Crows in search of grubs can cause a considerable amount of damage to the turf surface. Current research investigations are focusing on biological and cultural grub controls.

USGA/GCSAA Research Results You Can Use

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RESEARCH is like a fine wine — it takes time! After reading this article, I hope you will agree with me that as "environmental consciousness" has increased in the 1980s and 1990s, the research objectives of the USGA's turfgrass and environmental research programs have proven to be prophetic.

Turfgrass

Let's begin with an update on the ten-year (1983-1992) USGA/GCSAA Turfgrass Research Program, which is beginning its final year. The goals of the Turfgrass Research Program are to: develop minimal-maintenance turfgrasses for golf courses through a 50-percent reduction in water use and maintenance costs associated with golf course turf; develop the Turfgrass Information File, a large collection of publications on turfgrass science and management, and a database of this information, searchable by computer; develop young leaders in turfgrass science through our direct involvement and financial support of higher education in the United States.

Reducing the water use and maintenance costs of today's golf courses is a difficult, yet achievable goal! This research program started at a funding level of $250,000 in 1983, and has now become the most focused, well planned, national research mission in turfgrass science. An annual budget of $750,000 is currently distributed among 20 projects located in 14 states.

The USGA/GCSAA Turfgrass Research Program has made tremendous progress increasing the knowledge on water management strategies, extending the range and adaptation of turfgrasses that use less water, improving the heat and drought tolerance of preferred turfgrass species, and evaluating the turfgrass potential of native grasses.

Water management strategies developed through detailed physiological studies of the water use rates of desir-

able turfgrasses have allowed researchers to develop methods to make more efficient use of water. Ten years ago very little was known about the evapotranspiration rates (ET) or crop coefficients (K_C) of our major turfgrass species used on golf courses. This vital information, coupled with the computerization of irrigation systems, development of inexpensive weather stations, and technological improvements in the performance of delivery systems, has significantly reduced the water use of golf courses compared to 1982 figures. If your golf course is located in an arid part of the country and is not taking advantage of these improvements, then there is a strong likelihood that your golf course is wasting water.

By extending the range and adaptation of a turfgrass species which uses less water, substantial savings can be achieved. The best two examples include work on bermudagrass and zoysiagrass varieties to improve ease of establishment and their ability to survive transition-zone climates where water-dependent, disease-susceptible ryegrass and bluegrass varieties are currently used. Extending the green color retention of warm-season grasses in the mild coastal climates of California and Florida would reduce the need for overseeding with cool-season species. Improving the putting quality of bermudagrass to satisfy golfers will allow their usage in areas where bentgrasses require twice as much water and a much greater need for pesticide applications.

A more difficult task has been to improve the heat and drought tolerance of existing species preferred as the playing surfaces for golf. Bentgrass has received the most effort in this area, aiming to increase its ability to survive in southern climates where it is poorly adapted. Efforts to develop disease screening techniques to increase the resistance of bentgrasses will help reduce fungicide applications in locations where the turfgrass is better adapted. Developing bermudagrass and zoysiagrass varieties with better drought tolerance will help reduce the water needs of golf courses in the arid southwest.

Native grasses have the greatest potential in regions of the country where water, poor soils, or climate are the limiting factors in providing quality playing surfaces. Taking advantage of the natural selection that has occurred over millions of years obviously will be more successful than a ten-year breeding program; however, the domestication of native species is not a simple task either. Buffalograss is the shining example of how a species native to North America can be utilized for golf courses. To date, buffalograss has been improved to the point where it will make an adequate playing surface for golf course roughs. Continued research efforts should allow this species to be used on fairways where more traditional grasses are not well adapted.

Buffalograss is by no means a panacea, but it represents a major step in the recognition of a valuable natural resource for the turfgrass industry to utilize. Maybe someday grass nicknames like alkali, gramma, salt, or mesquite will be as familiar to our ears as rye, bent, fescue, and blue!

