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Automatic Irrigation – Some Considerations

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Overseeding with bentgrass is common practice on most northern championship courses. The second hole at Merion Golf Course — site of the 1981 Open Championship.

Bentgrass Fairways . . . Why Not?

by **PATRICK M. O'BRIEN**
Agronomist, Mid-Atlantic Region, USGA Green Section

FAIRWAYS COMPRISE the largest acreage that require maintenance at golf courses. In many areas of the transition and cool, humid zone of the United States, creeping bentgrass (*Agrostis palustris* Huds.) and Colonial bentgrass (*Agrostis tenuis* Sibth.) could be maintained as the principal fairway grass species. However, other turfgrasses in this area, including Kentucky bluegrass, perennial ryegrass, especially *Poa annua*, predominate. Without doubt, bentgrass, where managed correctly, provides some of the best fairways in its area of adaptation. Many of the most famous clubs in the Northeast, such as Baltusrol Golf Club, Springfield, N.J., Winged Foot Golf Club, Mamaroneck, N.Y., and Merion Golf Club, Ardmore, Pa., have chosen bentgrass for their fairways. Our technology and ability to grow bentgrass is certainly not lacking, so what are the problems?

Over-Irrigation

Perhaps no grass has been so mismanaged by irrigation practices as bentgrass. It ranks favorably but slightly behind Kentucky bluegrass and the fine fescues in drought tolerance. Bentgrasses are widely used in Scotland, where there is no artificial irrigation. The bentgrasses have also been found growing in desert areas. Yet somehow bentgrasses have the reputation of needing much more water than other permanent turfgrasses.

Before irrigating, it is good practice to use a soil probe to examine the moisture status of the soil. There should always be moisture enough in the rootzone to supply the plant's needs. When water is needed, only enough should be applied to restore the supply to the rootzone. Care must be taken not to irrigate to the point where macropores become saturated, since this interferes with oxygen supply, and grass roots will not function without oxygen. Wilting of the turf occurs when air is cut off

Golf carts cause damage when turf is under stress, then Poa annua *gains a foothold.*

from the plant. Unfortunately, the natural tendency is to put on a little more rather than a little less. We have learned the concept that turf roots require water, but we have a more difficult time learning that overwatering greatly reduces soil air and causes grasses to wilt.

Poa Annua Problem

The major criticism of bentgrass fairways is related to the *Poa annua* problem. Is this criticism justified? Fairway irrigation has contributed to the problem, along with increased soil compaction and turfgrass wear injury caused by golf carts. Forgotten is the fact that many fairways were originally dominated by common Kentucky bluegrass and the fine-leaved fescues. These unirrigated grasses produced a good lie but not the tight lie preferred now by golfers. When the bluegrasses and fescues were irrigated, golfers demanded that the golf course superintendent lower the cut. With the lower cutting height and irrigation, *Poa annua* quickly invaded the Kentucky bluegrass and red fescue. This is the primary cause of the high predominance of annual bluegrass fairways. It should be noted that

Fairway lies excel on well-managed bentgrasses.

the annual bluegrass had much more difficulty invading the bentgrass. The bentgrasses are able to withstand the lower cut and, so long as it was applied at reasonable rates, the extra water.

Presently, the increased soil compaction and traffic injury from maintenance equipment, golfers, and particularly golf carts have greatly encouraged *Poa annua* in our present bentgrass fairways. Frequent over-irrigation also contributes to soil compaction and the extra moisture necessary for *Poa annua* germination. The bentgrasses are not as competitive with *Poa annua* on compacted soils.

Also important to a bentgrass program is the judicious use of fertilizer. Bentgrass fairways require minimal amounts of nitrogen, and the preferred program is to fertilize lightly but more frequently. This provides a slow, steady growth of the bentgrasses. High rates of nitrogen, particularly in late winter and early spring, encourage *Poa annua*. Higher nitrogen levels also increase the water requirements of the grasses. Applications of phosphorus to bentgrass fairways should be carefully considered because high soil phosphorus also encourages *Poa annua*. Most soils in the United States contain adequate soil phosphorus levels, except areas in the southeastern states where weathering intensity is relatively high.

Sulfur fertilization has recently proven to be very beneficial to bentgrass turf. Dr. Roy Goss of Washington State University has been working with a *Poa annua* control program using sulfur as the key element to the program. Several clubs in the Mid-Atlantic Region have been applying sulfur to bentgrass fairways with good results. Sulfur materials available are elemental sulfur, ammonium sulfate, potassium sulfate, gypsum, and ferrous sulfate. Bentgrass fairways must receive proper cultural and mechanical maintenance practices to compete successfully with *Poa annua.* Soil tests should be taken periodically on bentgrass fairways to determine nutritional needs. Bentgrasses prefer a soil pH around 5.5. A higher pH in the fairway soils will favor *Poa annua.*

Too Expensive

Many people do not consider bentgrass for a fairway turf because they feel maintenance will be more expensive than for a Kentucky bluegrass or perennial ryegrass turf. Others equate the high cost of maintaining a bentgrass putting green with a bentgrass fairway. In reality, bentgrasses will provide an excellent fairway playing surface at only slightly higher maintenance standards than Kentucky bluegrass or perennial ryegrass. A comparison of management practices will help demonstrate the differences in bentgrass and Kentucky bluegrass/perennial ryegrass fairways.

