Photo by Tom Doak

PART II OF IV

TURFGRASS DROUGHT RESISTANCE

Turfgrass managers need to understand the difference between water stress and drought stress. In the second part of LANDSCAPE MANAGEMENT's four-part water series, we look at what it takes for plants to adapt to drought.

by Jeff Nus, Ph.D., Kansas State University

To gain understanding of drought resistance in plants, turfgrass managers must realize that no single factor is responsible for drought resistance. It is certainly a combination of factors that enables plants to survive conditions dry enough to kill other plants which do not have these characteristics.

An important issue in understanding drought resistance is to differentiate between drought and water stress. Drought is a meteorological term. It is defined as an extended period of low rainfall.

Water stress refers directly to the plant and occurs to varying degrees throughout the plant's life. Drought is always accompanied by plant water stress, but water stress may occur even when soil moisture is plentiful.

One definition of water stress—a lowering of the water potential—means that less energy is held within the tissue water due to a loss in turgor pressure or a concentration of solutes in the plant cells. Solutes become concentrated due to a decrease in water content or an active accumulation from the soil solution. Research has shown a day/night (diurnal) fluctuation in turgor and water potentials in Kentucky bluegrass (Table 1).

As plants develop more severe water stress (lower turgor and water potentials) during the afternoon hours, they are able to regain their water status—more positive turgor and water potentials—at night when conditions are less favorable for water loss. However, during drought stress, turgor and water potentials may only recover partially in the dark because soil moisture normally used to replace tissue water lost via transpiration simply isn't there in sufficient amounts. As a result, plant water stress increases as a drought continues.

Drought's damage

Drought affects the morphology or appearance of plants, especially the way plants grow. For example, leaves that develop during drought stress have thicker cuticles and fewer stomata. This growth pattern reduces the rate of water loss from the leaves and conserves plant and soil moisture.

During prolonged water stress, large cells collapse, resulting in leaf folding of most cool-season grasses and leaf rolling of warm-season grasses.

In addition, older leaves die, drop from the plant and contribute a mulch to the soil. Leaf senescence and death is accelerated by severe water stress. The remaining turfgrass leaves fold or roll up depending on action of cells located near the leaf midrib.

During prolonged water stress, these large cells collapse, resulting in leaf folding of most cool-season grasses (most fescues, bluegrasses, ryegrasses) and leaf rolling of warm-season grasses (Bermudagrass, St. Augustinegrass, centipedegrass and zoysiagrass). This reduces leaf area, so both radiative heat load and transpiring leaf surface are reduced. The net effect is moisture conservation.

Drought also influences delivery of photosynthates to the leaves, roots, tillers and rhizomes. Root-to-shoot ratios have been used to evaluate drought-resistant plants, because plants with higher root-to-shoot ratios are often more drought resistant. In addition, root-to-shoot ratios of plants increase during drought stress. This also is true of turfgrasses and is due to the differential sensitivities to water stress of different fractions of the plants. Research has shown that tillers and rhizomes are very sensitive to prolonged water stress (Table 1). This sensitivity accounts for much of the increase in root-to-shoot ratios of Kentucky bluegrass during drought.

Plants can be divided into three general categories concerning mechanisms of drought resistance. Those that:

1. escape drought;

2. avoid drought with high tissue water potential; and

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Turfgrass has developed water conservation mechanisms. Shown here is a cross-section of a tall fescue leaf blade (A).) with ridged upper surface and smooth under surface; (B) as moisture stress occurs, the leaf begins to roll; and (C) the final response, a tightly rolled leaf blade with the upper surface being protected to minimize water loss.

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The experience of Greenscape Lawn & Tree of St. Louis is typical of what you can expect when you use Super Trimec as your broadcast post-emergence herbicide for your first treatment of the year.

