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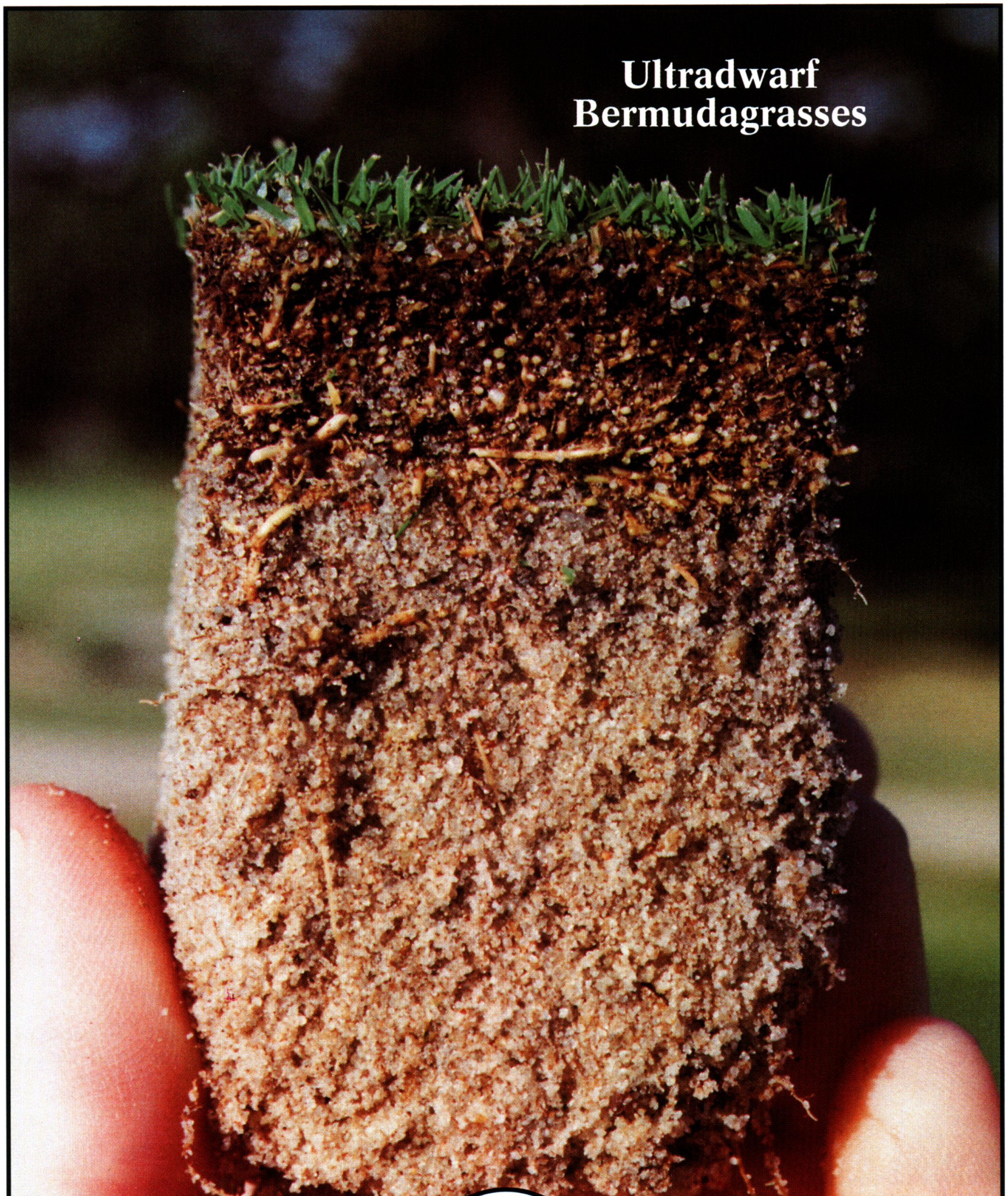

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Cover Photo: Excessive thatch accumulation can form on the new ultradwarf bermudagrasses without proper management.

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As opposed to the picture, the target with midday syringing is to cool the turf without allowing water to soak the rootzone. Puddling water or runoff denotes inefficient syringing. See page 9.

Rutgers University (New Brunswick, N.J.) is one of the leading universities in turfgrass development. Their research efforts encompass germplasm collections, variety development, and endophyte research. See page 19.

Opportunity Knocks with the Ultradwarfs

Success with an ultradwarf might be easier than you think.

by CHRIS HARTWIGER

CHANGE is exciting. Change can be intimidating. Change may be frustrating. The introduction of a new generation of bermudagrass varieties for putting greens, commonly referred to as the ultradwarfs, has evoked some or all of these emotions at golf courses that have tried them. Golfers at many courses with ultradwarf bermudagrass putting greens are enjoying green speed, smoothness, and firmness that are at an all-time best. An astonishing number of golf courses have eradicated their Tifdwarf greens and have converted to an ultradwarf. With these impressive credentials, one might assume that ultradwarf varieties would be universally accepted as *the* choice for bermudagrass greens. That assumption would be dead wrong.

Currently, the phrase "the ultradwarfs are not for everyone" is making the rounds from turfgrass conferences to magazine articles to green committee meetings. This comment and the underlying tone of negativity is scaring people. The phrase might be accurate, but it is devoid of any tangible information and only serves to frighten and intimidate. It evokes a fear of the unknown.

Given the success of ultradwarfs experienced by hundreds of courses, it is clear that they deserve strong consideration when establishing a bermudagrass putting green. This article is intended for those involved in selecting a new bermudagrass for their golf course, and it aims to replace fear with facts. The reader should have a clear understanding of what an ultradwarf is, the performance of the ultradwarfs in the field, and the tools necessary to make an ultradwarf a success.

Using side-by-side replicated field trials is a great way to compare the differences between the various ultradwarf bermudagrass varieties before making the final selection for your golf course.

What is an Ultradwarf?

No one knows who coined the term *ultradwarf*, but it is a term that has become widely accepted in the turfgrass industry. Champion, Floradwarf, MiniVerde, MS-Supreme, and TifEagle are the ultradwarf varieties commercially available today. The industry definition of an ultradwarf today is any variety that can withstand a mowing height of 0.125 inch (⅛ inch) or lower over an extended period of time.

Numerous turfgrass scientists have studied the ultradwarfs and have offered a more formal definition. Guertal and White described these varieties as having shorter leaves than are found on Tifdwarf and Tifgreen and being tolerant of lower mowing heights (Guertal and White, 1998). Gray and White have separated the ultradwarfs into vertical or horizontal dwarf categories based on vertical and horizontal growth rates (Gray and White, 1999). The morphological differences between the ultradwarfs and Tifdwarf have been reviewed, too (White, 1999; Beard and Sifers, 1996). Table 1 provides information about the physical characteristics and genetic origin of several ultradwarfs. Please note that although these varieties are all considered ultradwarfs, they do vary substantially in their physical characteristics.

The Ultradwarfs Find a Home

The past few years have seen a major change in attitude toward bermudagrass putting greens. In the traditional bermudagrass zone of Florida, the deep South, and the Southwest, courses regrassing or rebuilding putting greens have selected an ultradwarf variety an overwhelming majority of the time, hoping to take advantage of the potential for better putting surfaces. The ultradwarfs are having a big impact in the southern portion of the transition zone, where bentgrass has always been difficult to grow, too. In the past, many courses have felt that mediocre or poor-quality bentgrass produced a better putting surface than Tifdwarf.

The ultradwarfs are pushing the bentgrass line farther north, with successful ultradwarf putting greens established in North Carolina, Tennessee, Arkansas, and throughout the Southwest. Clubs are finding that the management program associated with the ultradwarfs is easier and less expensive than trying

Table 1
Physical characteristics and genetic origins of selected ultradwarf varieties.

Variety	Genetic Origin (Beard and Sifers, 1996)	Vertical Growth Rate vs. Tifdwarf (Gray and White, 1999)	Lateral Growth Rate (Gray and White)	Multiple of Thatch Accumulation vs. Tifdwarf (Gray and White)	Percent More Shoots per unit area vs. Tifdwarf (Gray and White)
Champion	Selection from Tifdwarf green	Slower	Faster	11.7X	100%
Floradwarf	Selection from Tifgreen	Slower	Similar	7.5X	50%
Mini-Verde	Selection from Tifdwarf	Slower	Faster	5X	100%
MS-Supreme	Selection from Tifgreen green	Slower	Faster	?	?
TifEagle	Gamma-induced mutant of Tifway II	Slower	Similar	7.7X	50%

to maintain bentgrass putting greens throughout the summer. Fungicide budgets are down, fans are not needed, and labor requirements have been reduced at the clubs that converted from bentgrass to an ultradwarf.

Are the Ultradwarfs Measuring Up?

To answer this question, it is necessary to examine performance on the golf course as well as in research trials. The expectations of the ultradwarf varieties have been high, success stories have been abundant, and failures have been publicized widely. To date, an overwhelming majority of golf courses with an ultradwarf are pleased with their selection and have no regrets for not selecting Tifdwarf. For the first time ever, reports from South Florida have golfers complaining about the putting greens being too fast! This is amazing, considering the unbelievably high expectations in this region and the frustration with Tifdwarf over the years.

In isolated instances, disease, scalping, shade, excess thatch, cold temperatures, and management errors have injured some of the ultradwarf varieties. Putting quality has been compromised at these courses and changes in putting green management have been necessary to resolve the problems.

A review of research trials yields some interesting observations as well. There are numerous sites throughout the country where the ultradwarfs and Tifdwarf were planted in replicated trials. Results have been positive, with a few notable exceptions. At Texas A&M, the ultradwarfs have been plagued with a myriad of problems (White, 2000). More than one visitor has left these trials thinking, "Why on earth would someone plant an ultradwarf?" At other locations, such as Auburn University and the USGA/GCSAA/NTEP putting green trials, the ultradwarfs have been as steady as a rock. A wealth of information on these trials is available free of charge at www.ntep.org, and in practically every variable measured, Tifdwarf finishes at the bottom of the rankings (NTEP, 2000).

With a diversity of results in the field and in research trials, what conclusions can be made regarding the performance of the ultradwarfs? First, it is obvious that the ultradwarfs are neither perfect nor foolproof. They require appropriate management and good growing conditions. Remember that Tifdwarf is haunted by numerous weaknesses, too. After more than 30 years of research and experience in the field, it is not too difficult on any given day to locate a Tifdwarf putting green in poor condition. Second, it is clear that we do not understand completely what stress or combination of stress factors leads to poor performance. Third, putting quality on an ultradwarf green with good management is significantly better than Tifdwarf or poor-quality bentgrass.

Ultradwarf Management Issues

The management of the ultradwarf varieties has been described as requiring more labor and expense. However, this description paints the maintenance requirements with too broad a brush because it does not differentiate managing for plant health versus managing for playability. Each of these management components will be reviewed.

Managing for Plant Health

The management protocol for maintaining healthy, viable ultradwarf greens has been changing over the last few years in response to turfgrass research and trial and error on the golf course. There are several areas that appear to be critical to managing the health of an ultradwarf. This section is not a "how to" primer on ultradwarf management, but it does focus on the areas most critical for managing plant health.

Biomass Management: The rapid buildup of organic biomass in the upper portion of the profile of ultradwarf turf is well documented (Guertal and White, 1998; Gray and White, 1999; White, 1999; Beard and Sifers, 1996). This biomass is primarily a layer of stolons that should be maintained at a depth of ¼ inch to avoid potential problems. Initially researchers hoped this layer could be managed through the traditional Tifdwarf program of light, frequent vertical mowing, core aeration, and topdressing, while still providing an excellent putting surface.

However, results in the field and in some research trials have indicated that the physical injury caused by the vertical mowing component of the program may increase the chance for decline problems (White, 2000).

Many superintendents have proven it is possible to maintain the biomass layer at ¼ inch in an ultradwarf putting green with brushing instead of vertical mowing. It requires a different method of management, but not at an extra cost. Because many of the ultradwarfs have very low vertical growth but have an increased lateral growth rate, low-growing stolons can escape the bedknife and grow to undesirably long lengths. This contributes to the proliferation of the stolon or biomass layer. Vertical mowing severs long stolons once they have developed, but brushing successfully stands up shorter, more juvenile stolons and clips them off before they become too long. Brushing every five to seven days is much less injurious to the plant than vertical mowing every seven to 14 days. Brushes are available that fit into the front roller bracket and can be set even with the bedknife. The beauty of this approach is the ability to mow and brush at the same time without any extra labor.

Core aeration followed by filling the holes with sand topdressing continues to be the most effective means to physically remove the accumulation of organic matter in the upper portion of the profile. The general school of thought is that no additional core aeration beyond what is appropriate for a sound Tifdwarf program is needed.

Light sand topdressing is essential for managing biomass. Light dustings of sand every seven to 14 days on average help dilute the accumulation of organic matter, improve air-filled porosity, and produce a firm surface without inconveniencing golfers. The rate is so light that only an irrigation cycle is needed to incorporate the sand into the canopy.

Some areas have reported difficulty finding sand topdressing that is easily incorporated into the canopy. Sand particle sizes between 0.25 mm and .75 mm are generally advised for this material. Coarse sand particles above .75 mm that remain on the surface can damage mowing reels and can interfere with putting quality. Many sand companies have the ability to screen out particles above .75 mm in topdressing sand if they are advised of this problem.

The long-term impact of using topdressing sand lacking coarse particles has been debated. Some feel that it may contribute to black layer formation (Unruh and Davis, 2001). Because black layer requires anaerobic conditions, it is hard to imagine that a well-managed profile, even with a finer topdressing sand, will consistently favor the development of black layer. After all, light and frequent topdressing with any kind of sand is a relatively new phenomenon. There are thousands of bermudagrass putting greens that were topdressed once or twice per year that exhibit no signs of black layer. Theoretically, the alternating layers of sand and organic matter in these greens should be havens for black layer development. In reality, it has not happened.

Moisture Management: The ultradwarfs have outperformed Tifdwarf in areas where water restrictions have necessitated reduced watering. The only moisture management issue that has arisen is the occasional sealing of the surface during periods of rapid growth. The surface canopies become so tight and dense that water runs off instead of soaking into the canopy. Localized dry spots and hydrophobic soil are common when the surface seals.

A sealed surface is best dealt with by taking a proactive approach. The first requirement is an irrigation system that provides good coverage. Next, hand watering should be practiced on areas prone to drying out or exhibiting poor water penetration. Also, superintendents can use wetting agents, solid-tine cultivation, and water injection to minimize dry spot problems. When managed proactively, moisture management should not be too difficult.

Disease: Reports of diseases such as bermudagrass decline (*Gaeumannomyces graminis var. graminis*), curvularia (*Curvularia* species), and spring dead spot (*Ophiosphaerella herpotricha*) have appeared in several articles (Unruh, 2001; White, 2000). However, in the broader view, disease outbreaks appear to be isolated, according to USGA Green Section agronomists traveling throughout the bermudagrass zone and southern transition zone. Virtually all courses use a curative program, and some courses with ultradwarf putting greens have never experienced a disease.

The presence of mechanical or environmental stress factors may help explain the large variation in disease incidence from location to location. In many cases where disease is a problem, there is an existing stress factor that induces or exacerbates disease injury. Light, frequent vertical mowing, poor water quality, mower scalping, shade, and prolonged cloudy or rainy weather are stress factors to watch out for.

Fertility: This is one of the least-understood aspects of ultradwarf management. There is no clear consensus among researchers regarding optimum levels of N, P, and K fertility for each of the varieties. To further complicate the issue, it is possible that the different ultradwarf varieties may require different fertility programs, particularly nitro-

Failure to cover ultradwarf greens when winter conditions warrant can result in an unnecessary level of winter injury.

gen rates (White, 2000b). There have been examples of poor performance at both high and low rates of nitrogen. Reducing the typical annual nitrogen program for Tifdwarf greens by 25% appears to be working reasonably well. Additionally, these clubs are finding that making scheduled applications may not be the best method. Instead, better success has been reported using observational techniques such as clipping production, color, and the density of the stand to schedule fertilizer applications. Spoon-feeding with liquid fertilizer has been widely used with excellent results, too.

Growing Conditions: Excellent site and soil conditions are a prerequisite for success with every turfgrass variety. Shade levels, rootzone quality, putting green size, irrigation coverage, and water quality all affect the health of an ultradwarf. Many feel that ultradwarfs are even less shade tolerant than Tifdwarf. While providing good growing conditions may seem like common sense, it is shocking how many golf courses compromise plant health by failing to address these factors. A minimum of eight to 10 hours of full sunlight daily is recommended, or poor performance will result. Providing the best growing environment is every bit as important as selecting the right variety.