1. The biggest difference in management will be the height of cut. Bentgrass fairways are cut between ½ and ⅝ inch, while Kentucky bluegrass/perennial ryegrass fairways are cut between ¾ and 1 inch. Best playing conditions are obtained on cool-season fairways by frequent mowing. However, Kentucky bluegrasses require more frequent mowing than the bentgrasses. The lower cutting height of the bentgrasses not only can produce better playing conditions, but also deters *Poa annua. Poa annua* is most competitive at ¾ to 1 inch.

2. The bentgrasses require more water during the summer months because they become very short-rooted during July and August. Frequent light waterings may be necessary during these months. Kentucky bluegrass and perennial ryegrass are more deeply rooted; therefore, light, frequent waterings to these species during the summer may reduce the root systems and produce a more tender plant.

3. Disease control programs are needed for all grasses. The best disease control program, however, is a sound cultural program using minimal fertilizer and water, proper mowing and thatch control. The peak disease period for bentgrasses, bluegrasses, and ryegrasses will be during July and August when heat and humidity are high. Normally, depending on weather conditions and the fungicide selected, a 7- to 21-day spray interval is followed in fairways in the late spring, summer and early fall.

4. The bentgrasses are also surprisingly heat tolerant. This is a characteristic usually overlooked. Bentgrass greens are present in areas of the deep south, and bentgrass tees are common in the southern limit of the transition zone on modified soil mixes. It is possible to grow bentgrass fairways further south than is currently practiced, if soils are well-drained.

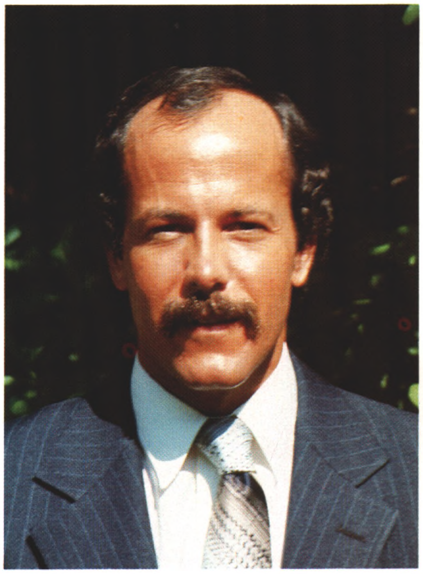
5. The wear tolerance of bentgrass is poor compared to Kentucky bluegrass and perennial ryegrass. Perennial ryegrass is the most wear tolerant of the cool-season grasses. Traffic control, particularly if golf carts are present, is mandatory to reduce wear on bentgrass fairways.

6. The bentgrasses are the most weed free of the cool-season turfgrasses. However, they are more susceptible to injury from herbicides, particularly preemergent and hormone-type chemicals. Clover, particularly on imperfectly drained, fine-textured soils, is the biggest problem. Kentucky bluegrass and perennial ryegrass have a higher tolerance to most herbicides.

The Future

Hopefully, the criticisms that bentgrass fairways are too expensive to maintain and are too subject to *Poa annua* invasion will be less in the future. Additionally, many managers may select bentgrass for areas previously considered too risky during the summer.

Intensive breeding work will one day produce bentgrasses with greater heat- and drought-tolerance. Wouldn't it be wonderful to have a bentgrass with the rooting characteristics of Kentucky bluegrass? Through breeding, we may one day have rhizomatous Colonial bentgrasses. This feature together with greater wear tolerance would significantly increase bentgrass use on golf courses throughout the country. The future for better bentgrass fairways through research now appears more promising than ever before.



Brian Silva Joins the Green Section Northeastern Region Staff

Brian M. Silva, Agronomist, has been appointed to the USGA Green Section staff. A native of Framingham, Massachusetts, Silva received his undergraduate and graduate training in turfgrass management at the University of Massachusetts. Immediately prior to joining the Green Section staff, he served as an instructor in the School of Golf Course Operations, Lake City College, Lake City, Florida. He brings considerable practical experience to his new position.

Technological Considerations For Automatic Irrigation

by **DR. DOUGLAS T. HAWES**
Mid-Continent Manager, USGA Green Section

THIS DISCUSSION will cover three important aspects of irrigation technology — the differences in method of sprinkler head rotation, the methods of controlling valves, and the controllers. These are the subjects that must be given serious thought when taking steps toward automating an irrigation system, but they have not been well compared in recent literature.