Greenscape is a quality-oriented lawn care company in Manchester, Missouri where it has easy access to the prestigious western suburbs of St. Louis. In every respect it is an extension of John Loyet, the owner and founder. A visit to Loyet's home immediately tells you that his vocation and his hobby are one and the same. His lawn is absolutely as immaculate and pristine as any ornamental turf you will ever find, as is evident from the picture on the opposite page.

The Greenscape program is based on rifle-shot care. They use granular fertilizer and handle all treatments on an individual basis of need rather than on a shotgun-type production-line schedule. They keep an eye on all of their lawns, and make it a point to be acquainted with their customers.

"For several years we've been using Trimec Applicator Formula," says Loyet, "and we've been extremely well pleased with its weed control. But the promises PBI/Gordon makes for Super Trimec are mighty hard to ignore, so in 1987 we decided to start earlier than usual and use Super Trimec in our first treatment, and then switch to Trimec Applicator Formula when the hot weather hit.

"The weed control from the early treatment of Super Trimec was so thorough," says Loyet, "that many of our lawns never did require a second broadcast. Spot treatment was more than adequate. As a matter of fact, we wound up 1987 with quite a carry-over of Applicator Formula."

A surprise benefit of Super Trimec

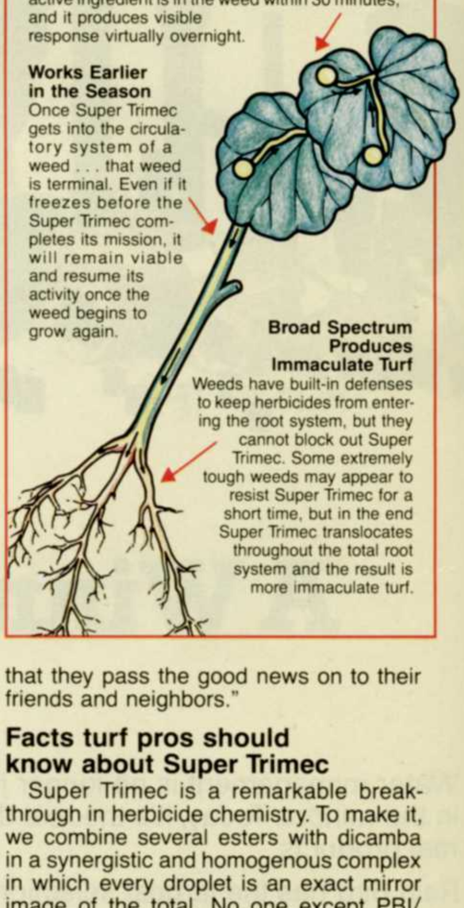
Loyet goes on to say that his customers were very pleased with the weed control of Super Trimec, and of course he was more than pleased that he was able to start earlier in the season and thus handle more customers.

"But there's another very important dimension to this," says Loyet. "Because of the way we do business, we have a chance to visit with many of our customers, and we notice they are very knowledgeable and concerned about environmental affairs. They recognize the need for pesticides, but they want to use only as much as is really needed. When we tell them that the amount of Super Trimec we use on the average lawn contains less than an ounce of 2,4-D and is biodegradable, we get very positive feedback, and we know from direct experience that they pass the good news on to their friends and neighbors."

Schematic drawing shows why Super Trimec is best herbicide for the LCO.

Fast, Visible Response Eliminates Call-backs
Super Trimec has unparalleled power to rapidly penetrate even the toughest weed. Most of the active ingredient is in the weed within 30 minutes, and it produces visible response virtually overnight.

Works Earlier in the Season
Once Super Trimec gets into the circulatory system of a weed . . . that weed is terminal. Even if it freezes before the Super Trimec completes its mission, it will remain viable and resume its activity once the weed begins to grow again.



Broad Spectrum Produces Immaculate Turf
Weeds have built-in defenses to keep herbicides from entering the root system, but they cannot block out Super Trimec. Some extremely tough weeds may appear to resist Super Trimec for a short time, but in the end Super Trimec translocates throughout the total root system and the result is more immaculate turf.