Winter Hardiness: As ultradwarfs replace bentgrass putting greens in the southern portion of the transition zone, protection against winter injury becomes more important. The relative cold hardiness of the ultradwarfs versus Tifdwarf is not completely understood at this time, although it seems there is little difference from observations in the field. Winter injury has been documented on ultradwarfs during the cold winter of 2000-2001 when temperatures reached as low as 0 to 10 degrees and covers were not adequately used. The use of covers during the winter when temperatures drop below 25 degrees F dramatically reduces the risk of winter injury.

Overseeding: Early in their development, there was concern that the ultradwarfs were too dense to overseed. This thinking has changed with the successfull establishment of *Poa trivialis* overseeding on all the ultradwarfs. Transition problems do not appear to be more or less severe than with Tifdwarf.

The percentage of golf courses that overseed their ultradwarfs is declining, however. One reason why courses choose not to overseed is the ability to set up the entire management program around the requirements of the ultradwarf. This results in even better putting green performance during the warmer months. The fact that several of the ultradwarf varieties maintain green color during the fall is another reason why many courses are not overseeding ultradwarf putting greens.

Putting on dormant or semi-dormant ultradwarfs has been widely accepted by golfers during the colder months. High green speeds, firmer surface conditions, and some wear are the primary liabilities on putting quality during the winter. Raising the mowing height to 5/32 or 3/16 inch prior to dormancy is necessary to avoid excessive winter green speeds and to improve wear tolerance.

Encroachment: The encroachment of surrounding fairway type bermudagrass varieties from the collars into the putting greens has not been an issue with the ultradwarfs. It appears the high turf density of these new varieties and the lower mowing heights employed discourages encroachment into the putting greens.

Off-Types or Mutations: No one is certain whether off-types or mutations will appear in ultradwarf putting greens, but the track record to date is spotless, with no off-types reported. This may be the result of superior genetic stability or stricter management of ultradwarf growers. This is quite a change from Tifdwarf greens, where off-types could be expected to appear after five or six years and regrassing was expected after 15 years.

The management protocol for maintaining a healthy ultradwarf is a departure from traditional Tifdwarf management, but it is not considerably more expensive or time-consuming if all the proper equipment is in place. This is a critical point to remember because it suggests that even mid- to low-budget golf courses can commit the resources to having healthy ultradwarf putting greens. The Aiken Golf Club, Aiken, S.C., and the Country Club of Lexington, Lexington, S.C., are successfully managing TifEagle on budgets of less than $300,000.

Managing for Playability

With a healthy turfgrass base, managing an ultradwarf for optimum playability can be fun. Historically, superintendents were required to manage Tifdwarf putting greens on the edge of failure to achieve the best playability. All this has changed with the ultradwarfs. Superior putting conditions can be provided on an ultradwarf without unduly sacrificing plant health. The level of quality achieved is a function of the effort expended, and this is where costs can vary widely.

The golf courses with the best ultradwarf greens commit the most resources and time to the putting greens. Quality has a price. The questions for a golf course considering an ultradwarf include, "Is that price within our reach?" For many golf courses, the answer is a resounding "yes," and here is why. Sixty percent of the game of golf involves the putting greens, but on average only 15% of the budget is spent on putting green maintenance. If the budget cannot be raised, some portion of the 85% of the budget spent on other parts of the course is available to be reallocated. Examples of reallocation include naturalizing pond and creek banks, eliminating unnecessary landscaping on the course, or reducing the intensity of bunker maintenance or other labor-intensive hand work. There is nowhere else on the golf course where such a small increase in costs can have such a dramatic impact on playability.

The extent to which a course with an ultradwarf can elevate putting quality is a function of available equipment and the staff to carry out a predetermined schedule. Outlined below are the areas that most influence ultradwarf performance. The list is not all-inclusive, but it provides the essential elements for an ultradwarf management program. Utilization and frequency can vary based on the geographic location where the ultradwarf is being grown and on the desired level of quality.

Mowing Equipment: Mowing has the largest influence on the quality of any putting green. The ability to mow lower on a regular basis results in approximately one to one-and-a-half extra feet of ball roll compared to Tifdwarf. Generally, walking mowers produce the highest quality of cut and are recommended, but triplex mowing can produce excellent ultradwarf putting surfaces, too. Mowing heights seen in the field on ultradwarfs have ranged from .090 to .150 inch.

Many courses find that it is beneficial to have two fleets of mowers. The primary fleet is used for daily mowing, while the secondary fleet, comprised of secondhand mowers, is used after sand topdressing.

Mowing frequency has a tremendous influence on putting quality, too. Double mowing is performed regularly

Tifdwarf bermudagrass is plagued with contamination and off-types, which disrupt uniformity. To date, this has not been a problem with the ultradwarf varieties.

at some courses to further improve green speed and smoothness. Critics claim frequent double mowing is taking management to an extreme. Supporters argue that the extra speed and smoothness achieved with double mowing are well worth the extra cost.

Specialty equipment for the mowers rounds out a high-quality management program. Groomers and brushes all have a place in the program.

Equipment Maintenance: The best agronomic program can be written on paper, but unless the equipment is maintained to a high level, the desired degree of quality will never be reached. The mechanic at a golf course with an ultradwarf can make or break the success of the program. As mowing heights move lower and lower, the amount of time necessary to set up and maintain the mowers increases dramatically. Daily backlapping is a given today, and bedknives are replaced as frequently as every two to three weeks. Golf courses with the highest standards find it is necessary to have at least one additional employee dedicated to working with the mechanic each day.

Rolling Equipment: The practice of rolling putting greens is an excellent way to temporarily increase green speeds by as much as 10% (Hartwiger, 1996). One or two rollers are recommended for courses that desire to further enhance putting quality. Many courses are finding the need for rolling is reduced because of better speeds created through lower mowing and more frequent topdressing.

Topdressing Equipment: Topdressing machines that have the ability to apply light and heavy amounts of sand are essential. The now rotary spinner topdressers have the ability to deliver light dustings of sand to improve smoothness and dilute the accumulation of organic matter. A traditional topdresser is recommended to fill aeration holes with sand.

Aeration Equipment: Two or three aerifiers are recommended to complete scheduled aerations on a timely basis. Some courses are obtaining water injection machines such as the Toro Hydroject or using ¼ quadratines on their regular aerifier to use in the summer to avoid surface sealing.

Making an Ultradwarf Work

Magic is not required to make an ultradwarf a success at a golf course. Plant health can be maintained with a reasonable amount of effort, and playability is a function of staff expertise, equipment, and labor. The final piece of any successful ultradwarf management program involves the human element.

Attitude of the Golf Course Owners: The putting greens must be the focal point of every golf course that wishes to succeed with an ultradwarf variety. Shortcuts in the equipment fleet and the frequency of routine maintenance are a formula for disappointment. The most successful clubs focus on the putting greens, provide the equipment and staff recommended in this article, and commit to carrying out the program. They also are open to change in the management program, as the turfgrass manager learns through experience and research.

Skill and Attitude of the Superintendent: The ultradwarfs are still in their infancy. Management programs are evolving as more information becomes available. Individuals uncomfortable with change will not be the best managers for ultradwarf putting surfaces. The most successful managers welcome the chance to elevate putting conditions and enjoy the challenge of discovering the best maintenance practices for that specific location.

Conclusion

We are experiencing the best bermudagrass putting conditions ever in the history of the game. The ultradwarf varieties are nothing to be afraid of, and with the right commitment and resources, they should be embraced. As research is conducted on and off the golf course, the potential for the ultradwarfs will be fully realized. Take the time to understand what it takes to make an ultradwarf a success, because the next time you hear the comment "the ultradwarfs are not for everybody," you will know exactly what they mean.

References

Beard, J. B., and S. I. Sifers. 1996. New cultivars for Southern putting greens. *Golf Course Management.* 64(12):58-62.

Gray, J. L., and R. H. White. 1999. Maintaining the new dwarf greens-type bermudagrasses. *Golf Course Management.* 67(3):52-55.

Guertal, B., and R. H. White. 1988. Dwarf bermudagrasses demand unique care. *Golf Course Management.* 66(7):58-60.

Hartwiger, C. 2000. Give me your poor, your tired, your dead bentgrass greens. *USGA Green Section Record.* 38(3):7.

Hartwiger, C. 1996. The ups and downs of rolling putting greens. *USGA Green Section Record.* 34(1-4).

Hanna, W. 1998. The future of bermudagrass. *Golf Course Management.* 66(9): 49-52.

NTEP Website www.ntep.org. 2000. Evaluation of bermudgrass for putting greens. *Progress Report 1999.* NTEP No. 00-7.

Unruh, J. B., and S. Davis. 2001. Diseases and heat besiege ultradwarf bermudagrasses. *Golf Course Management.* 69(4):49-54.

White, R. H. 1999. Unleash the potential of new bermudagrass cultivars. *USGA Green Section Record.* 37(5):16-18.

White, R. H. 2000. Relationship of environment, management, and physiology to bermudagrass decline. p. 27. In J. L. Nus and M. P. Kenna (eds.), 2000 Turfgrass and Environmental Research Summary. United States Golf Association, Far Hills, N.J.

White, R. H. 2000b. Performance and management of new dwarf bermudagrasses. 2000 Annual Research Progress Report. pp. 1-24.

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An Inside Look at Mole Cricket Management

Understanding these pests' behavior is vital to controlling their numbers.

by M. G. VILLANI, Ph.D., and R. L. BRANDENBURG, Ph.D.

TWO species of mole crickets, the tawny mole cricket (*Scapteriscus vicinus*) and the southern mole cricket (*S. borellii*) are among the most devastating insect pests in the southeastern United States. The tawny mole cricket is primarily a root feeder, while the southern mole cricket is a predator of other soil arthropods (insects).

The cost of control and the impact of damage often is measured in tens of thousands of dollars per golf course in many areas. Neither of these pests is native to the U.S.; they were introduced to several locations along the Southeast coast in the early 1900s. Since that time, they have migrated northward well into North Carolina and westward to eastern Texas. Soil type and temperature should limit much additional spread, but a few isolated infestations are also showing up in the southwestern United States.

The costs associated with controlling mole crickets, the lack of effective control following insecticide application, and the lack of an adequate understanding of mole cricket ecology and behavior prompted the development of a proposal to the USGA Green Section Research Committee in 1992. A collaborative effort was established to take advantage of the applied research program on mole crickets at North Carolina State University under the direction of Dr. Rick L. Brandenburg and the soil insect ecology program directed by the late Dr. Mike Villani at Cornell University.

This team received funding from USGA and for the next seven years embarked on an ambitious program to better understand the biology, ecology, and behavior of this most troublesome turfgrass insect pest. The research program focused on several field and laboratory research projects. Each of these projects was targeted toward developing information that will complement economically and environmentally sound mole cricket management programs.

Field Research

Field research was conducted on several golf courses in New Hanover and Brunswick counties along the southeastern coast of North Carolina. Additional studies were conducted in laboratories and greenhouses at North Carolina State University in Raleigh, N.C.

A study to monitor mole cricket development and to develop an equation to forecast or predict mole cricket egg hatch was initiated early in the research program. Acoustic sound traps that synthetically produced the mating call of the male mole cricket were used to monitor mating flights. These were placed at two golf courses in Brunswick County. In addition, a network of automated soil and air temperature recording units was installed throughout the two-county area to monitor degree-day accumulation.

Course fairways were monitored weekly from late spring to late summer. Intensive sampling consisted of using a 2% soapy water solution applied to square meter areas to bring mole crickets to the surface. Crickets were collected, returned to the laboratory, and recorded for species, size, and stage of growth. These data provided indications of egg hatch and cricket development as related to soil and air temperature. Monitoring over a three-year period of time provided situations with significant variations in degree-day accumulations, but did not establish a strong relationship with cricket egg hatch, development, or mating flight patterns.

Subsequent greenhouse evaluations at North Carolina State University determined that soil moisture does play a significant role in the egg laying process. Soil moisture affects the timing and intensity of mole cricket egg laying. Mole crickets prefer adequate soil moisture if they are to lay their eggs. Thus it appears there is an important interaction between soil moisture and soil temperature that influences mole cricket development each year.

Additional studies sought to define turf areas that could be considered at high risk for mole crickets. This project focused on the mole cricket abundance as influenced by soil moisture, various soil parameters, and topography. In addition, the relationship between the presence of adults in the spring and the subsequent outbreaks of the next generation of crickets in late summer was investigated.

The intensity of adult abundance was measured in the spring through a standardized grid rating system. A wide range of turf areas were monitored, including those with little or no damage. Soapy water flushes were then used in the same areas late in the summer to determine the abundance of recently hatched mole cricket nymphs. Soil samples were taken weekly and soil moisture, texture, silt and clay content, as well as pH and organic matter were determined. General observations on topography were also noted.

Results show a strong relationship between the presence of adults in the spring in a specific area and subsequent outbreaks of nymphs and turf damage later in the summer. This correlation is important since the majority of conventional insecticide applications are most effective when applied against small mole cricket nymphs long before obvious surface damage is visible. Such a relationship allows a superintendent to map areas of adult damage in the spring and strategically apply insecticides in those locations during the summer as egg hatch occurs.

This study also provided preliminary indications concerning the relationship of certain soil conditions and mole cricket abundance. Of greatest importance appears to be clay and silt content. Slight increases in clay or silt content of the soil were generally associated with reduced mole cricket abundance. While this relationship needs to be studied more closely, it does indicate two possible management options. One is that certain areas may be defined as "high risk" based on soil characteristics. Such information could be useful in managing these pests.

Research investigating the impact of irrigation, both before and after the application of insecticides, proved inconclusive. Large plots (50 ft. × 50 ft.) were established and subjected to various treatments and irrigation regimens. Treatments included no irrigation, pre-treatment irrigation, post-treatment irrigation, and both pre- and post-treatment irrigation on replicated plots. When the effects of these irrigation schedules were studied in conjunction with the use of several synthetic pyrethroid insecticides, the results were very inconsistent.

Two factors possibly added to this inconsistency. One is that as more water was applied (as either pre- or post-treatment irrigation), surface activity increased in spite of the insecticide. However, the extent to which surface activity increased with increasing soil moisture was difficult to assess in this experiment as it was designed.

Another important factor adding to inconsistent control is an avoidance behavior of the mole crickets when an insecticide is applied to the soil. The exact nature of this avoidance is not well understood, nor has the degree to which it occurs in the field been fully explored. However, reversed-rate responses in pesticide field testing trials are not uncommon. In other words, due to the insects' ability to detect and avoid the insecticide, higher insecticide application rates sometimes result in less control of the pests.

The field behavior of mole crickets was examined by creating castings of cricket tunnels with the use of a fiberglass resin. The resin, commonly used for auto body repairs, provided an easy-to-pour material that flowed smoothly into the tunnels in the soil and hardened quickly with the addition of a catalyst. The casting material formed a lightweight, durable casting that could be easily excavated from the soil. The fiberglass resin also often encased the cricket occupying the tunnel, making species identification easy.

Tunnels for the root-feeding tawny mole cricket almost always produced the "Y"-shaped castings consistent with those observed in the laboratory soil radiographs. The structure recovered from the predatory southern mole cricket consisted of a meandering type of tunnel that might be associated with general searching in the soil. Castings from this species of mole cricket were also consistent with radiographs taken in the laboratory. The castings document a consistent tunneling pattern for an individual species and marked differences between the two species. These are obviously related to the general diet of the two species and to the behavior required to meet those dietary needs.

The southern (left) and tawny mole crickets are the most serious soil insect pests in the southeastern United States.

Greenhouse studies of field-collected crickets also indicate differences in response and possible susceptibility to specific insecticides by the two species. The actual effect of behavioral differences and individual cricket susceptibility to contact with a particular insecticide needs further investigation. These species differences, in addition to soil type and climate, may account for the variability in product performance often observed by superintendents in a specific region.

An additional area of research focused on the use of a fungal pathogen to help add insight into the findings of specific laboratory experiments. Several strains of the pathogen *Beauveria bassiana* were applied for mole cricket control on golf course fairways and the effect on the population was monitored. Treatments included several strains of this pathogen applied with both surface and subsurface application equipment.

The results of their trials are not impressive in terms of level of control typically desired by golf course superintendents. However, the study does provide insight into the use of such control agents. The use of subsurface application equipment appears to improve the efficacy of these products, possibly by reducing the likelihood of exposure to sunlight or desiccation of the fungal spores. The results are consistent with laboratory findings examining fungal pathogens and mole cricket behavior.

Laboratory Research

To further our understanding of the impact of environmental factors and disease on mole crickets, a clear picture of "typical" tawny mole cricket and southern mole cricket behavior was necessary. Studies were initiated using radiographic technology (x-rays) to visualize the movement and feeding patterns of both tawny mole crickets and southern mole crickets in the soil matrix. Mole crickets were placed in plexiglass soil arenas (1.5 × 12 × 15 inches). Through the placement of a small lead tag on each cricket, tunnel construction and cricket movement in the tunnel could be monitored over extended periods of time.

