest advances in turfgrass began in 1950. Land grant universities and private industry alike devoted major research efforts toward solving the problems of turfgrass culture and toward developing a set of scientifically based principles. As a result, the 1960s and 1970s have been a golden era in the use of quality golf course playing surfaces, in the development of professional turf managers, and in the generation of research information concerning the fundamental science of turfgrass culture. The golf turf industry can be proud of these accomplishments.

Turf Equipment Advances

Some of the early research breakthroughs of the 1950s and early 1960s were achieved by private companies involved in the development of innovative turfgrass maintenance equipment. The primary motivation was a need to reduce labor requirements which would translate to increased efficiency and a lower maintenance cost. For the first time, machines were developed to meet specific turfgrass needs, including (a) various methods of soil coring, slicing, and spiking, (b) mechanical topdressers, (c) more rapid fertilizer application by means of centrifugal spreaders, (d) increased flexibility and maneuverability in mowing equipment, especially as a result of the application of hydraulic principles to mowers, and (e) hydro-planting equipment.

The late 1950s and 1960s also marked major advances in irrigation components, which brought on the increased feasibility of automatic irrigation systems. Again, most of these major advances occurred primarily through the research efforts of private industry. The end result was not only reduced costs for labor, but also a significant improvement in the quality of playing surfaces.

Wear stress simulator test on cool-season grasses at Michigan State University (left) and the wear pattern after use on bermudagrass at Texas A&M University (below).

Selective Weed Control

The common use of herbicides specifically adapted for the selective removal of objectionable weeds from desirable turfgrass species was almost non-existent before 1947. As a result of cooperative research between the chemical companies, the USGA Green Section and the state agricultural experiment stations at a number of land grant universities across the United States, there were developed 2,4-D and allied phenoxy herbicides, which, for the first time, offered a reliable, safe method for the selective removal of broadleaf weeds from turf. Subsequently in the 1960s, there was a second major breakthrough in selective weed control with the development of the organic arsenicals, which offered a reliable, effective method of post-emergence control of other annual weeds, especially crabgrass. This was followed in the 1960s by the development of a number of organic herbicides offering selective pre-emergence control of many annual grasses in perennial turfgrass species. As a result of these research efforts, the major broadleaf and annual grassy weed problems which previously were such a bane to quality turf have essentially been eliminated. Although the evolution of the art and science of turfgrass culture has a history of 150 years, selective weed control in turf is a phenomenon which has occurred only in the last 30 years as a result of turfgrass research.

Fungicide and Insecticide Development

USGA Green Section research in the 1920s and early 1930s not only identified several major turfgrass diseases on golf courses for the first time, but also developed inorganic mercury and cadmium fungicides, which proved effective in control of certain diseases. It was not until the 1950s and 1960s that effective organic fungicides for the control of specific disease problems were developed. Most of these fungicides were of the contact type, with the systemic fungicides being developed during the 1970s. Here again cooperative research between the chemical industry and the state agricultural experiment stations has resulted in great strides in achieving control of most of our major turfgrass diseases. A similar program has evolved in terms of insect control through organic insecticides.

Fertilizers

Significant advances in fertilizers for turfgrasses occurred during the 1950s. This research involved primarily the natural organic and ureaformaldehyde types of slow-release materials. Considerable research was also conducted concerning the proper timing and rate of application of various fertilizers on golf turf areas. However, not until the 1960s were significant strides made in the development and marketing of specialty fertilizers designed to meet golf turf needs. These new turf fertilizers were characterized by drastic changes in ratios of N, P, and K in comparison to agricultural fertilizers, and included the addition of slow-release nitrogen to the fertilizer mixture. After an initial thrust of attention solely on nitrogen, research began to emphasize the importance of proper balance between nitrogen and other nutrients, such as potassium and phosphorus. This more sophisticated research involved detailed assessments of wear tolerance as affected by potassium levels.