Sprinkler heads have really not changed dramatically in a long time. Pop-up sprinklers have been available since the 1920s, and gear-driven heads have been available since the 1930s. Golf courses installing an automatic system or converting a manual system to automatic need to decide whether to use impact (impulse) heads or gear-driven heads. Both types are available in many diameters of coverage with similar precipitation rates.

Those who prefer the impact-type head point out that these heads are easier to work on, have few moving parts, and, when they break down, they are relatively inexpensive to repair, compared to gear-driven heads. They also note that these heads have a reputation for handling dirty water better than the gear-driven heads, and that less pressure is needed to operate impact-type heads. It should be noted here that if dirty water is used for irrigation, any head or valve with a screen in the bottom will need to be removed periodically and cleaned, otherwise a pressure reduction will change the distribution pattern.

Those who prefer gear-driven heads cite the smooth, quiet, uniform rotation of these heads. The uniform rotation permits them to time syringe cycles accurately by knowing that if one head makes a full turn in two minutes, then all heads of that model will make a full turn in approximately the same time. In comparison, the spring tension of impact heads may need constant adjustment to compensate for changes in temperature and wear in order to obtain uniform timing of full turns. Head rotation of impact heads can become excessively slow and the distribution pattern can be poor if routine preventive maintenance is not properly carried out.

Some feel a big advantage for selecting the gear-driven head is that it is also available in two-speed models which can be very useful in watering the banks around greens and on the backs of tees where sprinklers don't overlap. Although two-speed heads are used in other situations, their use in the two locations cited gives them a distinct advantage. It should be noted that two-speed and part-circle heads have been known to go out of adjustment, so there is a need to monitor the coverage pattern. Those who use gear-driven heads do not feel that dirty water is any more a problem than it is with impact heads; the enclosed gears seem not to be affected by water quality.

Regardless of what type head is chosen, the control valve determines whether it comes on or goes off properly. The control valve is usually activated by an electrical current change or by a change in water pressure. Also available is a system to activate valves by dramatically lowering and raising the pressure at the pump station. Most valves, however, need electrical wire or hydraulic tubing to convey the signal to the valve. The trend appears to be electric control.

ONE ADVANTAGE of hydraulic control is great freedom of the system from lightning damage. In areas such as Florida, where lightning damage is a serious problem, this method of valve control has to be given serious consideration. Cost comparisons give an edge to hydraulic at time of installation, but the feeling is that this advantage is quickly lost when maintenance problems arise. Squirrels and gophers, for example, like to chew on hydraulic tubing, clean water is essential for hydraulic controls, and leaks in the tubing are always difficult to find. These potential problems result in increased maintenance costs. It should be noted that when hydraulic tubing breaks, not only is there an immediate need to repair the break, but after the break is repaired, dirt that entered the broken tubing may show up at the valve and cause further problems. The new electrical fault-finders make finding breaks in electrical wiring easier than locating leaks in hydraulic tubing. Hydraulic control of valves cannot be used where the difference in elevation between controllers and valves is more than 32 feet. Anything over this height variance will affect the operation of the valve.

Where freezing is a problem, the hydraulic tubing in the control boxes must be kept warm when temperatures drop below freezing or the normally open valves will be activated and the normally closed valves cannot be used to remove frost automatically. One solution to this problem used in at least one area of the country is to convert hydraulic controls to pneumatic controls. This can be done with minor changes in the system, but this practice is not encouraged by the manufacturer or by one superintendent who converted to such a system. The air must be dry or this system, too, can experience freezing problems.

In a few areas, the electrical code requires that any wiring above 20 volts of alternating current that is placed underground must be shielded. These requirements result in abnormally high costs of installation of electrical control wires, and this tips the cost balance to hydraulic tubing and valves, which then becomes a much cheaper control system. Superintendents who discussed these two methods of control expressed concern for closer quality control in valve manufacture. They believe strongly that

if you have poor valves, the method of valve control is unimportant. Quality control is an extremely important consideration for a product that is placed in the ground where it is difficult to repair.

THE NEXT QUESTION posed to the contributors was, "What type controller do you prefer and why?" All the golf course superintendents who contributed seemed to agree that they would prefer the flexibility of sophisticated computer controllers, even though they had not made that choice when installing their system. The reasons were not just a matter of cost, but they were not sure the computer controllers were completely free of problems. They were waiting for the technology to develop further, while those who chose to install it were spending time improving what they had. Reportedly, computerized systems are now taking hold rapidly on the West Coast, the heart of the turf irrigation industry. One assumes that in time this technology will prove itself and be used across the country. It certainly makes possible a flexibility that superintendents previously have only dreamed about.