Facts turf pros should know about Super Trimec

Super Trimec is a remarkable breakthrough in herbicide chemistry. To make it, we combine several esters with dicamba in a synergistic and homogenous complex in which every droplet is an exact mirror image of the total. No one except PBI/Gordon has ever been able to do this.

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SUPER

John Loyet (right), owner of Greenscape Lawn & Tree, shows Everett Mealman the job that Super Trimec has done on his own lawn. INSET: The Irish Leprechaun that Greenscape uses as a symbol. It dates back to the days when Loyet's grandfather played football for Notre Dame's Fighting Irish. Today it is Greenscape's promise of Emerald Isle green.

The esters have unparalleled penetrating power, which enables the complex to get through the cuticle and into the circulatory system of even the toughest weeds within 15 to 30 minutes. And once Super Trimec gets into a weed . . . that weed is terminal . . . period!

But please note: the dicamba in Super Trimec is in acid form and is virtually insoluble in water. Therefore it will not migrate in soil and endanger off-target ornamentals.

Because Super Trimec is so powerful, one gallon will cover 4 acres. And yet the spectrum is so broad that it controls even such tough species as ground ivy, oxalis and spurge.

The benefits of Super Trimec

1) **You can start earlier in the season:** Super Trimec gets into the weed within 15 to 30 minutes. Thus, neither a sudden rain nor a quick freeze is a threat. This allows you to start earlier so you can handle more customers.

2) **Eliminates call-backs:** Super Trimec produces quick, visible response. Your customers *see* that it is working, so they stay off the telephone.

3) **Reduces herbicide costs:** You use less herbicide per acre and you spray fewer times per year. Both your weed control *and* your profits are better.

4) **Your customers become your salesmen:** They tell their friends and neighbors about the quality of your work and your friendliness to the environment.

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Buy a gallon of Super Trimec anytime between January 1 and April 1 of 1988. Use it according to directions and if it doesn't deliver everything we promise, send us your sales receipt, tell us where it failed, and we will send you your money back. Offer, limited to one gallon per customer, expires July 1, 1988.

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WATER *from page 32*

3. tolerate drought with low tissue water potential.

Escaping drought

Plants that escape drought are plants like annuals that can germinate quickly and complete their life cycles (seed-to-seed) before the onset of drought. The plants escape drought by surviving those periods of little rainfall as seeds. Many desert annuals have evolved the escape strategy for drought resistance.

In some ways, *Poa annua* (annual bluegrass) is like that. It germinates during the fall when there is plenty of moisture. It sets seed profusely during late spring and early summer, before severe water stress occurs. During hot, dry summer months, poa growing under unirrigated conditions may be severely thinned because the plant itself has little drought tolerance.

However, the survival of annual bluegrass is assured because its life cycle is completed, seed is produced, and it germinates when the conditions are again favorable in the fall. It should be kept in mind that poa exhibits a great deal of genetic diversity.

The growth habits of poa range from tufted, bunch-type annuals to perennial, prostrate creeping types. This diversity in growth habit suggests that annual bluegrasses may differ widely in the level of drought resistance.

Avoiding drought

The second general strategy of drought resistance is avoidance. Plants that avoid water loss during prolonged water stress by maintaining high water potentials (high content of relatively pure water) are classified as being drought avoidant. These are plants that most people associate with arid environments like cacti and spurges.

Drought-avoidant plants have very efficient means of rapidly absorbing water when it is available and have growth characteristics that inhibit water loss. These plants are characterized by thick, fleshy plant parts, very thick cuticles, suberized roots, low surface-to-volume ratios, and a system of photosynthesis which allows them to close their stomates during the day when evaporative demand is very high.

It is important to realize the nature of various adaptive features of these plants because some of these features may represent selection criteria for turfgrass breeders whose goals are to improve drought-resistant turfgrass.