This research supported by the USGA Green Section at both Michigan State University and Texas A&M University demonstrated the important contribution of potassium to enhanced wear, drought, and cold tolerance, even though there is no direct effect in terms of color, density, or rate of shoot growth. Research during the 1970s has resulted in the less intense use of nitrogen and increased use of potassium and iron, especially as they relate to maintaining quality putting green surfaces. Allied with this has been a continued emphasis on the development of improved slow-release carriers. Examples of advances achieved by cooperative research of private industry and the state agricultural experiment stations include the work with IBDU and the sulfur-coated nitrogen carriers. Continued emphasis on the development of improved slow-release nitrogen carriers for maximum efficiency of nutrient utilization by turfgrasses will be required.

Turfgrass Variety Development

The mid-1960s marked a significant expansion in the turfgrass research effort. At this point several full-time turfgrass breeders were employed by the state agricultural experiment stations. Plant collections were made throughout the United States, with thousands and thousands of individual clones being grown, evaluated, and screened for desirable characteristics. Based on this assessment, additional thousands of crosses were made, the seed collected, and then grown out for further assessment in clonal nurseries. Subsequently, seeds from the more promising clones were increased and planted in small micro-turf plots to assess adaptability to close mowing such as occurs on golf course turfs. From this extensive program were spawned a number of improved turfgrass cultivars for greens, tees and fairways. Again, the USGA Green Section provided leadership in supporting this breeding effort, such as warm-season grass improvement at Tifton, Georgia, and cool-season grass breeding at Rutgers University and at Pennsylvania State University. A number of other turfgrass breeding programs were under way at state agricultural experiment stations across the country. As a result, we have seen major advances in the development of a wide range of improved Kentucky bluegrass cultivars and a major breakthrough in turf-type perennial ryegrasses. We can anticipate even more advances in the future because of the number of concerted programs devoted to turfgrass cultivar improvement underway at more than half a dozen state agricultural experiment stations.

Soil Modification

The intensity of traffic placed on putting greens when wet or dry makes for extremely adverse conditions for quality putting green maintenance. The 1960s marked a major advance in the development of specific methods for modifying root zones to avoid soil compaction and its associated problems. Much of this initial research was started in the 1950s but did not come to fruition until the mid-1960s. The construction of a proper soil root zone for intensively trafficked putting greens and tees is a problem that is unique to turfgrass culture. Thus, it required a concerted research effort to address this problem. Again, the USGA Green Section led the way in supporting research at Texas A&M University to develop the concept which has come to be known as the USGA Green Section method of putting green construction. It is the main method of putting green construction being practiced on golf courses today and has been a major advance in the science of turfgrass culture.

Growth Investigations

Through the 1950s, much of the research effort was devoted to improvements in equipment, pesticides, fertilizers and related cultural practices as they affect turf quality. By the mid-1960s, research was increased concerning the growth and development responses of the grass plant itself. The effects of cultural and environmental factors on root growth responses were of special concern. In the past, root responses tended to be overlooked, since the emphasis was on improving the quality of the above-ground playing surface. However, the trend to less availability of water and nutrients necessitated the development of cultural techniques and modification of the environment to enhance rooting in order to achieve maximum efficiency of water and nutrient absorption. Recently the first turfgrass rhizotron was constructed at Texas A&M University to investigate the growth and development of root systems in a continuous, undisturbed state. Discovery of the spring root dieback phenomena of warm-season turfgrasses resulted from this unique research facility.

Above-ground shoot growth responses have not been ignored during this period in turfgrass research. Continuing investigations have involved various approaches for using plant growth hormones and regulators to manipulate both the rate of growth and the growth habit of the grass plant. There is much progress yet to be made in this phase of turfgrass research which will contribute significantly to reduced turfgrass maintenance costs.

Turfgrass Stress Physiology Research

The 1970s marked the emergence of a major research effort in turfgrass stress physiology. Turfgrass culture involves the manipulation of the atmospheric and soil environment to ensure the most favorable conditions under which to produce quality playing conditions. For the first time we have developed sufficient funding and qualified turfgrass researchers capable of using the more sophisticated research techniques to characterize the turfgrass environment and the allied responses of turfgrasses to environmental stress. This includes both the effects and mechanisms of stress injury as well as the cultural practices and plant mechanisms that produce maximum plant hardiness to survive specific environmental stresses. These stresses include heat, cold, drought, shade, wear, and atmospheric pollution aspects.