(Top) Sand separator is used to remove sand from water since automatic irrigation systems need to be run on reasonably clean water.

(Above) Computer controllers should be located in the maintenance building to better protect them from vandalism and lightning damage.

When one considers that golf courses in the Southwest may have up to 2,500 heads that can be valve-controlled individually or by perhaps some 800 separate valves, the advantages that a computer provides certainly cannot be ignored. The problems with computer controllers, other than cost, appear to be their sensitivity to power surges and a difficulty in having repair work done. Surges occur in the power lines and when lightning strikes nearby.

Another disadvantage of this type of equipment is the need to re-program the computer if the electricity is lost for a longer period than the battery will maintain the memory. While computer programming has come a long way, it still is not for everyone. The electromechanical controllers have proven to be very dependable, and most superintendents consider them relatively easy to repair, allowing them to do much of their own repair work. However, when a problem occurs with a computerized operation, one must call in a factory technician or return the

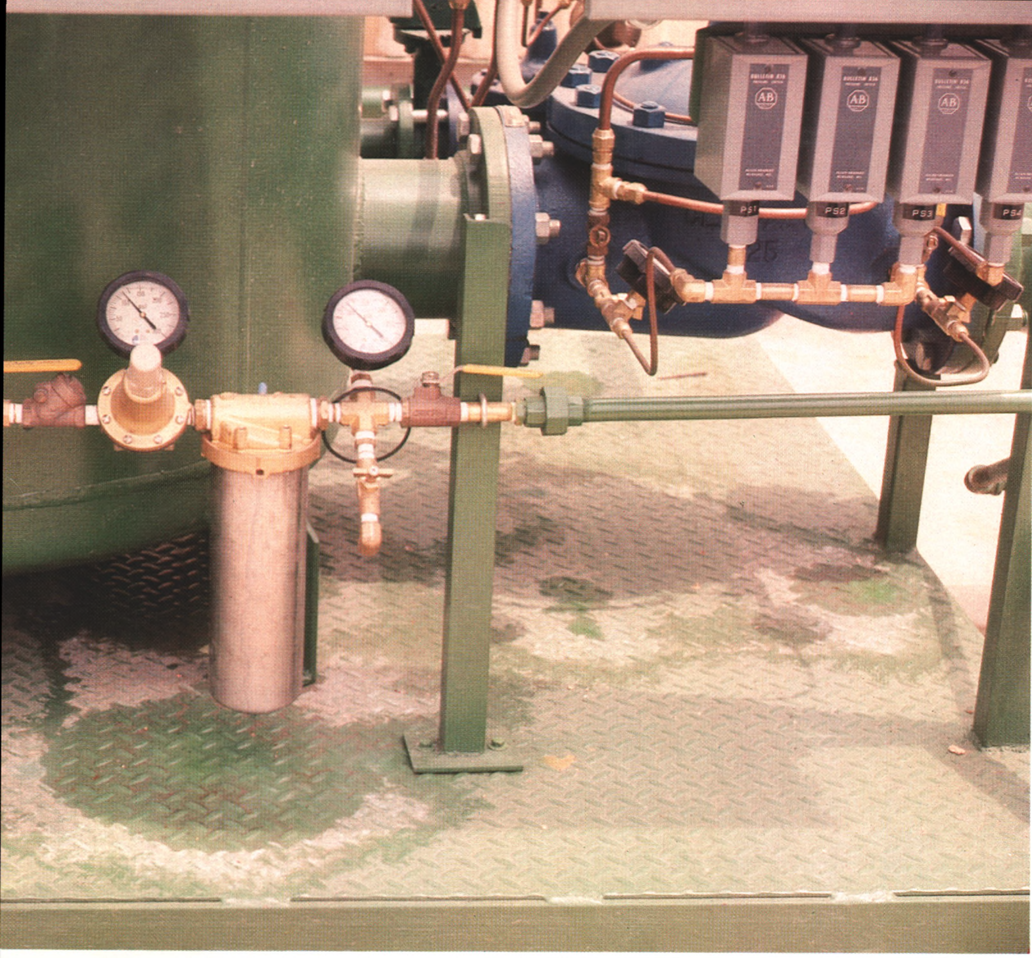
Gate valve and electric valve serving three fairway heads — note slack wire for easier repair of electric valve. Gate valve permits electric valve to be worked on while the system is pressurized.

device to the manufacturer for repair. It is believed that computer controllers will probably come down in price within 10 years. If so, their ability to assist the superintendent may increase. Irrigation computer technology and equipment are presently undergoing rapid development. Having the essentials now for an automatic system, how does one put it together so that it does what you want it to do? The ultimate in control would be a valve for every head and a station on the controller for each valve. The costs are not as severe as might be expected. The smaller valves needed to control individual heads are considerably cheaper than the larger valves needed for multiple head control. However, the cost of wiring or hydraulic tubing increases dramatically, and the controller costs will increase tremendously unless the large computer controllers are used.