Tolerating drought

The third general category of drought resistance includes plants that tolerate drought at low tissue water potentials (low content of relatively concentrated water). Many turfgrasses belong to this group. Plants belonging to this group react to prolonged water stress by making their tissue water quite concentrated with various salts, sugars and organic acids. This adaptation greatly increases the plant's ability to take up water. So, although there is less water available in the soil, the ability to extract that water is increased.

TABLE 1.

Relative growth of Merion Kentucky bluegrass subjected to increasing drought.

	RELATIVE PLANT GROWTH (%)		
PLANT	OSMOTIC PRESSURE		
PART	LOW		
MODERATE	HIGH		
Whole Plant	100*	52	29
Leaves	100	65	49
Roots	100	65	43
Tillers	100	41	12
Rhizomes	100	32	7

*Values are percentages of growth in low osmotic pressure or drought stress conditions.

Osmotic adjustment

The process of extracting water is called osmotic adjustment and serves an important purpose. Plants which can osmotically adjust can maintain turgor pressure to some degree. This is important, since turgor pressure is the driving force for cell expansion and plant growth. By maintaining turgor pressure, turfgrass roots can continue to grow and extract additional soil moisture. In addition, leaves can grow, increasing photosynthetic capacity, and stomates can stay open in the light when turgor is maintained. When stomates are open, evaporative cooling keeps the leaves from overheating. If osmotic adjustment does not maintain turgor, stomates close rapidly and turfgrass leaves soon overheat.

Several agronomically important grasses have been shown to have capacity for osmotic adjustment, including corn, sorghum, wheat and rice. Turfgrass research at Iowa State University demonstrated that Kentucky bluegrass can osmotically adjust under simulated drought stress conditions.

The recent interest in osmotic adjustment in response to water stress should not lead to false hope. It must be remembered that drought resistance is the result of many plant characteristics.

Osmotic adjustment is a process that may provide valuable insight in the development of drought-resistant turfgrasses. But it is only one process in many that deserves attention.

In addition, research has shown that the capacity of osmotic adjustment is clearly limited. That is, even plants with the greatest capacity for osmotic adjustment have a point at which it is useless to develop drought resistance because of high water needs.

Research at Kansas State University is investigating the relationship between water use requirement and capacity for osmotic adjustment in several Kentucky bluegrass cultivars. It is hoped that this research will yield information helpful to the development of drought-resistant turfgrasses.

Until more basic knowledge concerning drought resistance in turfgrasses is gained, however, performance of turf during drought is solely dependent upon the turfgrass manager's expertise.

Turf management

Management techniques have centered around the need to conserve water. They include limiting nitrogen use prior to drought's onset, tensiometer-controlled irrigation, and using wetting agents to improve wetting uniformity of the soil. Although these management strategies are certainly valuable, long range success may depend primarily on using drought-resistant species and cultivars.

Turfgrass species and cultivars that exhibit superior drought resistance and recuperative potential offer the best hope of ensuring quality turfgrass under non-irrigated conditions. It is gratifying to see that much recent turfgrass research is being conducted with this goal in mind. **LM**