Breeding Update

Buffalograsses adapted for use on golf course roughs and low-maintenance areas have been developed. The University of Nebraska has released NE 84-609, and it is being produced in Texas, Oklahoma, California, and Florida. Sod and plugs are the only available methods to establish 609; however, five seeded buffalograsses are currently being evaluated in the National Turfgrass Evaluation Program. A seeded buffalograss may be available for expanded testing by fall 1993.

Bentgrasses for putting greens and fairways with better heat, drought, and disease resistance have been developed through the turfgrass breeding efforts at Texas A&M University. The increased use of bentgrass on fairways and support of bentgrass breeding, on the part of the USGA, has renewed the interest of U.S. seed companies and universities. Several new varieties, including Providence, Pennlinks, Putter, SR-1020, Cobra, and others, have recently been made available to the industry.

Bermudagrasses that can be established by seed have been received favorably by U.S. and international golf course markets. NuMex Sahara seed supplies sold out in 1991 and produced royalty income in excess of $40,000 for the USGA Foundation to reinvest in turfgrass research. Oklahoma State University is nearing completion of new cold-tolerant seeded bermudagrasses for the transition zone climates of the U.S., and they will be entered into the National Turfgrass Evaluation Program in 1992.

The first year of selection for improved putting green bermudagrasses has identified several plants that can tolerate extended periods of close mowing under Florida golf course conditions. New fine-textured bermudagrasses which provide faster green speed and better winter color may decrease the need for overseeding with cool-season species (bentgrass, *Poa trivialis*, etc.).

Zoysiagrasses with better color retention and playing quality have been developed at Texas A&M University. The improved vegetative varieties DALZ 8502 for tees and DALZ 8507 and 8512 for fairways are nearing release. These improved types and seven other selections are currently being evaluated in the National Turfgrass Evaluation Program.

Native grasses, including alkaligrass, blue gramma, and curly mesquite, have been improved for turfgrass characteristics and have potential use for low-maintenance areas on golf courses or areas with poor water and soil quality. Colorado State University has begun negotiations with seed companies for new alkaligrass and blue gramma varieties. The University of Arizona is one to two years away from completing the assessment of curly mesquitegrass selections collected from wild populations growing naturally in the desert southwest.

Annual bluegrass varieties may become a reality with initial seed yield trials in Oregon underway. Researchers at the University of Minnesota have identified several lines with promising characteristics for golf course putting greens, including perennial growth, increased cold hardiness, and deeper root systems. The release of an improved "perennial" bluegrass is still two to three years away.

TGIF, or the Turfgrass Information File, will receive its last year of USGA funding in 1992 before becoming a self-sustaining operation at Michigan State University Library. TGIF has more than 21,000 publication records, greatly improved ease of use, and increased on-line and off-line usage. Plans to increase subscriptions and usage will be carried out with increased marketing efforts, development of software and print products, and optional interface with the USGA's GHIN system.

Biotech has developed the methodology to insert foreign DNA into the bentgrasses used for putting greens. Progress at Rutgers University will allow scientists to insert herbicide-resistant

genes and evaluate new disease-resistance mechanisms for creeping bentgrass. Extensive field testing will be needed to fully evaluate the benefit of the new "transgenic" grasses.

Young turfgrass scientists are being trained on USGA/GCSAA projects which will produce our leaders for tomorrow. Thirty-one graduate students have received M.S. or Ph.D. degrees on USGA/GCSAA-supported projects. More than 96 scientific publications, theses, and dissertations have been published. The financial support and leadership provided by the USGA/GCSAA Turfgrass Research Program are very important and significant contributions!

The Turfgrass Research Committee has been instrumental in making this project work. The USGA has successfully implemented several important research projects and kept university indirect costs down to 16 percent, or less in some cases. The members of the committee also make at least one on-site visit per year to each university to evaluate research progress firsthand and tell the USGA/GCSAA story to the university administration.