Where most of the water the green receives comes from irrigation, individual head control on greens, in my opinion, is preferable because this gives the superintendent the ability to overcome two problems. First, the front of the green does not normally need much water since greens tend to drain to the front and this area is usually overlapped by an approach head. The back of the green is normally not covered by overlapping sprinklers, is often elevated, sloped and exposed to wind, and, therefore, it requires more irrigation time. Secondly, the problem of shifting winds also helps justify the need for individual head control. Because the wind is constantly changing, there will be a need to alter the times of each sprinkler head with seasonal wind changes. It should be noted that even with individual head control on greens, there may still be a need for hand watering if greens are to be maintained uniformly and on the dry side. A teeing area can be watered from the same valve if one sprinkler head is located at the back edge of the tee. If not, the problem of coverage is similar to that which exists on the back of a green in that there is no overlap from other heads.

ON FAIRWAYS the usual tendency with double- and triple-row systems is to place two or three heads diagonally across the fairway on the same valve. On flat terrain courses with uniform soils this creates no problem, but as most golf courses are constructed on rolling terrain, this sometimes creates the problem of one valve controlling a sprinkler located in a low spot and another located on a high spot. When this occurs, the advantages of automatic irrigation quickly disappear because the low areas become overwatered and subsequently need to be drained. Golf courses in the arid Southwest often install as many drain lines as golf courses in the humid East. The cost of the installation and maintenance on a system with a valve per head is expensive. Therefore, compromises are made in the decision-making process even in the arid Southwest, which sometimes results in an automatic fairway irrigation system with less than desirable ability to put the water where it is needed.

In closing, it should be noted that there are many ways to successfully irrigate a golf course. Automatic irrigation, if quality designed and properly installed, places the responsibility of irrigation into the hands of the most highly trained individual on the staff, the golf course superintendent. If designed poorly, and if poor-quality



Filter and line for hydraulic controls. Hydraulic control systems require filtered water.

equipment is used, an automatic irrigation system may present more problems in irrigating a golf course uniformly than a manual system.

This article is partly made possible by the contribution of thoughts on the subject from the following: Golf Course Superintendents Art Snyder, II, Tucson Country Club, Arizona; Rollie Cahalane, Inverness Golf Club, Colorado; Donald Clemans, The Olive-Glenn Country Club, Wyoming; Gary Grigg, Raveneaux Country Club, Texas; and Karl Olson, Fort Douglas Club/Hidden Valley Country Club, Utah. Contributing from industry were the following: Charles Amos, Rain Bird Sprinkler Manufacturing Company; Richard Choate and Mike Morey, Weather-matic Division of Telsco Industries; and Donald Montgomery, Toro Manufacturing Company. Two members of our USGA Green Section Staff, Don Hoos and Charles White, contributed, also. The author accepts full responsibility for the blending of their thoughts.

Maintenance Aids

A TIP FROM

WILLIAM S. SMART, Golf Course Superintendent
Powelton Club, Newburg, New York

AFTER TORRENTIAL rains, water used to back up and thoroughly saturate acres of turf on holes bordering our pond. This problem was corrected by constructing the relief swale pictured, to allow the water to circumvent the dam during periods of excessive rain, and direct water away from the 14th green and other adjoining holes. The relief swale, constructed at the time the golf cart path was being installed to bridge the pipes shown, directs the excess water around the bridge and into the stream in the foreground, making these low holes playable and maintainable soon after heavy rains.

Tifway II Bermudagrass Released

by **DR. GLENN W. BURTON**, Research Geneticist, USDA, SEA/AR
and University of Georgia, Tifton, Georgia

TIFWAY II is an improved mutant of Tifway turf bermudagrass, developed cooperatively by the U.S. Department of Agriculture, SEA/AR, the Georgia Coastal Plain Station, the United States Golf Association Green Section, and the Department of Energy. It was created by exposing dormant sprigs of Tifway to 9,000 rads of gamma irradiation, growing plants from the treated sprigs, and selecting plants or sectors of plants that appeared to be different. Produced in 1971, it has been subjected along with other promising mutants to numerous tests. These tests show that Tifway II looks like Tifway and has the same desirable characteristics, but it makes a denser, more weed-free turf, is more resistant to root knot, ring and sting nematodes, is more frost tolerant, exhibits a little better quality, and often greens up a little earlier in the spring. It is the combination of these traits, none of which can be used for identification, that warrant the release of Tifway II.

Tifway II, like Tifway, is a sterile triploid and must be propagated vegetatively. It will be suited for lawns, fairways, tees, and football fields throughout the South and the rest of the world where Tifway is presently grown.