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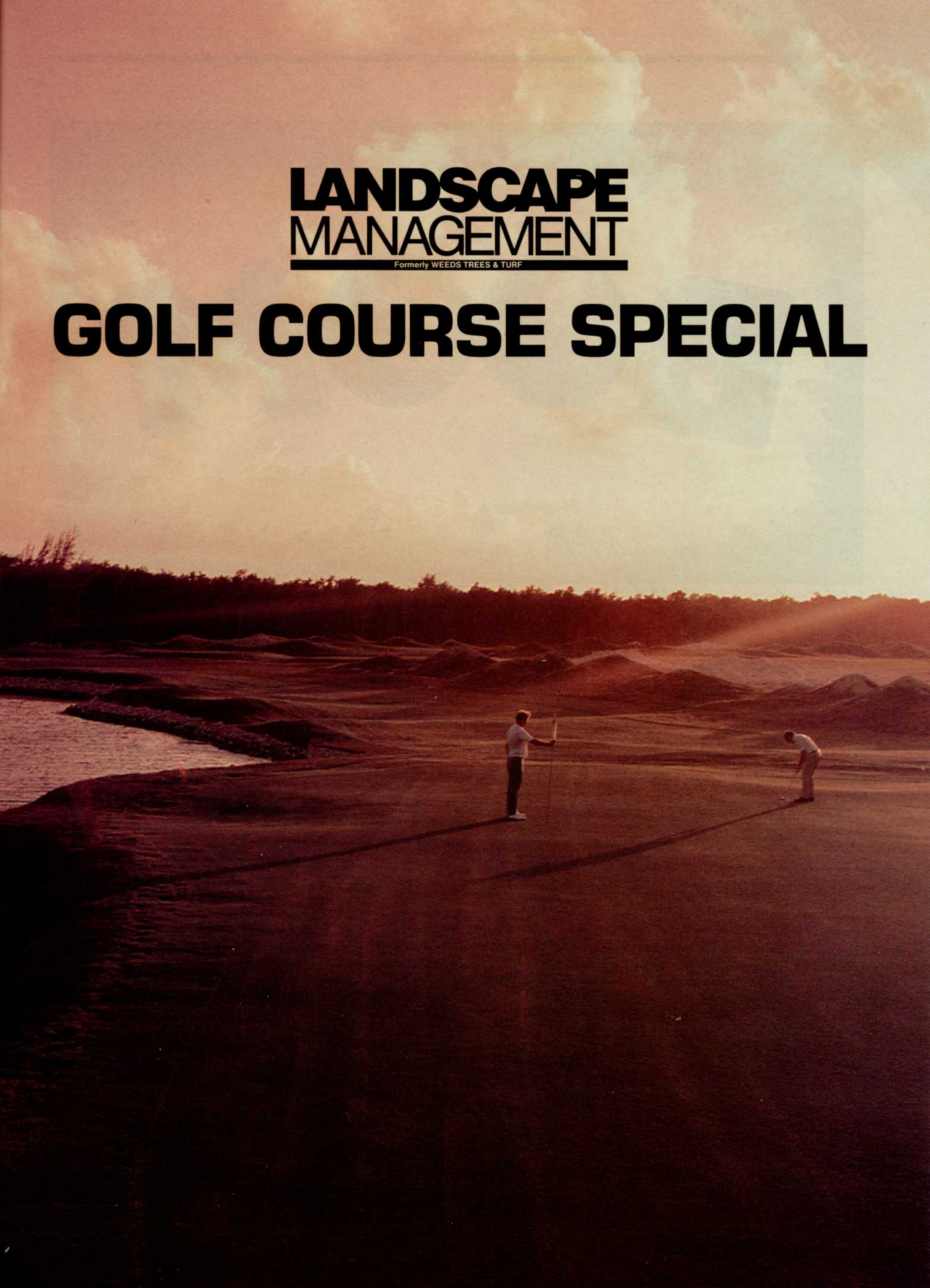