A series of radiographs indicate a consistent behavior of a single late-instar tawny mole cricket nymph. This nymph produces a characteristic "Y"-shaped tunnel that allows two escape routes to the surface and down into the soil to escape predators, including larger southern mole crickets, and a long tunnel into the soil profile that most likely aids in thermal and water regulation.

Tawny mole crickets typically feed at the root/soil interface between the "Y" arms and are therefore always near an escape route. As tawny mole crickets grow, their tunnels widen and extend further into the soil profile, suggesting a possible cause for the difficulty in bringing older crickets to the surface through soap flushes and baits. Crickets also seem to maintain their tunnel system, rebuilding collapsed tunnels over time.

The "Y" tunnel patterns of the tawny mole cricket do not seem to change in the presence of predatory southern mole crickets. Tawny mole crickets appear to "wall-off" their tunnels when southern mole crickets are present, but further studies are needed to confirm this behavior.

By comparison, southern mole crickets will move as far from each other as possible when placed together in a chamber. This behavior suggests the presence and activity of a chemically mediated avoidance behavior in this species. There is also an indication that mole crickets can detect and avoid conventional synthetic insecticides in the soil.

Additional studies on cricket behavior utilized arenas (12 × 20 × 8 inches) filled with moist sandy loam soil and topped with a commercial sod. A single tawny mole cricket was placed in the arena and allowed to tunnel into the surface. At the end of seven days, each arena was sampled to determine the tunneling pattern of the cricket. To form a paraffin cast, the entrance to the mole cricket tunnel was located by looking for a disturbed area of turf. Solid paraffin wax was heated until liquid and poured slowly, to allow escape of air bubbles, into the tunnel entrance. After a short time (about 10 minutes), soil was carefully excavated from around the hardened wax and the full casting was retrieved.

To reveal the tunnel of a single tawny mole cricket over a one-week period, soil was removed at 1.5-inch intervals from the surface to reveal the tunnel as it descended into the soil profile. The red-tinted casting represents that portion of the tunnel revealed by removing soil in that 2.5-inch layer (previously exposed tunnels are white). The castings showed the typical "Y"-shaped construction and extensive tunneling at the root-soil interface where the cricket foraged for food.

Preliminary studies with spray applications of the fungal pathogen *B. bassiana* indicate that reverse-rate responses often occur with higher rates. This may be the result of avoidance behavior associated with higher rates. Mole crickets detect and avoid formulations containing pathogenic fungi by remaining deep in the soil profile. This behavior allows mole crickets to avoid the fungal pathogen until it becomes inactive.

Laboratory studies were initiated to evaluate mole cricket behavior toward soil-borne, entomopathogenic fungi (fungi that cause disease in insects) and to evaluate the efficacy of subsurface and surface fungal applications. In these experiments, tawny mole crickets had no choice but to tunnel through a layer of fungal-treated sand in order to reach a sod food source. One late-instar tawny mole cricket was placed in each arena and allowed to tunnel for one hour before strips of sod were placed on top of the sand. After four days, the sod was removed and two inches of fungal-treated sand was added to the surface of the sand. An equivalent layer of clean sand was added in control treatments.

Two hours after treatment, 40% of the tawny mole crickets in both treated and untreated arenas had tunneled through the treatment layer and returned to the surface. After three and six days, 60% of treated and 80% of untreated tawny mole crickets had tunneled through to the surface sod. The amount of tunneling in the treatment layer area was significantly lower in arenas treated with the entomopathogenic fungi compared to the arenas containing the clean sand layers. Tunneling in the untreated layer below the interface was not significantly different in any treatment.

These findings of avoidance behavior in mole crickets suggest that placement of fungal pathogens in the soil profile may influence the effectiveness of a product to control mole cricket damage to turf. The avoidance response seen in these experiments may be evidence of an evolutionary adaptation to avoid infected insects and areas of soil with high concentrations of fungal spores. Avoidance behavior may explain the inconsistent results found in the field with high doses and surface applications of fungal pathogens. Subsurface applications of fungal pathogens, however, may lengthen the time a pathogen remains viable compared to pathogen survival after surface application.

This field and laboratory research demonstrates the value of a good understanding of pest biology and ecology. These studies help us better understand the reasoning behind some of our strategies for mole cricket management. At the same time, they also reveal why mole crickets continue to be such a difficult pest to manage. Further studies will help ensure our ability to cost effectively manage this serious pest.

Additional References

Brandenburg, R. L. 1997. Managing mole crickets: Developing a strategy for success. *TurfGrass Trends* 6:1-8.

Brandenburg, R. L., and M. G. Villani. 1995. Handbook of turfgrass insect pests. Entomological Society of America. Lanham, Md.

Brandenburg, R. L., P. T. Hertl, and M. G. Villani. 1997. Integration and adoption of a mole cricket management program in North Carolina, USA. Pages 973-979. *In:* International Turfgrass Society Research Journal, Vol. 8. Part 1. Univ. Printing Service, Univ. of Sydney, New South Wales, Australia.

Brandenburg, R. L., P. T. Hertl, and M. G. Villani. 2000. Improved mole cricket management through an enhanced understanding of pest behavior. Pages 397-407. *In:* J. M. Clark and M. P. Kenna (eds.). Fate and Management of Turfgrass Chemicals. Symposium Series 743. Amer. Chem. Soc., Washington, D.C.

Fowler, H. G. 1988. Dispersal of early instars of the mole cricket, *Scapteriscus tenuis*, as a function of density, food, pathogens (Orthoptera: Gryllotalpidae). *Entomol. Gener.* 13:15-20.

Fowler, H. G. 1989. Natural microbial control of populations of mole crickets (Orthoptera: Gryllotalpidae), *Scapteriscus borellii*, regulation of populations in time and space. *Res. Bras. Biol.* 49:1039-1052.

Hertl, P. T., and R. L. Brandenburg. 1997. Evaluation of *Beauveria bassiana* spore applications for control of mole cricket nymphs in turf. *Arthropod Management Tests* 23:323.

Hudson, W. G., J. H. Frank, and J. L. Castner. 1988. Biological control of *Scapteriscus* spp. mole crickets (Orthoptera: Gryllotalpidae) in Florida. *Bull. Entomol. Soc. Am.* 34:192-198.

Villani, M. G., and R. J. Wright. 1988. Use of radiography in behavioral studies of turfgrass-infesting scarab grub species (Coleoptera: Scarabaeidae). *Bull. Entomol. Soc. Am.* 34:132-144.

Villani, M. G., L. L. Allee, A. Diaz, and P. S. Robbins. 1999. Adaptive strategies of edaphaic arthropods. *Ann. Rev. Entomol.* 44:233-256.

Vittum, P., M. G. Villani, and H. Tashiro. 1999. Turfgrass insects of the United States and Canada. Second Edition. Cornell University Press, Ithaca, N.Y.

Xia, Y., and R. L. Brandenburg. 2000. Effect of irrigation on the efficacy of insecticides for controlling two species of mole crickets (Orthoptera: Gryllotalpidea) on golf courses. *J. Econ. Entomol.* 93:852-857.

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KEEP IT DRY!

Golf turf water management is tied to a number of variables. The goal is to maintain it dry.

by BOB BRAME

It is much better to hand water dry spots, ridges, and knobs as opposed to turning on the irrigation system and overwatering the majority of the area. A well-designed irrigation system will reduce hand watering, but it will still need to occur at some level.

FEW COMPONENTS of a turfgrass maintenance operation will impact both course health and playability like water management. The agronomic and playability benefits of maintaining relatively dry surfaces are far reaching. Contrary to what some golfers may think, there is much more to pursuing dry than to simply make the verbal declaration, "We want 'em dry." This article will focus primarily on putting surface management, although the principles apply to all areas of a warm- or cool-season grassed course.

First, why is it important to maintain putting surfaces as dry as possible? Volumes could be written to answer this question, but it comes down to four key benefits:

1. Healthier turf.
2. Less chemical usage/cost.
3. Reduced water usage/cost.
4. Improved playability.

Plant health, rooting in particular, is improved with deep and infrequent irrigation cycles. However, soil structure and root depth determine what "deep and infrequent" actually means. A key goal with the watering cycle is to maintain adequate oxygen in the root zone. In conjuction with the fertilization program, this strengthens rooting depth and mass, which in turn allows for a more aggressive pursuit of *dry*.

Virtually all turfgrass diseases are triggered and spread by readily available moisture/water. Soil and air temperature, humidity, and the microenvironment (sun and air movement) also influence disease activity, but turf management toward the dry end of the continuum will aid in reducing disease and fungicide usage. Less disease and fungicide usage equate to a more environmentally friendly operation.

Most experts agree that even those portions of the country that currently have no water availability problem may experience a shortage in the future. Water is a natural resource that should be conserved wherever possible. An agronomically sound maintenance program, which combines sensible fertilization and mowing practices along with healthy grass growing microenvironments, is part of the equation in keeping the upper soil profile dry and minimizing water usage/cost.

Although Mother Nature doesn't always make it realistic to pursue consistent putting surfaces, dry does. In fact, smooth, true, firm, and consistent all tie to dry. Conversely, wet leads to a soft upper root zone, which in turn can cause marking and rutting from equipment and foot traffic. This translates to surfaces that are not smooth, true, or consistent. Regardless of a player's handicap index, playability is better when the surface and upper root zone are maintained on the dry side.

Few would seriously challenge the benefits of keeping the course dry. So why doesn't it happen more? Following are several key pitfalls that help answer this question.

A Poor Irrigation System

Irrigation systems that do not provide for good coverage and individual sprinkler head control around greens and/or those that don't have a second set of sprinklers around greens to supplement bank watering would fall under the classification of being a poor system. In fact, a system with any component that restricts the superintendent's ability to water deeply and infrequently is a limitation that should be corrected. Another example would be the lack of or insufficient quick couplers used with hoses. Regardless of sprinkler head, pump station, and overall system efficiency, hand watering and/or syringing via hoses will occasionally be necessary to efficiently pursue dry. A well-designed irrigation system will reduce the need for hand watering/syringing, but the need will still exist. Clearly, a high-quality irrigation system is a vital component in the maintenance infrastructure. Should there be any doubts or concerns at your course, have an independent irrigation consultant make an evaluation to guide future investments.

Inadequate Drainage

Closely related to the irrigation system is drainage. While no one can control rainfall, the two primary aspects of drainage – surface water runoff and the internal movement of water into and through the root zone – can be modified.

It is common in most areas of the country for courses occasionally to be hit by a two- or three-inch frog strangler – the kind of water volume that can't possibly be handled by internal drainage alone. Design contours that avoid birdbath depressions or swales that hold water are critically important to runoff flow. Surface contours are an important feature to monitor closely during new course construction. Yet, even with initially positive surface water runoff, settling over time can obstruct flow. Installing drainage tiles is often perceived to be the quick fix. However, careful and precise reshaping of the surface to establish good runoff will provide better long-term value. This is true despite the likely short-term disruption to play and higher cost to implement as compared to simply installing a drain tile.

Aerification, topdressing, and drainage tile are all factors that affect water movement within and through the root zone. In today's golf turf management we have a variety of aeration options that must be custom fitted to a course's needs. It is common to see courses combining deep- and shallow-tine aeration. Typically, plugs are removed following shallow-tine coring. Backfilling aeration channels with an appropriate topdressing sand will enhance porosity, and this means quicker movement of water away from the surface. A consistent (integrating sand into the surface in sync with growth) topdressing program complements sound aeration, while also improving surface quality (smooth, firm, and true). Drain tile, properly placed, adds the quick removal of excess water. Yet, water must first get to the tile for any value to be realized, which points back to the importance of good aeration and consistent topdressing. Investing in better drainage is always money well spent.

Failure to Hand Water/Syringe

It is much better to hand water dry spots, ridges, and/or knobs as opposed to popping up a sprinkler and overwatering most of the spray pattern area. The intent is to extend the time between irrigation applications using the sprinkler heads in the pursuit of deep and infrequent watering cycles. In some cases hand watering/syringing is not done because of irrigation system limitations (e.g., inadequate or no quick-coupler valves). More often, however, it is play volume, staff size/budget and/or maintenance priorities that block hand watering/syringing.

Hand watering is normally done in the morning with the intent to move water down into the root zone. Syringing is typically done during midday heat to cool the leaf tissue without allowing water into the root zone. Both are important in pushing apart the use of sprinkler heads and pursuing dry surfaces. Hand watering and/or syringing needs cannot be scheduled around play. When it's needed, it should be done. Like properly timed aeration and topdressing, hand watering and/or syringing occasionally will cause some minor inconvenience to players. Not allowing the work to be done to avoid disrupting play is a mistake.

Staff size or budget is not normally a legitimate limitation to hand watering/syringing, although sometimes they are blamed. It boils down to the maintenance priorities. What's more important – hand watering or raking bunkers? Hand watering or trimming the creek bank? Bottom line: If dry is a priority, resources must be shifted as conditions dictate. Saying "we don't have the budget or staff size to hand water/syringe" is a cop-out. The superintendent should be given the latitude needed to pursue dry. This means the boss(es) must first understand and then support what it takes to keep it dry and that hand watering/syringing are important components in the equation.

Poor Turf Quality/Health

Shallow roots, inadequate sunlight, poor air movement and/or mowing too low are other common pitfalls that compromise turf health and, as a result, the quest for dry. Shallow roots or grasses that are shallow rooted (e.g., *Poa annua*) will block the push toward deep and less frequent watering cycles. In like manner, inadequate sunlight and/or pockets of poor air movement make dry surfaces more difficult, or at least more expensive, to achieve. Mowing too low, often done to increase green speed, compromises the plant's ability to conduct photosynthesis and, here again, elevates the cost of keeping the course dry. It is vitally important for the maintenance program to be fundamentally sound and yield healthy turf with reasonably deep roots. Healthy turf aids in moving toward dry, and dry improves turf health – they (*dry* and *healthy*) can't be separated.

Isolated Dry Spots

The occurrence of isolated dry spots is a major management problem for many superintendents. Pushing toward the dry end of the continuum increases and intensifies the occurrence of isolated dry spots. While wetting agents can aid in managing isolated dry spots, be sure to consider irrigation system coverage and the level of thatch accumulation. Improving system coverage and/or going after thatch more aggressively (via aeration and topdressing) often reduces or even eliminates the dependency on wetting agent usage.

Conclusion

It must be emphasized that the pursuit of dry requires a team effort. The superintendent must be given the needed tools and scheduling flexibility, and all parties involved must understand and support the fact that maintaining the course on the dry side is a high priority. Resolve now to push the envelope – keep it dry!

The loss of plant turgidity points to the immediate need for syringing. Water is best applied during the early morning hours.

BOB BRAME *is Director of the Green Section's North Central Region. He visits courses in Indiana, Kentucky, and Ohio, where the push for dry is a common discussion topic.*

Creative Uses for Plant Growth Regulators

They offer more advantages than growth reduction.

by NICK CHRISTIANS, Ph.D.

MY POSITION as a university educator has led to many opportunities over the years to speak to the general public about lawns. Whenever I speak to people who have little knowledge of turf management, I can always expect one question: "Is there anything that I can spray on my lawn so that I won't have to mow?"

Not having to mow has long been a dream of both the Saturday morning novice and the professional turfgrass manager. While the answer to the above question is a simple "no," there are a number of compounds that have the ability to slow the growth of grasses and consequently reduce the mowing requirements. This becomes particularly important on the golf course during periods of rapid growth such as in the spring for cool-season grasses and summer for warm-season grasses.

PGR Classification and Overview

Table 1 contains a list of both past and current plant growth regulating compounds (PGRs) that have been labeled for use on turf. The system by which PGRs are classified is undergoing change. The original system divided the compounds into two categories, Type I and Type II.[30]

Type I compounds are foliarly absorbed and inhibit cell division in the plant meristem.

Type II materials are usually crown and root absorbed. They suppress growth through the inhibition of gibberallic acid (GA), a naturally occurring plant hormone that reduces cell elongation. The Type II materials, which are also known as the GA inhibitors, include flurprimidol, paclobutrazol, and trinexapac-ethyl.

Most of the Type I PGRs are excellent seedhead inhibitors. Mefluidide is particularly well known for its ability to stop seedhead formation. Maleic hydrazide is also very effective at stopping seedhead formation. Both compounds tend to be somewhat phytotoxic and have limited use on

Table 1
Plant growth regulators that have been labeled for use on turf.