In summary, water management, and our knowledge about how much water golf turfgrasses use, has greatly improved. Turfgrass royalties, to be reinvested in turfgrass research for new varieties, started to trickle in in 1990 and 1991. At least five or six additional variety releases are expected in the next three years. Each additional new variety may gross royalties in excess of $50,000 per year for future research needs. The Turfgrass Information File, or TGIF, will be completed at the end of the year. More than 30 M.S. and Ph.D. graduate students have received degrees, and 96 scientific or technical articles have been published. Finally, 29 of the 36 projects started during the last ten years will be completed by January 31, 1993.

The future direction of the turfgrass research program will include continued involvement with conventional turfgrass breeding programs and more projects in biotech. Resource management projects will evaluate other alternative pest control programs and cultural practices that will help reduce maintenance costs. The program will continue to develop young leaders in the biological sciences and engineering. Of the 81 new pre-proposals submitted in fall 1991, 34 investigators were selected to submit full proposals for evaluation in March 1992, and 21 of those were selected for funding beginning in 1993.

Environmental

The USGA has just completed the first year of its three-year, $2.8-million Environmental Research Program. The important goals of this program are to: evaluate the impact and fate of chemicals applied to golf courses; explore alternative pest management strategies; document human, wildlife, and environmental benefits of golf courses.

The environmental research program covers a diversity of climates and geography across the contiguous United States of America. Institutions in 16 states are receiving nearly $900,000 in USGA Environmental Research grant funding. Specifically, research projects receiving grants for pesticide and nutrient fate research are located in these states: New York, Pennsylvania, and Massachusetts in the Northeast; Georgia and Florida in the South; Michigan, Iowa, and Nebraska in the North Central; and finally, Nevada, Washington, and California in the West.

The pesticide and nutrient fate projects began with a flurry of activity in 1991, and investigators have completed the construction of facilities and the development of procedures that will

(Opposite page) Research work on buffalograss establishment and cultural practices continues to aid the turfgrass industry in the utilization of this recently improved turfgrass species.

(Top) Water use, water quality, and conservation will continue to be important issues in the future. Reducing water use and maintenance costs on today's golf courses is a difficult, yet achievable goal.

(Above) Tissue culture techniques provide an effective method for screening large amounts of plant material for resistance to various biological and environmental stresses, in this case brown patch disease.

generate data on the fate of chemicals applied to turf managed under golf course conditions. An extensive quality assurance program was developed to insure that research results are of the best quality and are properly documented.

In addition, research studies concerning the evaluation and development of alternative pest management procedures have produced both interesting and promising results. Antagonistic microorganisms, nematodes, and other biological controls are being evaluated at Cornell University, USDA-ARS, University of Florida, University of California at Riverside, Iowa State University, and University of Kentucky. Much more needs to be understood about the management and efficacy of these "natural" products before they are highly recommended or widely used on golf courses.

USGA-supported projects on human and environmental benefits, wildlife toxicology, and the restoration and management of natural wildlife habitats are all making progress. As protectors of the game of golf, we need to document golf course benefits. A new book, *Golf Course Management and Construction: Environmental Issues*, is more than 900 pages in length and will be available in June of this year. This reference text is a comprehensive review of the scientific literature concerning what is known about the potential movement of pesticides and nutrients from turfgrass areas and will serve as a valuable resource text. A second book, *Naturalizing the Human Landscape*, will be available in late fall of 1992.

An article entitled "Benefits of Golf Courses and Turfgrass on the Environment, People, and Other Biological Organisms" will be submitted to *Science* magazine to initiate and encourage a factual, scientific debate on the value of golf courses in our society.

Two golf course benefits studies will be conducted over the next two years. The first is a study on the "Impact of Golf Course Activities on Wildlife." This research will tell us if, or how, pesticides and nutrients accumulate in the biological food chain. Second, a study on the "Human Benefits of Golf Course Views: Emotional Well-Being, Stress, and Performance" will be conducted.

Golf is more than just striking a small ball with a stick; it is an experience, an activity, an enjoyment of God's green earth. We need to document golf's impact on the environment and then tell the world why we value this game.