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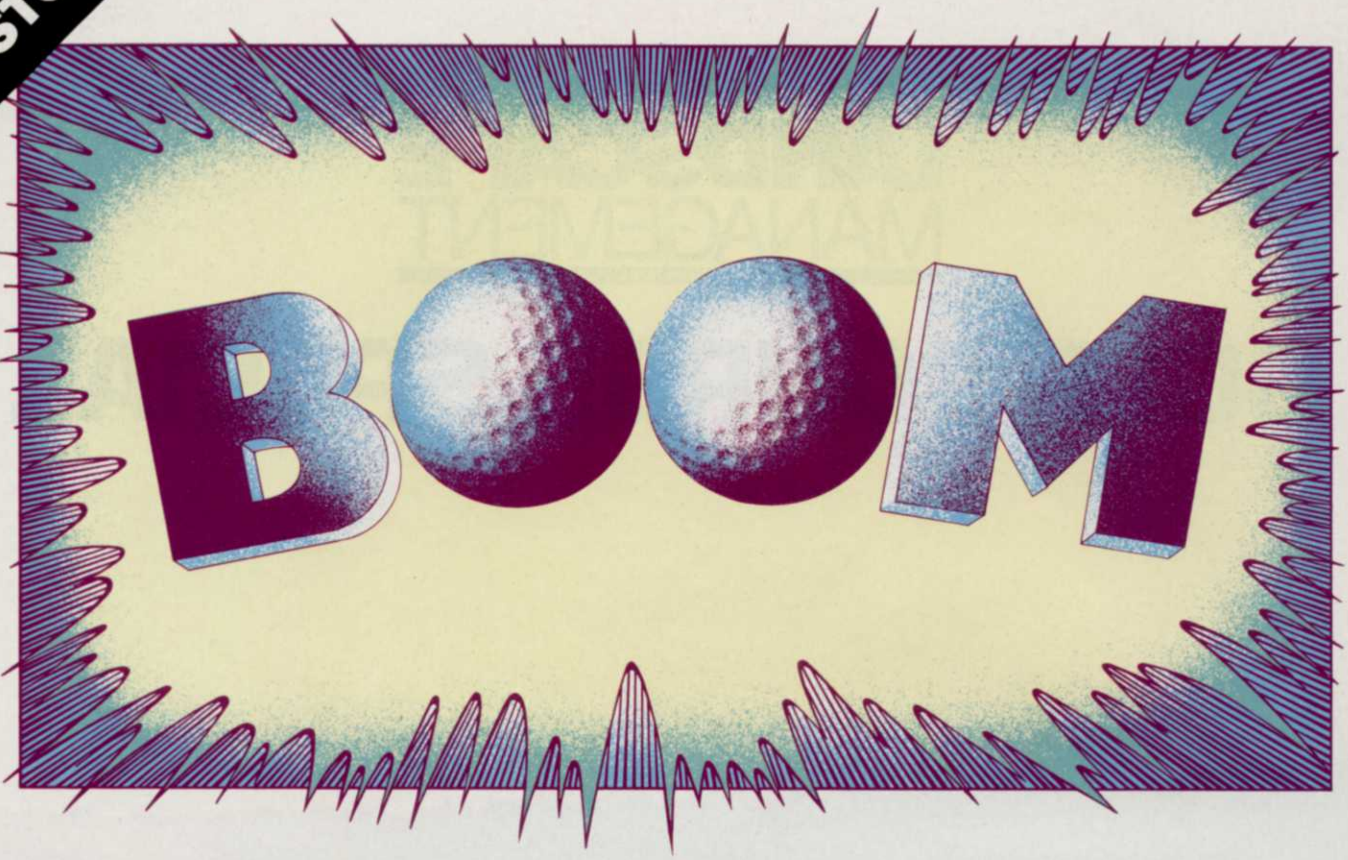

Golf course construction has reached new heights. Competition increases among golf courses to attract golfers. And that means more pressure on superintendents. It may not be the shot heard 'round the world, but it's being heard in the U.S.

by Jerry Roche, editor

Golf booms.

A record number of golf courses are in the planning stages, under construction or recently-completed, according to statistics from the National Golf Foundation. The NGF has determined that 102 new facilities were expected to open last year, 275 were under construction and 224 were being planned. More than 100 of those have opened or will open in Florida, America's favorite retirement state.

Many reasons exist for why golf booms. One of the most obvious is that post-war baby boomers are reaching ages where they are settling down to less strenuous athletic endeavors, and golf fills the bill. The NGF says that 20.2 million Americans golf today. The organization also theorizes that in 13 years, it could be 30 million to 40 million.