Common Name	Trade Name
Amidochlor	Limit
Chlorflurenol	Maintain CF125
Endothal	Endothal
Ethephon	Ethrel, Proxy
Flurprimidol	Cutless
Maleic hydrazide	Royal Slo-Gro
Mefluidide	Embark
Paclobutrazol	TGR, Turf-Enhancer, Trimmit
Trinexapac-ethyl	Primo MAXX

high-maintenance turf. However, they are quite useful on low-maintenance turf such as roadsides. Mefluidide also is used to inhibit *Poa annua* seedhead formation in golf course turf. *Poa annua* seedhead suppression is difficult because it requires very precise applications of mefluidide and a thorough understanding of how the grass will react.

Type II compounds are usually less phytotoxic, although they also can cause some grass discoloration. The Type II compounds are not as effective in stopping seedhead formation as are the Type I materials, although they are quite effective at slowing growth and can be used to reduce the need for mowing if properly used. In the golf industry, one of the primary uses of flurprimidol and paclobutrazol has been the gradual removal of *Poa annua*. These GA inhibitors are known to have a greater inhibitory effect on *Poa annua* than on creeping bentgrass. With careful application and proper management techniques designed to discourage *Poa annua*, these materials may help increase the amount of bentgrass in the stand.

Trinexapac-ethyl is the newest of the Type II materials. Its advantage over the two older compounds is that it can be taken up through the foliage, whereas flurprimidol and paclobutrazol are primarily root absorbed. It has been used extensively on golf course fairways and to a limited extent on lawns to inhibit tissue growth and reduce the need for mowing. Trinexapac-ethyl has recently been labeled for *Poa annua* conversion programs.

The new classification system divides PGRs into classes A, B, C, and D.[31] Class A materials are GA inhibitors that interfere with GA production late in the biosynthetic pathway. Trinexapac-ethyl is the only Class A material at this time. Class B materials are those that inhibit GA early in the biosynthetic pathway. Flurprimidol and paclobutrazol are included in this class. Class C materials are mitotic inhibitors like maleic hydrazide, mefluidide, and amidochlor. Finally, Class D materials are PGRs that produce a phytotoxic growth regulating response at low levels and act as herbicides at higher levels. Two herbicides, chlorsulfuron (Telar) and glyphosate (Roundup), are examples of Class D compounds.

The newest material to reach the turf market is Proxy (ethephon), although it has been available for years in the floriculture and crop production markets. This material affects the growth of plants by releasing the plant hormone ethylene. It does not fit into any of the existing categories. The most striking effect is on Kentucky bluegrass, which undergoes some very unusual structural changes when treated with this product. Ethephon-treated bluegrass develops elongated internodes from the crown area and shortened leaves. The net effect is a stoloniferous Kentucky bluegrass that looks more like bermudagrass than bluegrass.[5, 6] As is the case with other PGRs, the effect of the ethephon varies with species. Work is presently being conducted at Iowa State University to characterize these responses on cool- and warm-season grasses.[14] The effect of Proxy on creeping bentgrass fairways has been variable in recent studies, and more work will be required to fully evaluate this product for fairway use.[13, 22]

Growth reduction is generally the goal in the use of PGRs, but a number of other creative uses have been developed for these useful compounds in recent years. Some of these uses have been the result of studies in the scientific community, but others have come about as the result of observations made by turf professionals in the field.

Poa annua Control

Poa annua control remains a serious problem for golf course superintendents around the world. One of the creative uses of PGRs has been to use them as part of a carefully structured integrated program to reduce *Poa annua* in golf turf. As was mentioned earlier, this generally involves the GA-inhibiting (Type II) materials and has been most effective on bentgrass/*Poa annua* fairways. The GA inhibitors do not kill the *Poa annua*, but slow its growth more than that of the bentgrass. Over time, this results in an advantage to the bentgrass and reduction of the *Poa annua*. While this program became widely used in the 1990s, results have been quite variable by location. Success depends on the skill of the superintendents in adapting the program to their particular situation. Results also may vary with the *Poa annua* biotype in the region.[2, 24]

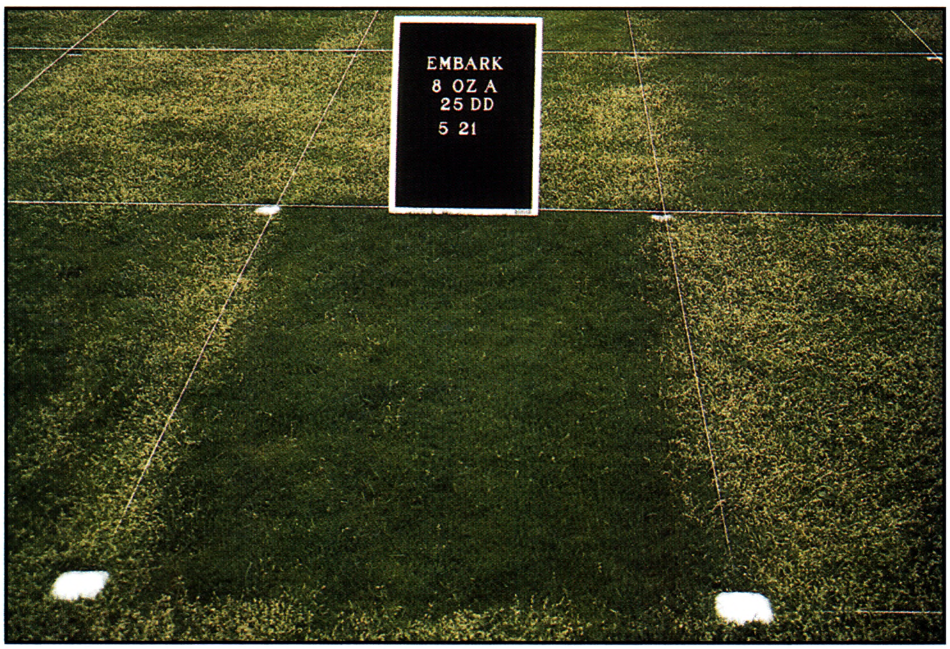
Flurprimidol (Cutless) was the first material to be used in this way, and paclobutrazol (TGR, Turf Enhancer, Trimmit) became the most widely used in the 1990s. In the spring of 2001, a new program that involves applications of paclobutrazol (Trimmit) in spring and fall and trinexapac-ethyl (Primo-MAXX) during the summer was also introduced to the market.

Seedhead suppression of *Poa annua* may also be a goal in the use of PGRs. The Type II materials are only moderately effective in reducing seedheads. Mefluidide (Embark) is by far the best seedhead suppressor, but its use is difficult and discoloration of the turf can easily occur. Ethephon (Proxy) has recently been tested as a seedhead suppressor. It has proven to be quite effective on some *Poa annua* biotypes in California, but results have been more variable in other regions of the country.

Color Enhancement

From the beginning of PGR use on the golf course, superintendents have observed color changes when these products are used. With the earlier Type I materials, there was often a negative effect and turf discoloration was common. With the GA inhibitors, however, improvements in turf color are often observed. This is particularly true with trinexapac-ethyl (Primo), which often results in a darker green color of treated turf.[21, 18]

Reduced growth and improved color are a very beneficial combination on highly maintained turf. As is usually the case with PGRs, this response can be highly variable.



Poa annua *contamination is a problem for golf course superintendents around the world. Embark is one plant growth regulator that effectively suppresses* Poa annua *seedheads, but there is potential for turf discoloration.*

Overseeding

PGRs have been employed as a tool to improve overseeding of cool-season grasses into warm-season turf. The goal is to slow the growth of the warm-season grass without inhibiting the establishment of the cool-season seedlings.[1, 11] Timing is critical to prevent inhibition of the cool-season seedlings[16, 29] and results may be quite variable.[12] Trinexapac-ethyl (Primo) tends to be one of the best PGRs for this purpose because of its foliar absorption and its reduced likelihood of inhibiting the cool-season seed germination.[8] A critical factor in using trinexapac-ethyl for this purpose is that it be allowed to dry on the bermudagrass tissue before overseeding takes place.[17] Current label recommendations suggest applying Primo one to five days before seeding.

Water Use

PGRs reduce growth, but does this translate into a reduction of water use? Research in Australia[15] showed a 25% to 30% reduction in water use rate on tall fescue treated with trinexapac-ethyl. There is a great deal of interest in this subject, particularly in arid regions, and more work is needed on a variety of species.

Freezing Damage

In northern regions, freezing damage can be a serious problem. PGRs slow growth, thicken cell sap, and may provide an antifreeze-like effect. Rossi and Buelow (1995) observed enhanced freeze tolerance of annual bluegrass treated with low rates of trinexapac-ethyl. However, Dunn *et al.* (1999) found no reduction in freezing damage on zoysiagrass treated with this product. Northern superintendents who often experience *Poa annua* loss during the winter may want to experiment with this idea.

Fungicides

One of the factors that limits fungicide efficacy is plant growth, or when the contacts are mowed off soon after application. PGRs tank-mixed with fungicides show promise in extending efficacy and in reducing the fungicide rates needed for disease control.[4, 25, 28, 32] Some PGRs may even directly suppress dollar spot on treated turf.[3]

Other Observations

Research has shown that PGRs can improve shade tolerance of certain species, particularly zoysiagrass.[10, 20, 21, 26, 27] Trinexapac-ethyl is now being widely used for this purpose in the transition zone of the United States and throughout the Orient.

Finally, trinexapac-ethyl has been shown to reduce clippings, prevent scalping, improve establishment of new sod,[23] and stimulate tillering of Kentucky bluegrass being grown for sod.[21]

These are only a few of the potential uses for PGRs in the turf industry, and other innovative ideas are likely to follow. A number of these uses had their origin from observations made by golf course superintendents and other turf professionals working with the materials in the field. Those with other creative ideas are encouraged to share them at meetings or on-line so that they can be further developed and tested.

The product works. A Poa annua*-infested sod strip was untreated before it was used down the center of a golf course fairway. The strip stands out amongst fairway turf that had been treated to suppress* Poa annua *seedheads.*

References

[1]Baker, B. 1997. New tools for overseeding success. *TurfGrass Trends.* 6(9):14.

[2]Bingaman, B. R., N. E. Christians, and M. B. Faust. 1998. Effects of Primo and Beacon on *Poa annua* populations in creeping bentgrass maintained at green height. *1998 Iowa Turfgrass Res. Rep.* p. 54-56.

[3]Burpee, L. 1995. Dollar spot management in fairways: PGR-fungicide interactions. *Proceedings of the 66th International Golf Course Conference.* p. 16-17.

[4]Dernoeden, P. H., J. M. Krouse, Y. Feng. 1998. Brown patch control with Novartis fungicides, 1998. Fungicide and Nematicide Test. 54:483.

[5]Diesburg, K. L., N. E. Christians, and R. J. Gladon. 1989a. A continuous air-exchange roomette and gas-metering system. *Crop Sci.* 29:344-348.

[6]Diesburg, K. L., and N. E. Christians. 1989b. Seasonal application of ethephon, flurprimidol, mefluidide, paclobutrazol, and amidochlor as they affect Kentucky bluegrass shoot morphogenesis. *Crop Sci.* 29: 841-847.

[7]Diesburg, K. 2000. Growth regulators boost density in different ways: More tillers vs. more leaves per tiller: Products offer distinct results. *Golf Course Management.* 68(4):61-63.

[8]DiPaola, J. M., D. P. Shepard, L. D. Housework. 1997. Regulation of turf-impact on growth and performance. *Proceedings of the 8th Inter. Turfgrasses Res. Conf.* 8:146.

[9]Dunn, J. H., R. H. Ervin, M. R. Warmund, B. S. Fresenburg. 1999. Cold tolerance of zoysiagrass as influenced by cutting height and Primo. *Missouri Turfgrass Res. Report.* p. 11.

[10]Ervin, E. H., C. Ok, B. S. Fresenburg, J. Dunn, S. Dunn. 1999. Primo for sustaining zoysiagrass quality in shade. *1999 Missouri Research & Information Rep.* p. 2-3.

[11]Green, R. L. 1999. Improvement of the spring transition of overseeded bermudagrass putting greens: A two-year project funded by the Hi-Lo Desert GCSA. *California Fairways.* 8:12.

[12]Henry, M. J. 2000. An evaluation of plant growth regulator and contact herbicide pre-treatments during initial overseeding of bermudagrass with perennial ryegrass. *Calif. Turfgrass Culture.* 50(1-4):3-6.

[13]Howieson, M. J., N. E. Christians. 2000a. Effect of mower setup and plant growth regulators on mowing quality. *2000 Iowa Turfgrass Res. Rep.* 21:1-5.

[14]Howieson, M. J., N. E. Christians. 2000b. Bermudagrass, creeping bentgrass, fine fescue, Kentucky bluegrass, manilagrass, perennial ryegrass, tall fescue, and zoysiagrass responses to ethephon. *Agron. Abs.* 160.

[15]King, R. W., C. Blundell, L. T. Evans, L. N. Mander, and J. T. Wood. 1997. Modified gibberellins retard growth of cool-season turfgrasses. *Crop Science.* 37:1878-1883.

[16]Menn, W. G., R. H. White, and M. H. Hall. 1998 to 2000. Effect of Primo on perennial ryegrass (*Lolium perenne*) overseeding establishment in Tifway bermudagrass (*Cynodon* sp.). http://dallas.tamu.edu/-pub/ttrr98/turf-98-20.html.

[17]Miller, G., and S. Killingsworth. 1997. Primo influences: On overseeded perennial ryegrass and *Poa trivialis*. *Florida Turf Digest.* 14:24.

[18]Pound, W. 1993. Primo growth regulator evaluation on creeping bentgrass. *Ohio Turfgrass Res. Rep.* p. 115-119.

[19]Rossi, F., and E. Buelow. 1995. A preliminary report on the effect of plant growth regulators on freezing stress tolerance of cool-season turfgrasses. *Wisconsin Turf Res.* 13:83-85.

[20]Nus, J. 2000. Improving shade tolerance of zoysiagrass. *Golf Course Management.* 68(10):80.

[21]Shepard, D. P., and J. M. DiPaola. 1999. Using trinexapac-ethyl to enhance turfgrass stress tolerance. *Agron. Abstracts.* 91:123.

[22]Stier, J., Z. Reicher, and G. Hardebeck. 2000. Effect of the growth regulator Proxy on creeping bentgrass fairway turf. *J. of Envir. Hort.* 18(1):53-58.

[23]Stowell, L. 1997. Primo-treated sod: harvest, establishment, and transplant (field validation). *PTRI Turfgrass Res. Report.* p. 78-79.

[24]Street, J. R., and P. Sherratt. 1998. Plant growth regulator effect on creeping bentgrass/annual bluegrass sward. *Ohio Turfgrass Res. Rep.* p. 92-94.

[25]Tredway, L. P., B. B. Clarke, G. W. Towers, E. N. Weibel, and P. R. Majumdar. 1999. Evaluation of fungicides for control of brown patch, 1998. Fungicide and Nematicide Tests. 54:484-485.

[26]Qian, Y. L., and M. C. Engelke. 1999a. Zoysiagrass in shade: Influence of trinexapac-ethyl. *TurfGrass Trends.* 8:12-14.

[27]Qian, Y. L., and M. C. Engelke. 1999b. Influence of trinexapac-ethyl on "Diamond" zoysiagrass in shade environment. *Crop Sci.* 39:202-208.

[28]Uddin, W., and M. D. Soika. 1999. Evaluation of fungicides for control of gray leaf spot (blast) on perennial ryegrass fairway. Fungicide and Nematicide Tests. 55:526.

[29]Waltz, C., M. Blalock, and T. Whitwell. 1997. Growth regulators as overseeding aids. *Clemson Univ. Turfgrass Prog.* p. 98-104.

[30]Watschke, T. L., M. G. Prinster, and J. M. Breuninger. 1992. Plant growth regulators and turfgrass management. Turfgrass-Agronomy Monograph no. 32 of the ASA-CSSA-SSSA. p. 557-565.

[31]Watschke, T. L., and J. M. DiPaola. 1995. Plant growth regulators. *Golf Course Management.* 63(3):59-62.

[32]Wilkinson, H. T., J. M. McMeans, T. W. Fermanian. 1998. Plant growth regulators and disease management on creeping bentgrass. *1998 Illinois Turfgrass Research Report.* p. 23-25.

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PRIORITY DECISION MAKING

A useful long-range planning technique to help get the most from your resources.

by TERRY NELSON

EVERY good decision made is a step forward. Formulating good decisions in the golf course environment often requires a consensus among board members, committee members, or owners. Commonly, people who speak the most tend to influence decision making the most and leave other participants with a lesser impact. A system that affords equal input and is more objective in reaching the best decisions will likely generate the best results. The process described in this article has worked very well for our 36-hole Whitefish Lake Golf Club (Montana). I first learned of this system of decision evaluation in the mid-1980s while attending a workshop for health-care providers. The basis of the information is from a book entitled, *How to Make Decisions That Pay Off,* written by J. Daniel Mathien and Morris Squire.