Tifway II will be released only to people who qualify as certified growers. To qualify they must have their land inspected and approved by their State Crop Improvement Association. Foundation stock is limited, but Georgia Crop Improvement Association registered stock is available to plant certified acreages.

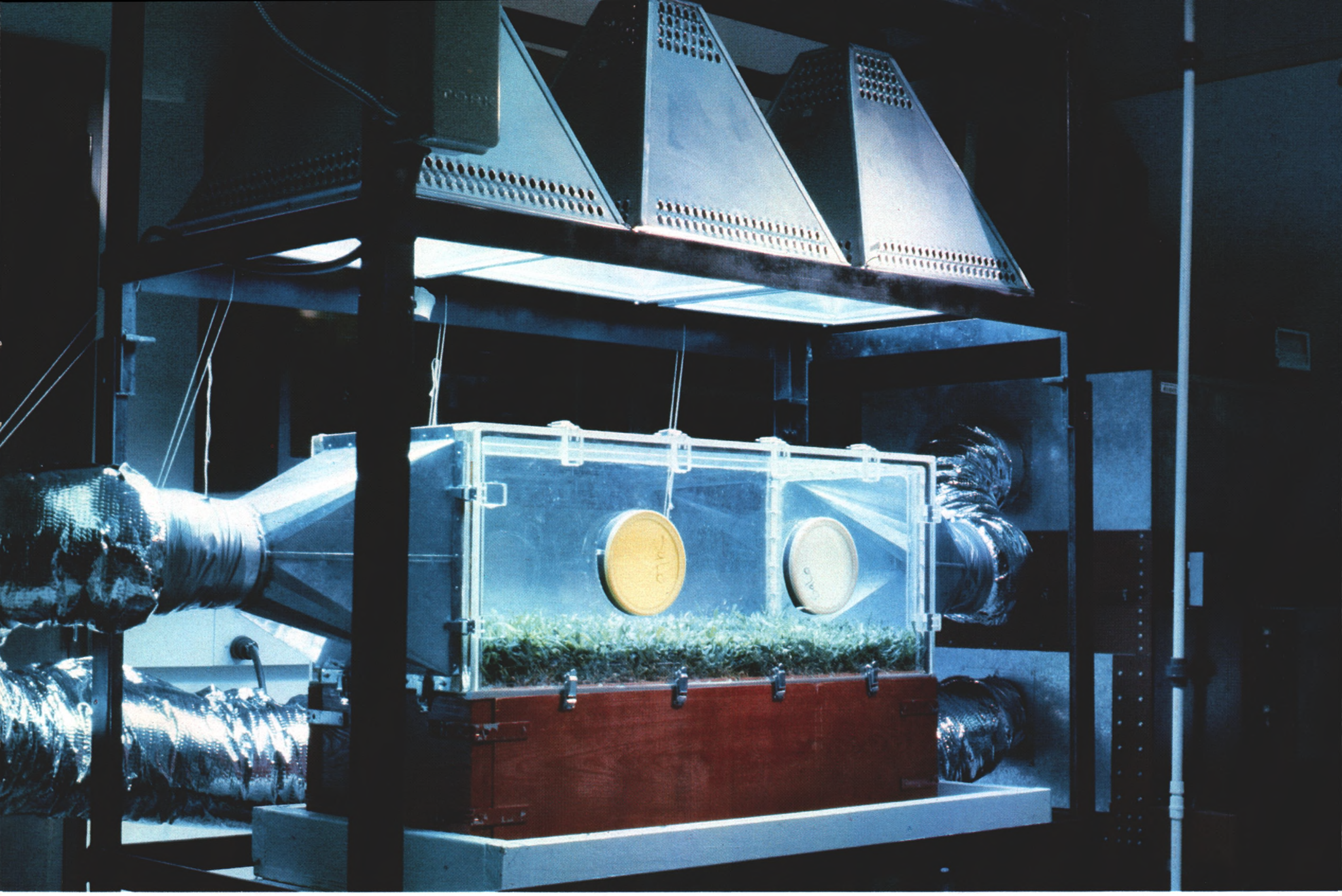
Those interested in producing Tifway II for sale should contact the Georgia Seed Development Commission, Whitehall Road, Athens, Georgia 30602.

The Toronto C-15 Bentgrass Syndrome

by **ALEXANDER M. RADKO**
National Director, USGA Green Section

FOR MANY YEARS, Toronto C-15 creeping bentgrass provided some of the finest putting surfaces in the Midwest. However, for several years now, and with no specific pattern of occurrence, many Toronto C-15 greens have become thin, weak and in some instances failed to survive.