During this period, we have begun to look inside the plant to see how it responds to stress environments. This involves the use of sophisticated laboratory instrumentation. It ranges from monitoring of carbon dioxide and oxygen levels as related to respiration and photosynthesis of grasses to detailed biochemical assessment of various plant components such as carbohydrates, proteins, amino acids, and enzymes as they are affected by various environmental stresses.

An objective of this research is the identification of physiological and biochemical markers that can be used in a breeding program to greatly speed the screening process to identify selections that possess superior stress hardiness. Also utilized are costly, sophisticated environmental stress simulation chambers where most of the environmental factors are held constant and one dimension of the environment is varied to assess how that specific environmental perimeter affects grass growth.

Typical of this type of research is the wear tolerance investigation supported at Texas A&M University. Both field and laboratory dimensions are involved. First, a wear stress simulator was developed and tested which can simulate both foot and vehicular traffic. Then the commonly used turfgrass species were characterized in terms of relative wear tolerance, followed by the assessment of various cultural practices, such as cutting height, nitrogen/potassium fertility and root zone mixes as they affect wear tolerance. Paralleling this has been a laboratory dimension in which detailed biochemical analyses and histological studies have identified lignin and the scarified tissue component of stems as being the major factors contributing to enhanced wear tolerance. This information is being used to characterize a range of turfgrass cultivars within a species for comparative wear tolerance. Hopefully this will lead to a major biochemical marker that can be used in the breeding program to select for wear-tolerant cultivars. This investigation is continuing through the support of the USGA Green Section and the Carolinas Golf Association.

Future Research

Among the future challenges to turfgrass research, I rank water, both availability and quality, as the major problem facing the turfgrass industry. It is a much more significant factor than energy; energy will be available at a cost, and I have confidence that our energy researchers will develop a combination of alternate energy sources. Adequate water supplies, however, may not be available for turfgrass use. Only 1 percent of the total world water supply is available to man. By the year 2000, the demand for water will increase by 34 percent. It is probable that this increased demand will necessitate the establishment of priorities in water allocation for various uses. The amount of water available for turf use on golf courses will be of very low priority. This allocation of water resources could even apply to golf courses possessing wells within their own property. Thus, it is imperative that research develop turfgrass cultivars and cultural practices with a drastically reduced water requirement. It is also important to develop grasses that have the ability to grow under higher saline conditions, since the use of effluent water containing a higher salt content will be increasing in the coming decade. Another area of research emphasis will be the development of minimal-maintenance turfgrasses and cultural systems which will have a lower requirement for our energy and nutrient resources. This dictates a relatively slow shoot growth rate and increased efficiency of fertilizer use. A third area of emphasis will be increased use of the integrated pest management concept.

In summary, researchers have a great responsibility to develop new cultivars and cultural practices that will possess a slow vertical shoot growth rate, low water use rate, minimum nutrient requirement, drought hardiness, wear tolerance, disease and insect resistance, and green color retention at low fertility levels. The results of this research will be critically needed by the turfgrass industry during the 1990s and beyond. Most of the easy turfgrass research has been accomplished. The problems facing researchers require more sophisticated and costly facilities and research personnel. Thus, every professional turf manager should do his part to both articulate and work for the support of the turfgrass research programs. The turfgrass researchers have a major challenge facing them. Be assured that we will be doing our best to maximize the research effort to provide answers to these problems. We appreciate the efforts you have made in helping achieve the research accomplishments of the past and look forward to joining with you in a continued and increasing effort to provide the research funds needed to solve the problems facing the industry in the decades ahead.

(This paper was delivered at the USGA Green Section Educational Conference at Anaheim, California, in 1981.)

Equipment to monitor photosynthesis and respiration rates in relation to heat, cold and water stress.