The process develops objective decision making on two levels and then graphically depicts the results. This rather unique approach has the flexibility to be used in committee or individual decision making situations. It combines the best of brainstorming (collecting ideas) with management by objectives to develop time-effective, efficient problem solving.

Participants develop creativity in looking at problems from all angles using brainstorming techniques. Brainstorming allows ideas to flow without any barrier or censorship. Often, functional fixation interferes with our thought process and blocks the most creative ideas, so the free flow of ideas brings forth new solutions.

As you move through the process of making priority-based decisions, you will learn how to quickly value each item in relation to other ideas and just how important a particular idea or project could be. The final product will enable the committee to focus resources on those projects that offer the highest opportunity to yield the greatest return.

The process begins by gathering a group of people with a common focus, such as your green committee, general manager, golf professional, course officials, and golf course superintendent. The group collects ideas for projects that will improve the golf course playability, appeal, efficiency, or overall condition. These ideas come from brainstorming and input from the superintendent, architect, USGA agronomist, golf professional, committee members, and suggestions from players. Brainstorming, if used effectively, offers the best opportunity for unique solutions or divergent thought (remember that during brainstorming there are no bad ideas, so just collect, don't evaluate at this level). Perhaps your facility needs new cart paths, an improved irrigation system, larger putting greens, a better practice facility, flower gardens, etc.

As the list of ideas is compiled, it is time to enter the second stage. This is referred to as *objective setting.* The participants select a non-duplicated list of ideas (usually between 10 to 20) to evaluate on an intensive level. These ideas are listed numerically on the paired weighting worksheet (Figure 1). The participants are then asked to assign a relative value to these items by comparing each item to every other item.

Figure 1
Paired Weighting Worksheet

										Value	%
1. Plant trees between 1 and 12	①/2	①/3	1/④	①/5	①/6	1/⑦	①/8	1/⑨	①/10	1= 6	30
2. Reconstruct practice facility net		2/③	2/④	2/⑤	2/⑥	2/⑦	2/⑧	2/⑨	②/10	2= 1	40
3. Increase tee size at practice facility			3/④	3/⑤	③/6	3/⑦	3/⑧	3/⑨	③/10	3= 3	80
4. Enlarge No. 3 green				④/5	④/6	④/7	④/8	4/⑨	④/10	4= 8	40
5. Relocate cart path No. 11					5/⑥	5/⑦	⑤/8	5/⑨	⑤/10	5= 4	60
6. Landscape club entrance						6/⑦	⑥/8	6/⑨	⑥/10	6= 4	25
7. Enlarge No. 4 tee							⑦/8	7/⑨	⑦/10	7= 7	60
8. Add forward tee No. 16								8/⑨	⑧/10	8= 3	65
9. Replace pump station									⑨/10	9= 9	30
10. Cut down hill No. 8										10= 0	90

- Key question — If you could have equal amount of 1 or N, which would you like a little more of (or which is more important)?
- Circle the appropriate number.
- Always work from left to right.
- Enter the total number of circles under value.
- Enter percentage satisfaction based on a scale of 0% to 100%, with 50% "just getting by."
- Plot the reference numbers by value/percentage on the opportunity profile (Figure 2).

Paired weighting worksheet. Ideas for the golf course can be listed and compared against one another to prioritize importance. Current levels of satisfaction are also identified on this worksheet.

Priority decision making should involve input from the golf course superintendent, green committee, golf professional, club officials, architect, and USGA agronomist. Good planning will help prevent unwelcome surprises.

This comparative valuation is called *paired weighting* and is step three of the process. The example in Figure 1 shows a paired weighting worksheet for 10 items and can be expanded to cover any number selected. Experience suggests that more than 20 ideas can be cumbersome.

The most effective method of utilizing the worksheet is to move from left to right along the top line with each participant *independently* comparing item 1 with each other item (1-2, 1-3, 1-4, and so on). The key question in paired weighting is, "If I could have equal parts of #1 or #2 (1 or 3, 1 or 4), which one would I want a little more?" (or which is more important?). Use your first impression and circle the appropriate number. Continue the process with item #1 (moving from left to right), then move to the second line, then the third, etc. Circle or mark your choice for each item in all instances. You do not work back up the page.

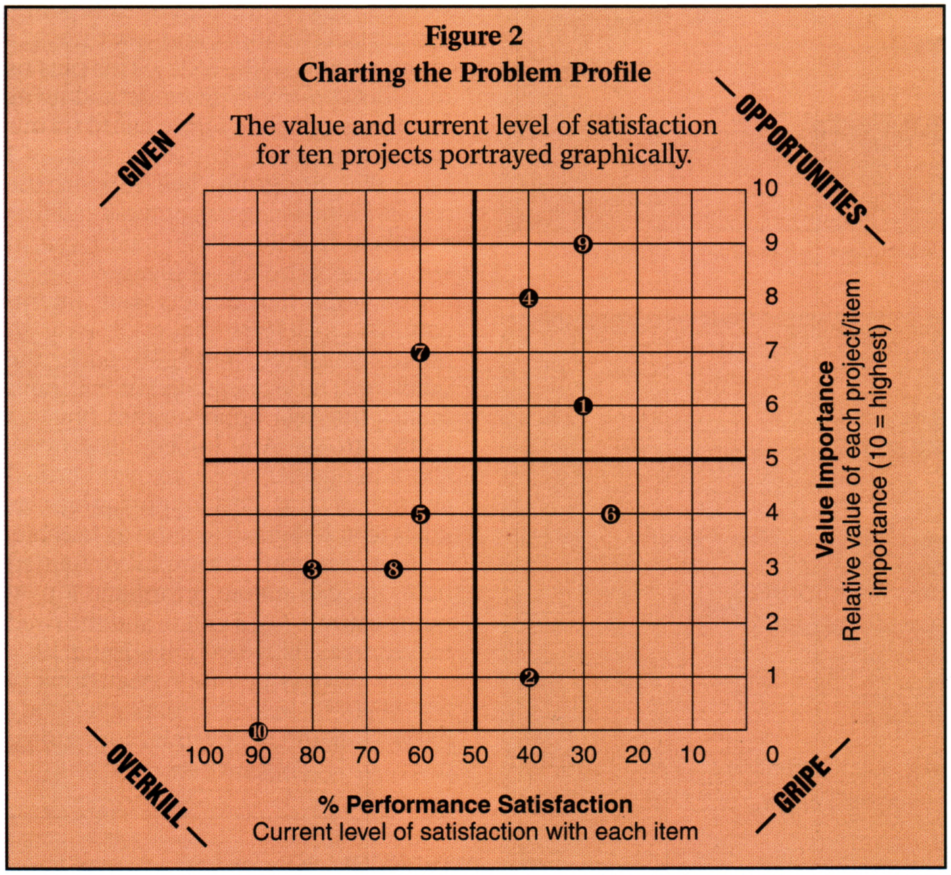
The relative valuation is found by counting the total number of times you circle or mark each item (as in the attached example). As you count, be sure to mark the items to avoid duplication in totals. It works best to count from left to right on line one, and then from top down and then left to right (an "L" shape). Record the total number of times each item was circled or marked on the right side of the sheet. You will now have an objective view of how each participant values each item in relation to every other item.

The next step is to measure each participant's *subjective level of satisfaction* relative to each of the ideas selected. This is done by asking the question, "On a scale of 0 to 100, with 50 considered getting by, how satisfied am I with this item?" An example might be your car – if you have a brand-new BMW, you might give it a 90 to 100%. If you have a two-year-old Ford Taurus, you might give it a 50% (you're getting by). If you have a ten-year-old Plymouth Reliant, you may give it 10% or 15%. Score each item and record your percent level of satisfaction to the right of the previously recorded value as shown in the attached example.

You now have established your personal value for each item and also your percent level of satisfaction. With these two measurements you can develop your *opportunity profile*. In Figure 2, the opportunity profile is set up with 10 parameters. As you expand the number of parameters (items to evaluate), simply enlarge the graph. Always keep the horizontal axis at the midpoint of the number of objectives on your list.

You will see that the axis divides the graph into four quadrants. The upper left is an area of high value and high satisfaction. This area contains the *givens* because the items falling there are highly valued and with which you are satisfied. The lower left contains items of low value with which you are also satisfied. You don't value these items highly, but you have high satisfaction. These are classified as *overkill* items.

To the right of the 50% satisfaction line, the lower right half contains items of low value and low levels of satisfaction. This is the *gripes* area. In the upper right quadrant of your graph will fall the items of highest value and current lowest level of satisfaction. It is these items that offer the true *opportunities* to improve your operation.



Opportunity profile. Plotting the average importance and level of satisfaction for each idea for the golf course will identify which yields the greatest return on investment.

In many cases, a poorly functioning irrigation system deserves the highest priority for improvement.

Bunker renovation is an inevitable necessity at most older golf courses. Objective analysis may identify this as a priority.

Perhaps a regrassing program is a priority that will improve presentation and playing quality.

In Figure 2 you will see a graphic portrayal of the values from Figure 1. Reviewing the graph, you can ignore those items classified as *overkill* and *gripes*, while working to maintain those that are *givens*. Those items classified as *opportunities* deserve your attention because any investment of time, effort, resources, or money will give you the greatest incremental rate of return on your unit of investment.

By working through the process you have creatively examined all of your options, established value and level of satisfaction, and objectively determined the best *opportunities* for solving a problem or making a decision.

To develop a group consensus, you simply graph the group's *average* value and level of satisfaction for each item. It is important to note that any individual can vary widely from the norm. Based on results, each person may want to ask what the group knows that they don't, or if they are biased related to a certain item. Those consensus items with a high degree of agreement (low standard deviation) and falling into the opportunity area will provide the greatest payback for the group or organization as a whole.

This process helps determine which objectives should be seriously considered. The whole idea is to describe the perfect situation, and not to worry about what it is like today. This puts us in a *forward thinking mode* and away from projecting the future based on our past experiences. You may find as I have that the group will support the results found using this process and that members feel they had equal input in solving operational problems.

The graph that depicts your organization's consensus makes it easy to make decisions that pay back the quickest. The visualization of the graph makes the best opportunities obvious to the group. Any budgeting process should consider those areas described as highest and best opportunities as goals to accomplish as soon as feasible. In the fictitious example presented here, the committee prioritized a new pump station, no. 3 green, and the need to add trees between holes 1 and 12.

This process can be repeated every few years to help the managing body to develop and review their long-range plan.

TERRY NELSON *is a USGA Green Section committeeman and club secretary at the Whitefish Lake Golf Club.*

Nitrogen and Phosphorus Loss from Greens and Fairways

Is there a potential problem?

by LARRY SHUMAN, Ph.D.

GOLF COURSE management seems to become more complex every day. One essential practice that requires regular attention is fertilization. A golf course fertilization plan must provide a sufficient level of available plant nutrients without causing fertilizer "burn" to the turf, or salt buildup in the soil.

Today, however, there is another component in the equation: environmental protection. Golf course superintendents, as well as the public, are becoming more aware that fertilizer nutrients can cause potential environmental problems, especially if they find their way to surface water or groundwater. Fertilizer nutrients in surface waters, especially phosphorus, cause algae growth, which, in turn, causes toxins and lower levels of oxygen in the water.

Until recently, research on phosphorus fertilization and potential for movement has been conducted almost entirely on agricultural row crops. In recent years, the USGA has funded research on nutrient leaching and runoff from golf course turf. The goal of this research is to create better management practices for golf courses to reduce the potential for nutrient loading to both surface waters and groundwater. The following experiments were conducted as a result of that funding.

Tracking Nutrient Movement

Starting in 1995, we monitored nitrate (NO_3^-) and soluble phosphate in lysimeters placed in two practice greens at a golf course located in a northern suburb of Atlanta, Georgia. The lysimeters are simple stainless steel kitchen sinks with the tops placed about three inches below the green surface. The drains are connected to pipes that run to the edge of the green to collection bottles. Leachate was sampled after each major rainfall and analyzed for nitrate and soluble phosphate. The second green was removed at the end of 1998, so after that date we only have data for green one.

The phosphorus (P) concentration in the leachate was initially very high, especially for green two (Figure 1). The phosphorus decreased thereafter until 1999, when it started to increase again due to an increase in application rates. The high P concentrations in the leachate indicated that P can indeed leach, and this can be a potential problem since drainage water from putting greens may eventually lead to surface waters.

The nitrate data told a different story. The nitrate concentration in the leachate was low initially and increased to a maximum in 1998 (Figure 1). After that, levels of nitrate in the leachate decreased somewhat. We speculate that during the first several years, nitrogen (N) was being sequestered in the organic layer as it built up. Subsequently, the nitrogen started to mineralize at a rate equal to that used by microbes, and a nitrogen balance was achieved. The pattern also may have to do with different rainfall and nitrate additions for those years.

A rough estimate of the percent of applied P and N found in the leachate was calculated. Although this calculation has many assumptions, it serves as a ballpark figure. By our calculations, 27% of the applied P and 4% of the applied N were accounted for in the leachate. Thus, our concern regarding P leaching was confirmed.

Simulated golf greens were constructed in the University of Georgia greenhouse and used for studying nitrogen and phosphorus leaching through the soil

Greenhouse Studies

Simulated golf greens were set up in the greenhouse to examine nitrate and phosphorus leaching. Growth boxes (40 × 40 cm, 15 cm deep) were set on top of PVC columns that were 15 cm in diameter and 53 cm deep. Columns were filled with a rooting medium prepared according to USGA green specifications and 'Tifdwarf' bermudagrass sod was established.

Fertilizer sources used for the first experiment were a Peters soluble 20-20-20 and a Lesco micro-granular 13-13-13 that is poly- and sulfur-coated. These fertilizers represented a completely soluble source versus a slowly available nutrient source. Fertilizer rates were 0, 0.11, and 0.22 lb. P/1,000 sq. ft. and 0. 0.25, and 0.50 lb. N/1,000 sq. ft. applied every other week for a total of six treatments. Each treatment was replicated 3 times.

This experiment was carried out twice with different irrigation schemes. The first was with the 0.25 and 0.5 inches/day throughout the experiment with one large simulated rain, and the second with a lower irrigation rate per day with one large simulated rain. Leachate samples were taken weekly and analyzed for nitrate and soluble P.

As expected, the soluble fertilizer source resulted in more nitrate and phosphorus in the leachate than did the granular poly- and sulfur-coated fertilizer source (Figure 3). Lower application rates of P gave somewhat less leaching, probably due to a greater proportion being adsorbed by the rooting medium. However, similar to the lysimeter data, a much higher percentage of the applied phosphorus leached than nitrogen.

A practice that is common in green maintenance in some areas of the country is periodically flushing the green to remove salts and other materials. This was simulated in both greenhouse experiments and yielded some interesting results. Nitrogen concentrations in the leachate were not affected. The nitrogen moved through the simulated greens readily even without flushing.

Phosphorus reacted differently. Phosphorus was not detected in the leachate at all until after the flushing event; then it increased for the next several weeks before starting a long, gradual decline.

Different Fertilizer Sources

In a second greenhouse experiment, we compared eight fertilizer sources, all applied at 0.22 lb. P/1,000 sq. ft., and, where applicable, 0.5 lb. N/1,000 sq. ft. The 20-20-20 soluble source was included along with two other balanced granular fertilizers (10-10-10, 13-13-13). Other sources included granular 16-25-12, 9-18-18, and 19-25-5. Superphosphate was used in two treatments with two N sources (a liquid controlled-release source and a granular sulfur-coated urea). These were added every other week for a total of four treatments. Sample collection and analyses were as previously described.

The 20-20-20 soluble source and the 16-25-12 starter fertilizer produced the most leaching of phosphorus (Figure 5). The lowest leaching came from the superphosphate and 8-18-18 materials. The other sources were intermediate. These results indicate that the more soluble the source, the less should be applied at any single application since the more soluble sources are prone to leaching. Superphosphate and less soluble granulars do not leach as readily.

The nitrate results indicate less leaching. The 20-20-20 resulted in the most nitrate leached. The 10-10-10 and the liquid source were intermediate, and the coated granules were lowest in nitrate leaching. The 13-13-13 is poly- and sulfur-coated and the other coated N source was sulfur-coated urea.

Runoff from Simulated Fairways

Field runoff experiments were carried out using a facility with 12 individual plots (12 × 24 ft.) built on a 5% slope. The soil was typical of the Piedmont region of the southeastern United States, and the turf was 'Tifway' bermudagrass. A collection trough was installed in a ditch at the front of each plot to collect runoff water and direct it to a tipping bucket apparatus that measured the runoff volume and took a sub-sample of the water. Overhead sprinkler heads provided one-inch-per-hour simulated rainfall.