Last year was an especially difficult year for Toronto C-15 greens in the Chicago area. As a result, the Chicago District Golf Association, the GCSAA and the USGA decided to sponsor jointly a research project to determine the reasons for this puzzling loss of Toronto bentgrass. The project coordinator is Dr. Houston B. Couch, professor of Plant Pathology, Virginia Polytechnic Institute. Other scientists involved are Dr. Charles Krauss, USDA Research Laboratory, Delaware, Ohio; Dr. Phil Larsen, Ohio State University; Dr. Malcolm Shurtleff and Dr. David Wehner, University of Illinois. The USGA is pleased to enter into this joint research support effort with the Chicago District Golf Association and the Golf Course Superintendents Association of America, which, hopefully, will correct this problem so that healthy Toronto C-15 greens can once more be enjoyed throughout the Midwest.



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

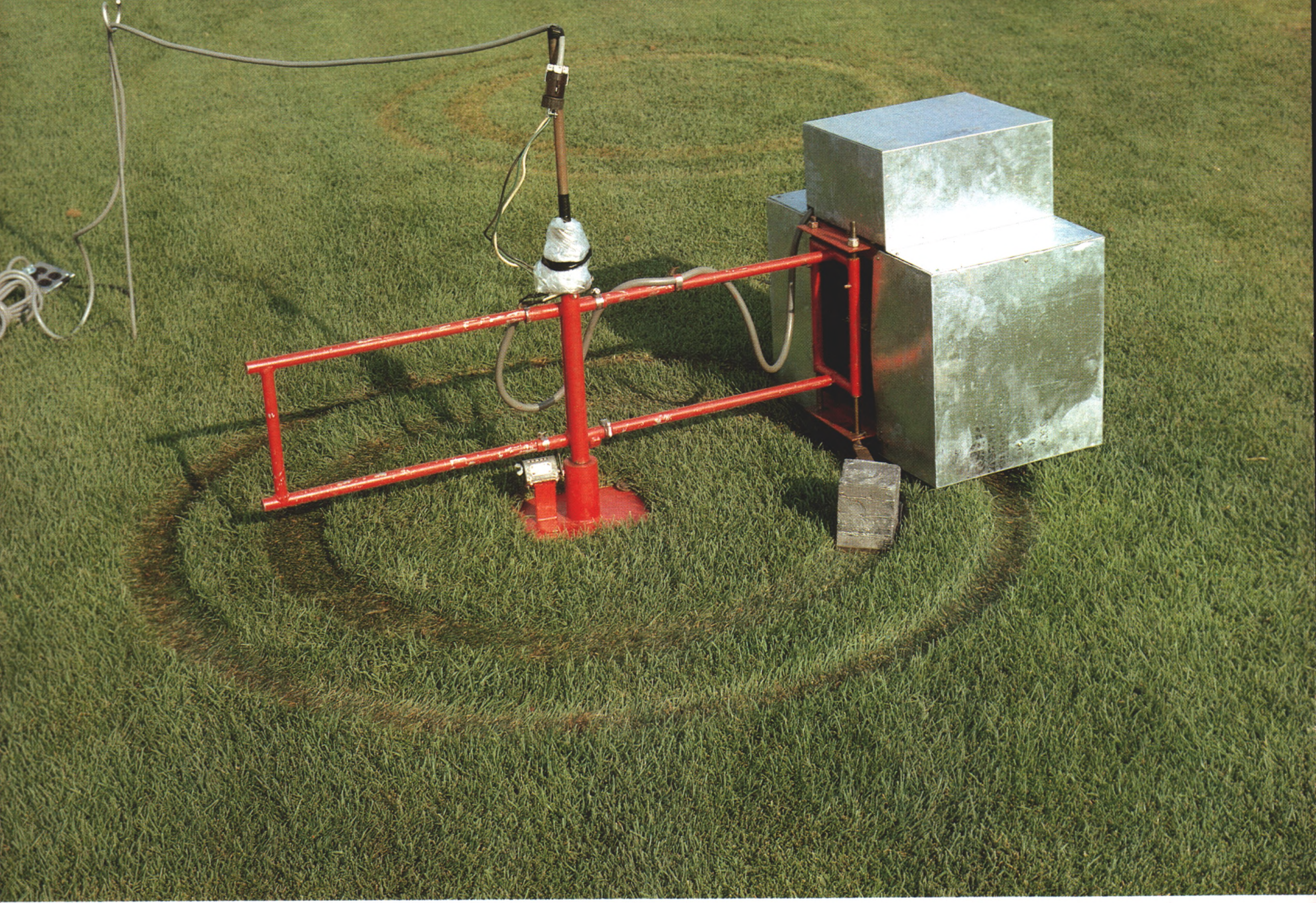
Quality Playing Conditions–The Role of Research

by **DR. JAMES B. BEARD**
Texas A&M University, College Station, Texas

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.

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.

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).

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.