We applied 10-10-10 at rates of 0, 0.11, and 0.22 lb. P/1,000 sq. ft. on each plot. Two inches of simulated rainfall were added four hours after treatment (HAT) and again at 24 hours after treatment. An additional one inch of simulated rainfall was added at 72 and 168 hours after treatment. The same experiment was repeated on two different years and the results were averaged. A second experiment was carried out where the same treatments were applied, but ¼-inch of irrigation was applied to the plots to water-in the fertilizer immediately after application, and three days were allowed to elapse before the same simulated rainfall sequence was initiated.

Phosphorus concentrations in the runoff increased in step-wise fashion as P application rates increased for the first two runoff events (Figure 7). The phosphorus concentrations detected in runoff were much higher for plots receiving simulated rain on the same day as treatment (4 HAT), compared to treatments that were watered in and allowed to wait three days before the first simulated rain (72 HAT). These results show that phosphorus runoff can be significant if phosphorus-containing fertilizers are subject to heavy rain soon after application. Results also show that adding ¼ in. of irrigation immediately following fertilizer application can be very helpful in preventing phosphorus runoff.

Use Fertilizers Judiciously

Our experience has led to some general observations and recommendations. Although leaching is not considered a problem on fairways, our results indicate that it certainly can be a problem for greens. Both nitrogen and phosphorus leach readily through porous greens, although nitrogen leaches more quickly than phosphorus.

The major problem with phosphorus is that the turf does not use a great portion of it, so it eventually moves out of the rootzone into the drainage water. However, phosphorus is usually added at very low rates on greens compared to nitrogen. The only time it is used on greens in large amounts is during grow-in. Because phosphorus leaches from porous rootzones, judicious use is advised.

Supplying turf with nitrogen in a controlled fashion greatly reduces the potential for leaching and runoff. This can be accomplished by spoon feeding or using controlled-release fertilizers. These two practices help increase nitrogen efficiency use by keeping it in the rootzone where it can be absorbed by the turfgrass. Any excess nitrogen that cannot be absorbed or used by microbes will quickly pass through the green into the drainage water, which is often piped to surface outflow. Even nitrogen taken up by microbes may eventually leach as it becomes mineralized over time.

For fairways the major problem is runoff. Both nitrogen and phosphorus are readily transported with runoff water. Since turfgrass holds soil well, the water does not carry soil particles with phosphorus adhering, as is the case in agricultural row crops. Instead, phosphorus runoff from turfgrass is in the soluble form, which is the most readily available for algae growth in surface waters.

These results reaffirm the importance of applying phosphorus only according to soil test results. Also, avoid placing fertilizer on hard surfaces such as roads and cart paths. Any fertilizer on hard surfaces is washed directly into storm drains and into surface waters. As a responsible turfgrass manager, be sure to consider water quality as well as turfgrass quality in your fertilization program.

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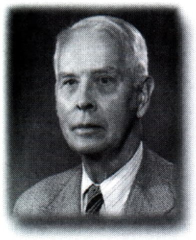
70 Years of Turfgrass Improvement at the New Jersey Agricultural Experiment Station

The Garden State's Rutgers University has long been in the forefront of turfgrass development.

by C. REED FUNK and WILLIAM A. MEYER



Rutgers University has a long lineage of researchers who have achieved prominent success. Five USGA Green Section Award winners have connections to the Rutgers program (clockwise from top): Dr. Glenn Burton (1965), Dr. Ralph Engel (1993), Dr. Reed Funk (1980), Dr. Richard Skogley (1992), and Dr. Howard Sprague (1974).

THE genetic improvement of turfgrass was initiated at Rutgers University by H. B. Sprague prior to the Second World War. Dr. Howard B. Sprague, the world-renowned agronomist at Rutgers, included turfgrass science as one of many areas of accomplishment and activity. He recruited Glenn Burton as a Ph.D. student to assist during the mid-1930s. Dr. Sprague believed that velvet bentgrass offered great potential for turfgrass improvement. It required little or no added fertilizer to produce a fine, dense, very attractive turf in shade or full sun, and at high or low mowing. He developed 'Raritan' velvet bentgrass, released in 1940. Turfgrass enthusiasts, including leading golf course superintendents, also cooperated with research personnel of the United States Golf Association and the United States Department of Agriculture at the Arlington Turf Gardens in northern Virginia. This resulted in the development of many vegetatively propagated creeping bentgrasses, 'Merion' Kentucky bluegrass, and 'Meyer' zoysiagrass. These productive programs were interrupted by the building of the Pentagon on the Arlington research facility property in 1942 and loss of key personnel to military service or critical jobs in support of the war effort.

Turfgrass extension, teaching, and research were re-established at Rutgers following the Second World War under the able and energetic leadership of Dr. Ralph Engel and later strengthened by the addition of Dr. Richard Skogley. Dr. Henry Indyk became Extension Specialist in Turfgrass when Dr. Skogley left to lead the Turfgrass Program at the University of Rhode Island. Each was convinced that significant opportunities existed in the development of improved turfgrasses. They and their turfgrass advisory committee recognized that more turfgrass, including home lawns, golf courses, sports fields, parks, institutional grounds, and road berms, existed within 100 miles of Rutgers than perhaps any other agricultural research institution in the world. They were aware that our major cool-season turfgrass species were introduced from higher latitude, maritime climates of the British Isles and northwest Europe. These grasses were not well adapted to the hot, humid summers, relatively cold winters, diseases, and insect pests of the mid-Atlantic and transition zones of the USA. This presented a real challenge to turfgrass managers but a great opportunity for genetic improvement. The administration of what is now Cook College agreed, and the turfgrass breeding position was offered in December 1961 to Reed Funk, a new Ph.D. with experience in breeding for salt tolerance at Utah State, alfalfa at Iowa State, and corn at Rutgers. It should be recognized that most turfgrass scientists at that time had received their graduate education in fields other than turfgrass. The startup funding and first year's budget was $400 and part-time use of a university car for germplasm collection. Fortunately, Dr. Ralph Engel provided additional support in turf maintenance. Drs. Engel, Indyk, and Felix Juska at the USDA, agronomists at the United States Golf Association Green Section, and seed growers in Oregon, Washington, and Idaho provided much needed and very useful advice and suggestions.

The turfgrass germplasm collection program started in 1962 has continued to the present with thousands of hours spent by turfgrass professionals examining tens of thousands of hectares of old turfs and heavily grazed pastures for elite turfgrass germplasm. Many single plants of Kentuck bluegrass, creeping bentgrass, dryland bentgrass, strong creeping red fescue, zoysiagrass, bermudagrass, and one clone of centipedegrass had persisted and spread to produce patches of turf as much as 25 meters in diameter. Single plants of perennial ryegrass, colonial bentgrass, velvet bentgrass, hard fescue, blue fescue, and Chewings fescue occasionally ranged from 1 meter to 4 meters in diameter. These rare plants came from the billions of seeds planted over past decades and contained genes for adaptation to their various environments. A unique, highly apomictic plant of Kentucky bluegrass has the possibility of being released as a new cultivar with most of its seeds producing plants genetically identical to the mother plant. Elite selections of creeping bentgrass, zoysiagrass, or bermudagrass can be propagated vegetatively to produce a new cultivar. However, plants of sexual, cross-pollinated species, including perennial ryegrass, tall fescue, fine fescues, rough bluegrass, and seed-propagated bentgrasses, zoysiagrasses, and bermudagrasses must be intercrossed with many other elite plants of their species to produce a useful cultivar. Normally, they must also be subjected to many years of population improvement to make them superior to turfgrasses already on the market.

Starting in 1962, a number of attractive plants of perennial ryegrass were found in old turfs near the sheep meadow in Central Park in New York City. Other interesting plants were found in Warinaco Park, Elizabeth, N.J.; Paterson Park and Riverside Park in Baltimore, Md.; the Colonia and Atlantic City golf courses; and the campus lawn of the University of Maryland, College Park, Md. Evaluation of selected plants in mowed clonal tests, spaced-plant nurseries, and disease screening tests and subsequently as single-plant progenies in closely mowed turf trials showed that the plants thriving in Central Park, New York City, had considerable promise. A synthetic of the 16 best performing plants was sent to other locations for testing.

It was soon apparent that 'Manhattan' had outstanding qualities compared to perennial ryegrasses in commercial use at that time and should be released. This required a decision by the New Jersey Agricultural Experiment Station as to the most appropriate method of making high quality seed of new turfgrass cultivars available to the public. After considerable discussion with leaders in the turfgrass industry, plant breeders at Rutgers and other universities, administrators, officials at the New Jersey Department of Agriculture, and seed certification personnel in New Jersey, Oregon, and Washington, we drafted a proposed release policy. A public meeting of interested parties was held on the turf trials at Rutgers, followed by indoor discussion. A number of useful comments and suggestions were made and incorporated, followed by a general agreement of the need for and advantages of restricted release. This would make it feasible for one or more commercial seed companies or groups of seed growers to invest their time, resources, and efforts in high quality seed increase by financing grower contracts with the most qualified farmers for seed production, maintaining seed inventories, promotion, and distribution throughout New Jersey, the USA, Canada, and, if appropriate, overseas. Rutgers would concentrate on research involving more effective breeding and evaluation techniques, germplasm collection and enhancement, and cultivar development.

With additional support from the United States Golf Association and a slowly increasing royalty stream, turfgrass breeding was gradually expanded. The New Jersey Agricultural Experiment Station also provided a technician in 1967. After Bill Siebels left, William K. Dickson accepted this position in September 1968. Ronald F. Bara was promoted to this position in October 1986, when Bill Dickson became Farm Supervisor at Horticultural Farm II.

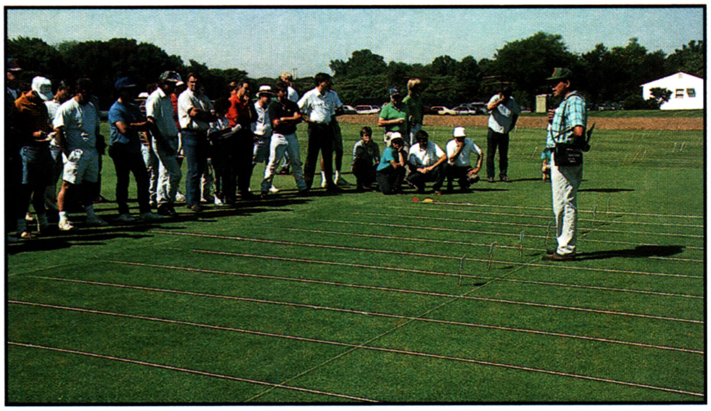
We were all delighted to have Dr. William A. Meyer take over direction of turfgrass breeding in April 1996. He gave the program new energy, leadership, enthusiasm, and abilities. He has brought it to a new level of productivity and stature.

The labor supporting the Rutgers Turfgrass Breeding Program was provided by many individuals too numerous to name. More than 150 technicians, graduate students, administrative assistants, Rutgers faculty, and student employees have made countless contributions to the overall success of the program.

The effects of fungal endophytes in enhancing turfgrass performance and resistance to many harmful insects became apparent in the Rutgers University turfgrass field trials following research by Drs. Charles Bacon in Georgia and Ron Prestidge and associates in New Zealand. Scientists at Rutgers led and/or participated in studies that found that endophytic fungi are associated with many instances of enhanced turfgrass performance of perennial ryegrasses, tall fescues, Chewings fescues, hard fescues, blue fescues, and strong creeping red fescues. They showed an association between the presence of endophytic fungi and enhanced resistance to sod webworms, chinch bugs, and billbugs; improved summer performance and fall recovery; and resistance to crabgrass invasion in tall fescue and perennial ryegrass. They found that endophytic fungi were associated with resistance to chinch bugs and dollar spot disease in many species of fine fescues. They subsequently developed many useful perennial ryegrasses and fescues with endophyte-enhanced performance.

In order to continue Rutgers' leadership in endophyte research, Drs. Faith Belanger, James White, Qin Yue, Cecil Still, Thomas Gianfagna, Michael Richardson, and John Sacalis were hired or encouraged to do basic studies on endophyte biology and turfgrass-endophyte interactions. Assisted by a number of very capable graduate students and post-doctoral research scientists, these faculty members have made and continue to make many

The Rutgers turfgrass germplasm collection program started in 1962. Over time, tens of thousands of samples have been collected to include in the evaluation program. Biotechnology offers a new avenue for speeding up the improvement of turfgrass varieties.



Members of the Rutgers faculty share their expertise at annual field days held at the two main research farms. Turfgrass practitioners from all disciplines of the industry gather to learn about the latest research progress.

outstanding discoveries and contributions. Rutgers has the best and most productive program in the world on endophyte research in relation to turfgrass improvement.

Bentgrasses

Many golf courses and other fine turf areas developed during the late 1800s and the first few decades of the 1900s were seeded with fine fescues and South German mixed bentgrass. The latter was harvested from roadsides and non-tilled farmlands in central Europe and included varying percentages of colonial, creeping, dryland, and velvet bentgrasses. Recent collections from that region show that these bentgrasses were poorly adapted to New Jersey and other regions with hot, humid summers. It is apparent that only a few of the best plants survived to produce large patches of turf. The most attractive of the creeping bentgrasses were selected and evaluated by the USGA Green Section and USDA scientists and became the vegetatively propagated cultivars and much of the foundation of current breeding programs. Dr. Ralph Engel, with the assistance of Alexander Radko of the USGA Green Section, collected many promising creeping bentgrasses and established a large replicated test at Rutgers in October 1962. By this time, 'Penncross,' a three-clone synthetic developed at Penn State, was becoming widely accepted, reducing the need for vegetatively propagated bentgrasses. With financial support from Golf Course Superintendents Associations in New Jersey, Long Island, and the New York City metropolitan area, Professor Engel continued his lifelong interest in fine turf and his collection and evaluation program. USGA Green Section agronomists assisted in these germplasm collections, and their financial support helped provide assistantships for Phil Catron, Richard Rathjens, and Charles Kupat. The cultivars 'Cobra' (Engel *et al.*, 1994) and 'Viper' were developed from this program in cooperation with International Seeds, Inc. (now Cebeco International Seeds). As Dr. Engel was nearing retirement, Drs. Richard Hurley and Reed Funk initiated a new bentgrass improvement program directed primarily at cultivars useful on putting greens. They selected more than 1,000 creeping bentgrass plants from dozens of old golf courses in New Jersey, New York, Pennsylvania, California, and Arizona between 1981 and 1985. After clonal evaluation in New Jersey and Oregon, 203 plants were selected to produce 'Southshore' (Hurley *et al.*, 1990) released in 1992. 'Lofts L-93' was also developed from this program after extensive testing and population improvement.

The opportunity to substantially increase the bentgrass breeding program at Rutgers was one of the primary incentives used to attract Dr. William A. Meyer to New Jersey. He is assisted by Dr. Karen Plumley, Dr. James Murphy, Pieter den Haan, Stacy Bonos, Ronald Bara, William Dickson, and Dirk Smith. Bridget Meyer, Anita Szersen, and Gengyun Zhang also have assisted in germplasm collection. They are making excellent progress in the genetic improvement of velvet, creeping, and colonial bentgrass. Dr. Meyer and his team are also working with and assisting Drs. Faith Belanger, Barbara Zilinskas, and Tseh An Chen in their development of transgenic bentgrasses with herbicide resistance, stress tolerance, and disease resistance. The future is indeed bright for bentgrass breeding.

Turf-Type Perennial Ryegrasses

'Manhattan' (Funk *et al.*, 1969) was released in 1967 and proved to be a landmark cultivar that significantly enhanced the usefulness of perennial ryegrass for turf. Its success caused a number of plant breeding institutions throughout the world to redirect their programs to the development of improved turf-type ryegrasses. 'Manhattan' and other germplasm sources developed at Rutgers have been used in many breeding programs in North America and Europe. 'Manhattan' and the Kentucky bluegrass hybridization program gave considerable international recognition to the Rutgers program. It also convinced our administrators that the program was worthy of the support of a full-time technician and a graduate assistantship. 'Manhattan II' (Funk *et al.*, 1984) was developed jointly with Pure-Seed Testing and the Manhattan Ryegrass Growers Association. It was released in 1983 to replace 'Manhattan' in the USA. However, the excellent wear tolerance and winter performance of the original 'Manhattan' have encouraged managers of European soccer fields to continue its widespread use.