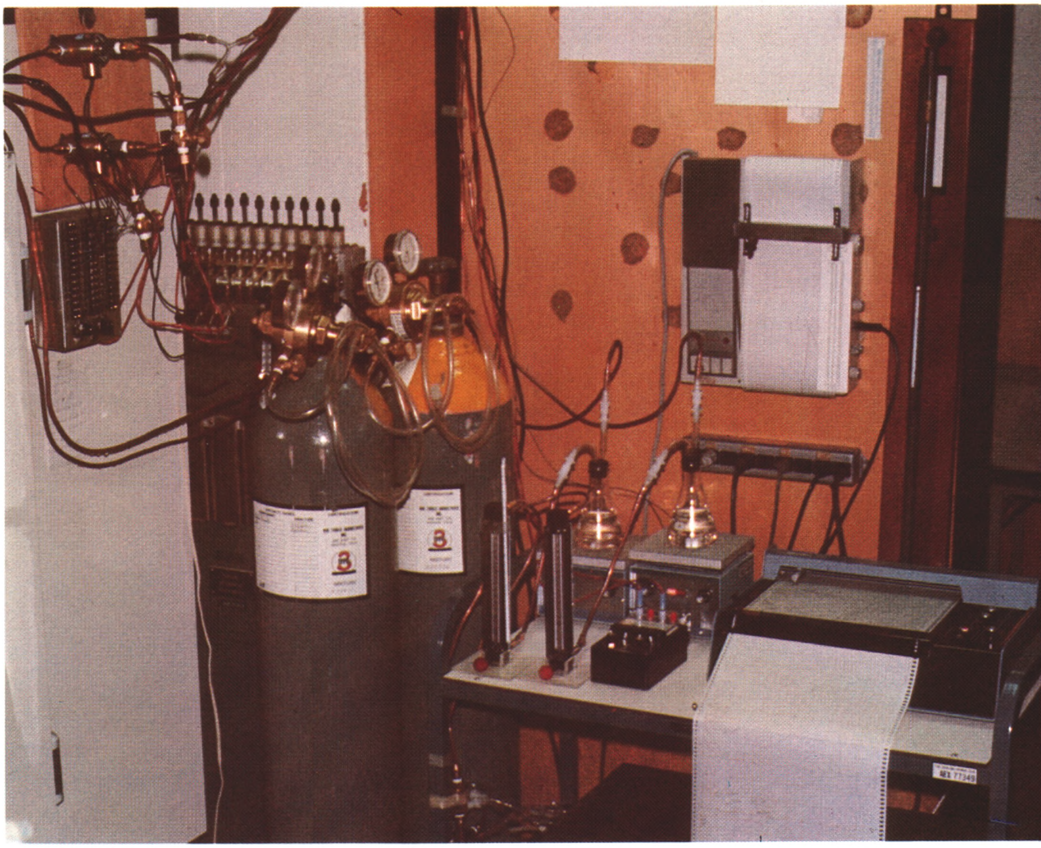
Future Research

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.



TURF TWISTERS

IT'S A CHINCH

Question: We experienced more turf loss from chinch bugs during the dry summer of 1980 than in any previous year. Is there any cool-season grass that is resistant to this insect? (New Jersey)

Answer: Research hasn't fully determined where the chinch bugs draw the cool-season line. From personal observation, however, we have never seen tall fescue damaged by chinch bugs, even though every other cool-season turfgrass in its wake was totally destroyed. Whether this means tall fescue is resistant to chinch bug injury, we can't say for sure . . . maybe they just don't bother with it so long as there are other, more palatable grasses to feed upon.

TO APPLY IRON

Question: Iron has long been an important nutrient applied to turfgrasses. Who was first to recognize the importance of iron to plant life? (North Dakota)

Answer: We're not certain it's the first, but to cite our earliest reference, scientist Salm-Hortmar in 1849 showed that "plants which grow in soils or media destitute of iron are very pale in color and that addition of iron salts (sulfate or chloride of iron) speedily gave them a healthy green color."

E. Gris in 1843 was the first to trace the reason for these effects . . . he found that in the absence of iron, the protoplasm of the leaf cells remained a colorless yellow mass, destitute of visible organization. When iron is added, grains of chlorophyll begin at once to appear and pass through the various stages of normal development. Thus, in the absence of iron, there can be no proper growth. (From *How Plants Grow*, by Samuel W. Johnson.)

DURING SUMMER DORMANCY

Question: We have often heard that bentgrass putting greens enter a dormant stage in summer. What does the term "summer dormancy" mean? (Washington)

Answer: Nature designed cool-season turfgrasses to better survive the hot, dry periods of summer by going through a dormant stage. During its dormant stage, reduced growth occurs. This is one of Nature's safeguards, so forcing the turf while dormant can weaken it, thereby opening the door for the invasion of *Poa annua* and other weedy grasses. Careful study of annual irrigation and nitrogen applications is advised to help bentgrass putting greens through their summer dormancy period.