Continuing germplasm collection and population improvement programs at Rutgers and elsewhere have resulted in a continued stream of better performing cultivars widely used in North America, Europe, Japan, eastern Asia, and Australia. Seed production of turf-type ryegrasses in the USA exceeded 200 million pounds in the year 2000. With each new National Turfgrass Evaluation Program (NTEP) trial, the best performing cultivars of the previous test usually end up mostly on the second page of the new test only four or five years later. This documents the effectiveness of the continued population improvement programs. They involve many cycles of phenotypic and genotypic selection and population backcrossing. Each cycle of improvement builds on the achievements of all previous cycles in these cross-pollinated species.

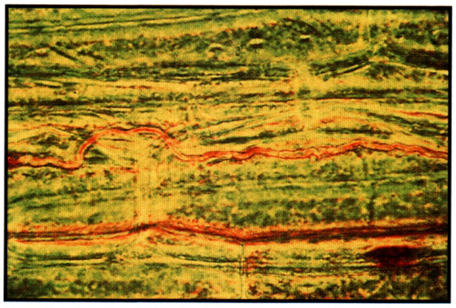
The occurrence of gray leafspot, a new disease on many ryegrass turfs, presents another challenge to turfgrass breeders. Fortunately, genes for resistance have been found in new germplasm collections made in eastern Europe by Dr. Meyer and his associates. These resistant plants have been crossed and backcrossed with the best plants from Rutgers and already combine good turf performance with genetic resistance to gray leafspot and other diseases.

Tall Fescue

Tall fescue is native to Europe and parts of Africa. It is best adapted to the hot, dry summer climates surrounding much of the Mediterranean Sea. The selection of 'Kentucky 31' and its release in the early 1940s initiated its widespread use throughout the warm, humid transition zone of the USA and the Mediterranean climates of California and Oregon. Natural selection of the best-adapted plants occurred over many decades on seed from Europe planted on a hillside pasture in Kentucky. Only plants able to survive the environmental stresses, diseases, and insect pests of this hot, humid location were able to produce multiple generations of seedlings. This concentrated the genetic factors for better adaptation to this new environment. Plants selected from this pasture were used as the parental germplasm of 'Kentucky 31.' It rapidly became widely used for reducing soil erosion, providing forage, and as a deep-rooted, heat-tolerant turfgrass.

Many turfgrass scientists recognized the useful qualities of tall fescue but also the need to overcome its limitations as a high quality turfgrass. An extensive germplasm collection effort covering many thousands of hectares of old turfs throughout the USA located a few attractive tall fescue plants that had persisted and spread to produce attractive turfs from 1 to more than 5 meters in diameter. Their appearance and the history of the turfs indicated that they likely originated from seed sources brought from Europe many decades earlier. After evaluation in mowed clonal trials and spaced-plant nurseries, the best performing plants were intercrossed and single-plant progenies were seeded in turf trials mowed at 2 cm. Plots of 'Kentucky 31' and other cultivars were unable to persist under these conditions of frequent close mowing and were soon replaced by weeds. The best appearing plants were then selected from the best surviving progenies to initiate another cycle of selection. Additional germplasm was added as it became available from the continuing collection effort. A few promising plants selected from tri-species hybrids of perennial ryegrass, meadow fescue, and tall fescue developed at the U.S. Regional Pasture Research Laboratory, University Park, Pa., were included.

'Rebel' tall fescue (Funk *et al.*, 1981) was released in 1980 following 18 years of plant selection and population improvement. 'Rebel' is considered a landmark cultivar, being the first of a new class of turf-type tall fescues with



Endophytic fungi are associated with enhanced turfgrass performance and improved turf resistance to harmful insects. Work at Rutgers University has focused on perennial ryegrass, tall fescues, and fine fescue performance.

finer leaves, greater density, a slower rate of vertical growth, better shade tolerance, a brighter darker-green color, improved wear resistance, and greater persistence under close mowing. 'Rebel' and subsequent turf-type tall fescue cultivars and enhanced germplasms developed at Rutgers have contributed to most improved turf-type tall fescues on the market today.

Data from NTEP tests show continuing improvements in overall turf performance in tall fescue cultivars. Many new tall fescues are consistently outperforming cultivars available only four or five years earlier. A substantial percentage of these best performing new cultivars come directly from the Rutgers turfgrass breeding program and from companies working jointly with Rutgers (Table 1).

Fine Fescues

Fine fescues include strong creeping red, Chewings, hard, blue, and slender creeping fescues. As a group, they have fine, bristle-like leaves and the ability to produce a dense, fine-textured turf tolerant of medium-low soil fertility, moderately acid soils, moderate shade, tree root competition, and cold winters. They do not tolerate high nitrogen fertility, flooding, or poor drainage, especially during warm to hot weather. Continuing genetic improvements make each of these species more useful to homeowners and turfgrass professionals.

Professor Robert W. Duell and his students, including Richard Schmidt and Tony Palazzo, showed great interest in fine fescues and participated in the development of 'Banner' Chewings fescue (Duell *et al.*, 1976) released in 1985 and 'Fortress' strong creeping red fescue. Forty-five plants selected from old turfs in New Jersey, Maryland, Pennsylvania, and New York were used as the parents of 'Banner' after extensive clonal evaluation and progeny testing. Ongoing collection and population improvement are continuing to improve Chewings, hard, blue, and strong creeping red fescues. Cultivars developed by or with the participation of Rutgers continue to perform very well in NTEP tests (Table 1). Screening of large seedling populations under short-day-length, cool-temperature winter greenhouse conditions has been effective in selecting plants with greater disease resistance, higher tiller number, a slower rate of vertical leaf elongation, and a richer, brighter dark-green color. Similar results have been obtained in screening large seedling populations of tall fescue and perennial ryegrass.

Rough Bluegrass

Rough bluegrass (*Poa trivialis* L.) is adapted to cool, moist, shaded environments but rapidly becomes dormant in summer when subjected to heat and drought. Improved turf-type cultivars are often very useful for the winter overseeding of dormant warm-season turfgrasses in the southern USA and similar regions. However, this species is frequently a weed in many cool-season turfs in temperate climates. Drs. Henry Indyk and Ralph Engel collected a number of attractive plants from old turfs in New Jersey and surrounding states. William K. Dickson, a technician on the turfgrass breeding team, was eager to see if he could make a high quality turfgrass cultivar from these and other collections. Intercrosses of the best performing selections were subjected to cycles of phenotypic recurrent selection and produced the cultivar 'Sabre' (Dickson *et al.*, 1980) released in 1977. Sabre quickly became accepted in the winter overseeding market and eventually encouraged other turfgrass breeders to develop turf-type rough bluegrasses. Richard Hurley, studying for his Ph.D. degree at Rutgers, chose to work with rough bluegrass for his thesis project. A new, expanded germplasm collection and population improvement program resulted in the development of 'Laser' (Hurley *et al.*, 1990) and subsequently 'Winterplay' and 'Laser II.'

Kentucky Bluegrass

Kentucky bluegrass (*Poa pratensis* L.) is a major lawn-type turfgrass for much of the northern two-thirds of the USA and southern Canada. The land growing Kentucky bluegrass lawns has a higher real estate value than the land growing any of our major crop plants such as corn or soybeans! Its high and variable chromosome number (2n=28 to 153), its complex embryology, and its apomictic method of reproduction present great challenges and opportunities to plant breeders. Apomixis is a method of asexual reproduction in which nearly all seeds of a highly apomictic plant produce plants genetically identical to their maternal parent. Sperm nuclei from the pollen merely fertilize the polar nuclei to produce the endosperm. Apomixis is a nearly ideal method of producing a hybrid cultivar. It can retain maximum hybrid vigor through future cycles of seed increase and eliminates the disadvantages of vegetative propagation. The development and use of apomictic reproduction in major crops such as wheat, rice, soybeans, cotton, tree crops, and alfalfa would substantially increase world production of food, forage, and fiber.

Kentucky bluegrass has great genetic diversity and is naturalized throughout virtually all temperate regions of the world. The species includes germplasm with virtually every characteristic wanted in an ideal lawngrass. However, turfgrass breeders have yet to develop a rapid, efficient breeding method to recombine all of these characteristics into one interbreeding population or apomictic cultivar.

Currently, the Rutgers turfgrass breeding group is expanding its Kentucky bluegrass improvement program. Capable, energetic young scientists will produce both better cultivars and more effective breeding and evaluation techniques.

References

Dickson, W. K., G. W. Pepin, R. E. Engel, and C. R. Funk. 1980. Registration of 'Sabre' roughstalk bluegrass. *Crop Sci.* 20:668.

Duell, R. W., R. M. Schmit, C. R. Funk, and R. J. Peterson. 1976. Registration of 'Banner' fine fescue. *Crop Sci.* 16:123.

Engel, R. E., G. W. Pepin, and C. W. Edminster. 1994. Registration of 'Cobra' creeping bentgrass. *Crop Sci.* 34:306.

Funk, C. R., R. E. Engel, W. K. Dickson, and R. H. Hurley. 1981. Registration of 'Rebel' tall fescue. *Crop Sci.* 21:632.

Funk, C. R., R. E. Engel, and P. M. Halisky. 1969. Registration of 'Manhattan' perennial ryegrass. *Crop Sci.* 9:679-680.

Funk, C. R., W. A. Meyer, and B. L. Rose. 1984. Registration of 'Manhattan II' perennial ryegrass. *Crop Sci.* 24:823-824.

Funk, C. R., and J. F. White, Jr. 1997. Use of natural and transformed endophytes for turf improvement. In: C. W. Bacon and N. S. Hill (ed.) Neotyphodium/Grass Interations: Plenum Press, New York.

Hurley, R. H., V. G. Lehman, J. A. Murphy, and C. R. Funk. 1994. Registration of 'Southshore' creeping bentgrass. *Crop Sci.* 34:1124-1125.

Hurley, R. H., M. E. Pompei, M. B. Clark-Ruh, R. F. Bara, W. K. Dickson, and C. R. Funk. 1990. Registration of 'Laser' rough bluegrass. *Crop Sci.* 30:1357-1358.

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Table 1
Top Performing Cultivars Developed with Participation of the Rutgers Turfgrass Breeding Program in Recent National Turfgrass Evaluation Program (NTEP) Tests

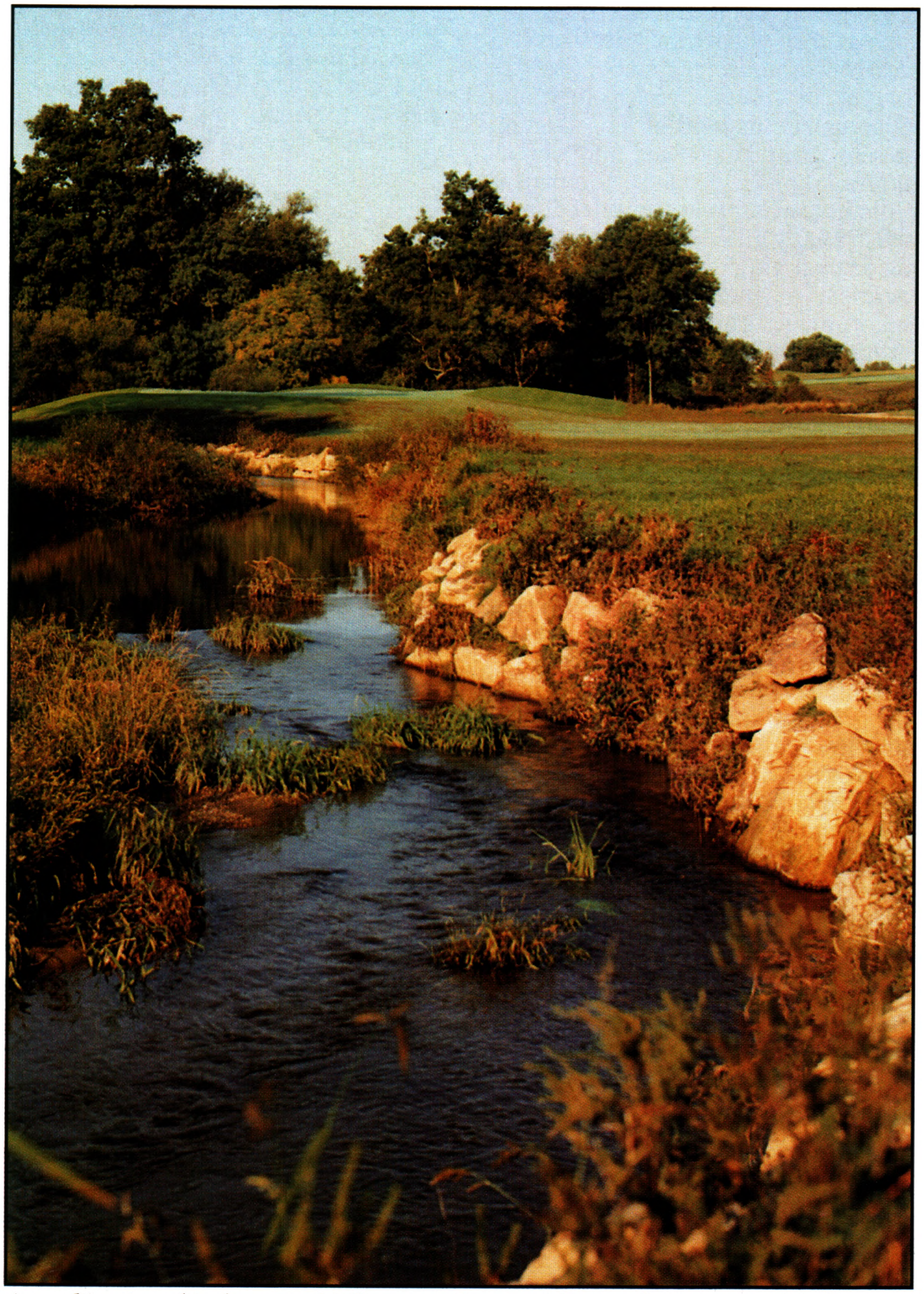
National Tall Fescue – 1992 – Final Report 1993-95 – 92 Entries	
*1. Jaguar 3	8. Coyote
3. Houndog V	9. Finelawn Petite
4. Genesis	10. Pixie
5. Pride	
National Tall Fescue – 1996 – Progress Report 1999 – 129 Entries	
1. Rembrandt	7. Coyote
2. Millennium	9. Shenandoah II
4. Plantation	10. Jaguar 3
5. Masterpiece	
National Perennial Ryegrass – 1994 – Final Report 1995-98 – 96 Entries	
1. Palmer III	4. Calypso II
2. Brightstar II	5. Premier II
3. Secretariat	7. Monterey
National Kentucky Bluegrass – 1995 – Progress Report 1999	
Medium-High Input – 103 Entries	*Low Input – 21 Entries*
1. Midnight	2. Eagleton
5. Princeton P-105	4. Caliber
	10. Dragon
National Bentgrass – 1993 – Final Report – 1994-97	
Putting Green – 28 Entries	*Fairway-Tee – 21 Entries*
1. L-93	4. Southshore
8. Southshore	
National Bentgrass – 1998 – Progress Report – 1999	
Putting Green – 29 Entries	*Fairway-Tee*
7. L-93	1. L-93
National Fineleaf Fescue Test – 1998 – Progress Report 1999 – 79 Entries	
Strong Creeping Red Fescues – 22 Entries	
1. Jasper II	6. ISI FRR-7
2. SRX-52961	7. ISI FRR-5
3. ABT-CR-2	8. PST-4FR
4. ABT-CR-3	9. Florentine
5. PST-EFL	10. Pathfinder
Chewings Fescues – 24 Entries	
1. Longfellow II	6. Treasure
2. Ambassador	8. Pick FRC A-93
3. ABT-CHW-3	9. Shadow II
4. ABT-CHW-2	10. Pick FRC 4-92
5. Intrigue	
Hard Fescues – 24 Entries	
1. 4001	6. Nordic
2. ABT-HF1	7. ABT-HF2
3. Oxford	9. ISI FL-12
4. SRX 3961	10. ISI FL-11

*Numbers refer to rank in turf quality averaged over all locations.

WHAT IS A *BUFFER*?

Placed between turfgrass and a body of water, a buffer can significantly reduce nutrient and sediment runoff.

by JEAN MACKAY



A combination of turfgrass and taller vegetation provides an effective natural buffer along this stream bank at Honeybrook Golf Club (Honey Brook, Pa.). Such management practices have become increasingly accepted at many golf courses.

MAINTAINING good water quality is a prominent environmental concern for golf courses. The Audubon Cooperative Sanctuary Program and many regional best management practice (BMP) guidelines routinely recommend that superintendents maintain a *vegetated buffer* around water bodies. On sites where fertilizers and pesticides are routinely used, these buffers are an important way to protect water quality, as well as provide habitat for aquatic creatures. "But what, exactly, is a buffer?" people often ask.

A vegetated buffer is an area around the edge of a water body specifically maintained with plants that reduce storm water flow and potential pollution from runoff. A buffer may be made up primarily of turfgrass, or include a combination of grasses, herbaceous (non-woody) plants, and shrubs. The plants in a vegetated buffer absorb nutrients, trap sediments, reduce erosion, and slow down water as it moves from the land into a pond, lake, or stream.

One type of effective vegetated buffer, often referred to as a *vegetated filter strip*, is turfgrass mown at a height of three inches, or as high as possible for the particular turfgrass species. In research trials, such filter strips, maintained at widths between 15 feet and 30 feet, reduced nutrient runoff from adjacent areas by 90% to 99%, respectively. Sediment removal rates are generally greater than 70% (USEPA, 1993).

Choosing What's Best for Your Site

In the field, the best height, width, and overall size of a vegetated buffer depend on several factors: slope, type of vegetation, playability, and potential pollution from maintenance practices, including chemical applications.

Many golf courses are able to maintain a full buffer all the way around a pond or stream bank. For sites where this is not feasible, golf courses combine partial vegetated buffers with specialized management zones, such as no-spray zones or limited-spray zones that may involve spot treatment of disease and weed problems. The proper use of slow-release or natural organic fertilizers or spoon-feeding also reduces the potential for chemical runoff into water sources.

Because of the Audubon Cooperative Sanctuary Program's focus on both water quality and wildlife habitat, we also recommend that golf courses add emergent and shoreline plants *other than turfgrass* around water bodies where practical. Taller emergent vegetation, such as arrowhead, pickerelweed, sedges, and bulrushes, help

Cattails and yarrow provide an extended and dense buffer for this lake on Hole #9 at Haymaker Golf Course (Steamboat Springs, Colo.). Buffering water bodies filters storm water runoff and provides wildlife habitat. Haymaker G.C. is a certified Signature course in the Audubon Signature Program.

To protect water quality, Blue Hills Country Club (Kansas City, Mo.) maintains a higher mowing height around water features and widened no-spray zones to 25 feet. Blue Hills C.C. is fully certified in the Audubon Cooperative Sanctuary Program for Golf Courses.

oxygenate the water and provide food and shelter for a great variety of wildlife.

This type of naturalization alters both the aesthetics and wildlife value of streams, lakes, and ponds. On golf courses, it also may affect playability, or at least the perception of playability, and therefore must be undertaken with careful consideration. Where taller plants cannot be added, a turfgrass buffer remains a valuable management strategy.

Sources

Madison, C. E., *et al.* 1992. Tillage and grass filter strip effects upon sediment and chemical losses. p. 331 in *Agronomy Abstracts*. ASA. Madison, Wis.

Baird, J. H., N. T. Basta, R. L. Huhnke, *et al.* 2000. Best management practices to reduce pesticide and nutrient runoff from turf. p. 268-293. *In* J. Marshall Clark and Michael P. Kenna (ed.) *Fate and Management of Turfgrass Chemicals*. ACS Symposium Series 743. American Chemical Society, Washington, D.C.

U.S. Environmental Protection Agency. 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* Doc. #840-B-92-002, U.S. EPA Office of Water, Washington, D.C.

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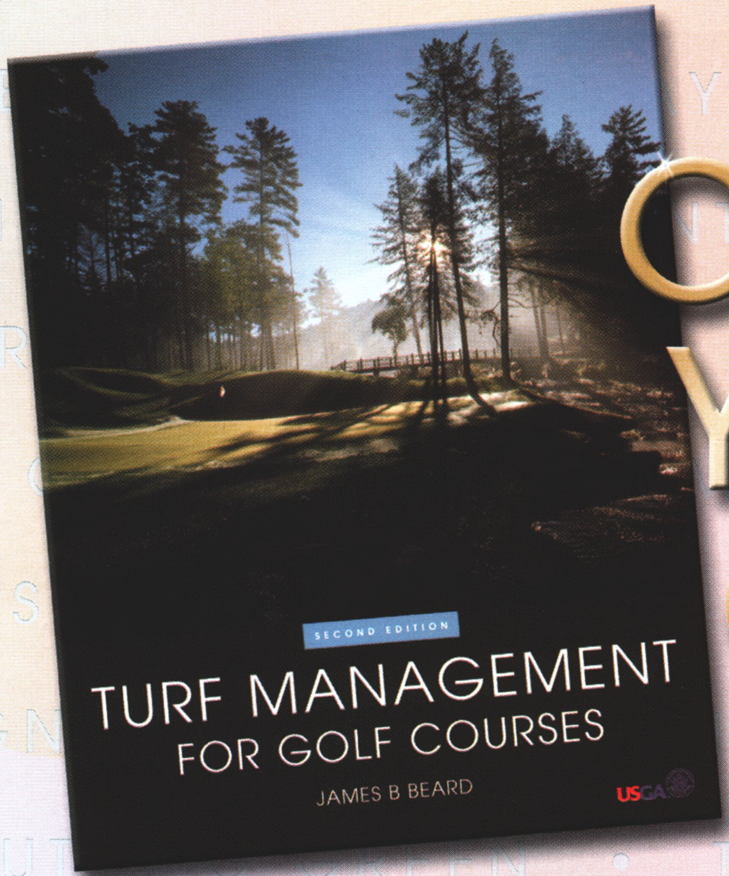

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Guidelines for Establishing Quality Control Tolerances

A CRITICAL COMPONENT of putting green construction is the production of the rootzone material. Whether this material is straight sand or a composite of sand and amendments, it is very important that the material remain as consistent as possible throughout the blending and installation processes.

Quality control sampling and testing is the best means of assuring the consumer that they are *getting what they paid for.* The quality control process is accomplished by collecting samples throughout the blending and installation steps, submitting these samples to an accredited laboratory for analysis, and comparing the results to a "benchmark" or target sample.

When comparing quality control samples to the target sample, it is unreasonable to expect the test results to be identical. There are many factors throughout the *entire chain of custody* of a rootzone mixture that inevitably result in differences from one test to another in spite of the best efforts of everyone concerned. Factors that result in differences in test results can be grouped into two categories — **Field Variables** and **Laboratory Variables**.

Examples of Field Variables

- Changes in the makeup of the sand source.
- Changes in the composition of the organic matter or other amendment.
- Variability in the blending processes.
- Variability in how quality control samples are collected.

Examples of Laboratory Variables

- Variability in carrying out the test procedures.
- Variability that occurs due to limitations in repeatability of the test procedures (also referred to as test ruggedness).

To keep laboratory variability to a minimum, it is critical that the same accredited laboratory be utilized throughout all phases of the project. Through extensive statistical analysis, it has been determined that the amount of test variability within the same lab is quite small (assuming they are testing the exact same material each time). However, sending the same sample to different laboratories greatly increases the amount of test variability that will occur. This is due to differences in test equipment and laboratory technique. Although the USGA and the accredited laboratories are diligently working together to minimize these differences and reduce inter-lab variability, the best option by far is to utilize only one lab for the entire project.

USGA CONFIDENCE INTERVALS FOR QUALITY CONTROL TESTING

Test Parameter	USGA Confidence Interval
Fine Gravel	50%
Very Coarse Sand	50%
Coarse Sand	10%
Medium Sand	10%
Fine Sand	15%
Very Fine Sand	30%
Silt	25%
Clay	25%
Total Porosity	10%
Air-Filled Porosity	10%
Capillary Porosity	10%
Saturated Conductivity	20%
Percent Organic Matter of Mix	0.2*

*The confidence interval for percent organic matter is not represented as a percentage. Thus a reported value of 0.7% organic matter could range from 0.5% to 0.9%.

These factors should be given strong consideration when establishing variation tolerances for quality control testing. Setting tolerances that are unrealistically tight can result in the disqualification of a perfectly good rootzone mixture, significantly increased cost of the project (for both the owner and the contractors), unnecessary litigation, and lengthy construction delays. Setting tolerances that are too loose could result in large changes in the makeup of the rootzone mixture — to the point that the performance of the greens could suffer.

With assistance from university and laboratory scientists, the USGA Green Section has identified the maximum amount of variation that should be tolerated for key test parameters measured during quality control testing. The accompanying table details a variability percentage for each parameter. This variability percentage is more accurately referred to as the ***confidence interval*** and is used to establish plus or minus values for each measured parameter. For example, assume the laboratory test indicates a value for fine sand to be 10%. Using the confidence interval percentage for fine sand of 15%, the acceptable variance is 10% plus or minus 1.5% for an acceptable range for quality control testing of 8.5% to 11.5%.

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USGA

IT JUST HAS TO BE CHEAPER OR BETTER

If not, why make the change?

by ROBERT C. VAVREK, JR.

CONTRARY to popular belief, P. T. Barnum never said, "Another sucker is born every minute." However, he sure had an exceptional talent for hype and marketing. Open any turf management trade magazine and read the advertisements for some of the new turf care products. The exaggerations, half-truths, double-talk, and just plain deception would make Mr. Barnum proud. Notice that the ads having the most outrageous claims are those that rely more on testimonials than hard science to support the product.

It's no surprise to find less hype in the insecticide, fungicide, and herbicide ads. These regulated materials are, as a rule, evaluated using widely accepted scientific procedures at different locations over a period of several years. Some of the research is done in-house by the manufacturer, but new products are usually pitted against current materials and untreated controls in unbiased performance trials at a number of university research sites. Even though efficacy claims are not regulated by the EPA, it should come as no surprise that the efficacy of a particular material is well documented before the familiar name of a major company appears on the label.

Carl Sagen said, "Extraordinary claims require extraordinary proof." Unfortunately, the majority of snake oils, magic potions, and silver bullets never receive anywhere nearly the same scrutiny as pesticides. Too bad, considering the not-so-subliminal message that some of these materials control or suppress disease activity in addition to the many other unsubstantiated claims. Small companies often won't spend money for research, and some university researchers have found it difficult or impossible to obtain certain products for field trials. The favorable data from only a few sampling dates of a single experiment are sometimes given much more credibility than they deserve. Is this creative marketing or an unethical manipulation of data? You make the call in this gray area.

The less expensive and readily available substitute for unbiased scientific evidence used in marketing an unproven product is the all-too-familiar *testimonial*, and there is no shortage of these in any of the turf trade journals. I have a considerable amount of respect for and value the opinion of many superintendents. However, there are approximately 16,000 superintendents just in the United States, and the testimonial of only one is not always pertinent to the other 15,999. To be honest, there is an advantage to actually using a product on the golf course rather than gleaning information only from university test plots. Even so, one can easily be misled by the performance of a product in the field in the absence of replication and untreated controls.

Superintendents can, at times, make a relatively good in-house evaluation of a product by covering a small area of turf with plywood prior to treatment. It's not all that bad of a technique if you want to evaluate one, and only one, active ingredient, such as a particular fungicide on a green. New miracle products, though, are sometimes a mixture of several ingredients, including a little urea and/or micronutrients, particularly iron. Separating the fertilizer effect from the effects of the other active ingredients then becomes a more complicated, if not impossible, procedure.

Over the years I have often been accused of being overly critical of turf care products or turf management strategies that have little, if any, scientific evidence to support the manufacturers' extraordinary claims, and I've missed out on my share of hats, pens, and rulers at trade shows. True, I play the devil's advocate regarding unproven products, and I have no doubt that some products actually improve turf quality under certain conditions. The bottom line regarding my recommendations is whether or not marginal improvement in turf quality (if there is any at all) is worth the cost of the product.

Maintain the following attitude when considering turf products that sound too good to be true: Would you try it if you owned the course and had to pay for the product out of your own pocket? Whether or not biostimulants, humates, soil amendments, water polarizers, balancing cations, microbial additives, and other assorted products and techniques actually improve turf quality is one issue. The other issue is whether or not the benefit (if any) justifies the cost.

I see many excellent golf courses each season during Turf Advisory Service visits. The common denominator among the best courses is a superintendent who understands and implements sound turf management principles. Regardless of the operating budget, they cover the bases – careful water management, sensible fertilizer applications, and timely cultivation operations. They pay attention to the turfgrass plant's basic needs: light, air, water, and nutrients. What rubs me the wrong way about the sales techniques for some new products is the underlying assertion that you can't live without them – that is, if you really want to provide a top-notch course. Well, I see numerous top-notch courses that don't use these materials. Before I make a recommendation to substitute a new product for an old product, it has to perform significantly better than the old material or perform just as well and be less expensive. In other words, it needs to be cheaper or better; if not, why make the change?

BOB VAVREK *provides a variety of recommendations and opinions regarding course maintenance options while on Turf Advisory Service visits in Michigan, Wisconsin, and Minnesota.*

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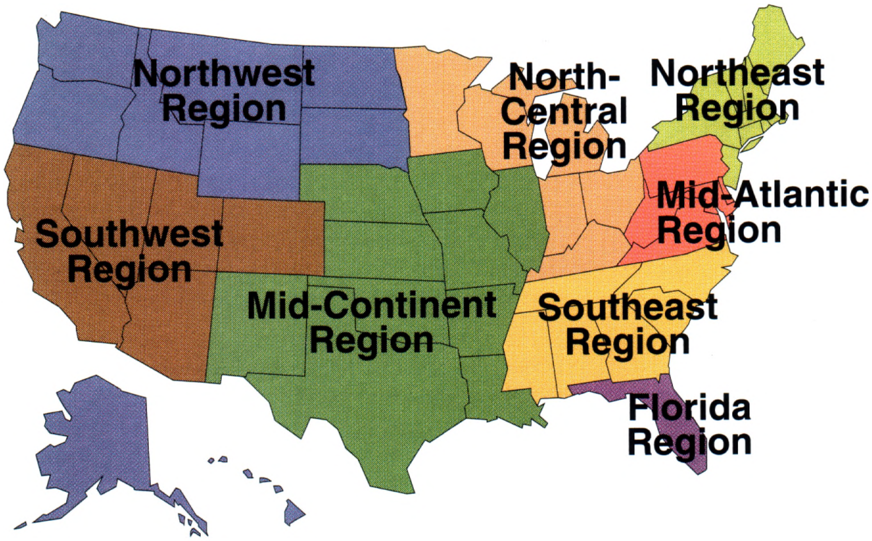

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TURF TWISTERS

NEW VARIETIES

Question: Our 20-year-old Tifdwarf greens are now severely contaminated with off-type bermudagrasses and will be replanted in the next couple of years. We are considering making a switch to one of the new ultradwarf cultivars, but I am concerned about being able to overseed the greens for the winter because of the very dense turf cover that is produced. What have been the Green Section's findings in regards to winter overseeding of the ultradwarfs in the northern Florida area? (Florida)

Answer: When Tifdwarf was first released in the mid-1960s, winter overseeding was a concern because of its greater density compared to Tifgreen (328) bermudagrass. Superintendents across the South quickly developed successful overseeding programs, and this also is occurring today with the ultradwarfs. At a number of golf courses, satisfactory overseeding results have been achieved with ultradwarf bermuda greens using *Poa trivialis*. While we are still learning about the ultradwarfs, they are raising the bar and will more than likely replace Tifdwarf as the standard at courses where premium quality putting greens are expected or demanded.

TRANSLATE TO

Question: Last year our golf course installed a new irrigation system that cost nearly $1 million. After watching our superintendent this summer, I wonder if he knows how to use it. Some days our golf course was so dry I don't think he knew how to turn it on. Other times I saw him hand watering the greens. How can that possibly be necessary, and isn't it a ridiculous waste of time when he has a new system at his disposal? (New Jersey)

Answer: By the sound of it, your golf course superintendent is handling the situation correctly. The purpose of irrigating turf is to keep it alive, not make it green and lush. Dry, firm, and fast are considered the best playing conditions. Turf that is lush doesn't play as well and tends to be more prone to pest problems. With regard to the hand watering, even with perfectly built greens and a state-of-the-art irrigation system, some portions of greens dry out more quickly than others. Hand watering is a critical tool in handling those miscellaneous dry spots and still achieving top-notch playability on the putting greens.

IMPROVED CONDITIONS

Question: Superintendents typically prepare budgets based on line items for various spending categories. However, I have no idea how this translates to money spent on primary playing areas. I've also been informed that I need to decrease the course operating budget by 10%. How do I show the Green Committee where the money is going, and what is my best way to prioritize those dollars? (Tennessee)

Answer: Using your maintenance objectives, prioritize the playing areas in order of importance. Most golf courses rank the playing areas in the following order: putting greens, fairways and green slopes, tees, rough, and hazards. Some superintendents also break out the budget percentages into the playing area categories. This method can help show the Green Committee where the money is allocated and how it is prioritized. Do not begin by reducing maintenance on the high-priority areas. Instead, target intensive tasks in the areas of low priority. The golf course may not have as many finishing touches, but quality on the important playing areas will not suffer.