Robert Adams, Ph.D., of the University of New Hampshire, recently predicted "a coming crisis in golf course availability." Adams, speaking at an NGF event, said that the crisis would be the result of:

- the current inadequacy in golf course supply;
- the recent downturn in public course construction; and
- the projected significant increases in demand for golf.

Travel, too, to recreational havens like North and South Carolina is increasing. The World Tourism Organization, a division of the United Nations based in Madrid, predicts travel will be the world's largest industry by the year 2000.

"There's a sizeable market of people willing to pay top dollar for a non-plastic, uncrowded experience," says Donald Holecek of the Michigan Travel, Tourism and Recreation Resources Center. "What a lot of people need is to get away from the computer terminal and TV, and get back to situations they can control."

And—again—golf certainly fills the bill.

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the value of a golf course as a recreational facility for its residents, an attractive green belt, and as a magnet for tourists, golf course development will continue to boom," says Roger Rulevich, president of the American Society of Golf Course Architects.

Yet the increased number of courses and cries from the public for increasingly higher maintenance have placed a greater pressure on golf course superintendents: pressure to use more sophisticated chemicals, equipment and seed.

"The trend toward more play on golf courses will challenge the most sophisticated superintendent," says Don Parsons of Old Ranch Country Club in Seal Beach, Calif. "Our technology is increasing at a phenomenal rate, (but) there always seem to be new problems that rear their ugly heads."

Golf vs. EPA

One recent problem superintendents face is a more critical look at golf course pesticides by the Environmental Protection Agency.

"A large portion of our most effective chemicals have been taken off the market; some rightfully so, some not," wrote Reed LeFebvre of Plant City (Fla.) Golf & Country Club in *The Florida Green*. "We don't have the answers right now, but we are working hard to find them."

LeFebvre, president of the Florida Golf Course Superintendents Association, pointed out these figures:

- In 1977, it cost $25 to $50 per acre to treat a course for nematodes;
- In 1987, it costs up to $300 an acre to treat a course for nematodes;
- Treatment for mole crickets (a big problem in Florida) this year cost his golf course $400 to $800, depending on which rate was used.

And the problem could get worse before it gets better.

Black layer

Anaerobic black layer has taken the golf industry by storm. Every day, reports come in about another course that has developed this black layer that kills greens.

Many hypotheses have been put forth on the cause.

Michigan State suggests that the layer is made up of insoluble precipitates formed by the reaction of hydrogen sulfide with metal ions. The hydrogen sulfide is produced by anaerobic bacteria that live under high moisture conditions.

Iowa State believes that algae and their muscilagenous by-products cause poor water infiltration, thus causing the anaerobic material.

No matter its cause, attempts are being made to find acceptable solutions through university research. Until such solutions are found, superintendents cannot rest easy.

Technology

The introduction of new bentgrasses to the seed market is an indication of increased need for more material to handle more golfers. In the recent past, it has been extremely difficult to obtain bentgrass seed, so the seed industry is answering the superintendent's call.

Spurred by wholesome competition, equipment-makers continually improve their products. Despite more restrictions imposed by the EPA, chemical companies continue to release new, better pesticides. Last year, the newest control product—Triumph insecticide—received the EPA's official blessing.

The increased number of courses and cries from the public for increasingly higher maintenance have placed a greater pressure on golf course superintendents.

Infrared thermometers that can read the drought stress level of turf have hit the market. Michigan State has developed a set of disease models that are very accurate at predicting the possible introduction of pathogens in turf. Some disease testing kits have been marketed recently.

And university research is creating options to chemical control. In recent years, insect-resistant endophytes have been found in certain grasses, decreasing the need for pesticide use. Biological control for annual bluegrass is being worked on at Michigan State (see Research Update page 92).

"Biotechnology is on the cutting edge of new discoveries. They are developing plants that are disease and insect resistant," says Parsons. "They may be none too soon. The pesticide restrictions and regulations are absolutely scary. The ability to make adjustments will be essential as we continue to experience more restrictive environmental restraints."

The outlook for golf course superintendent-ing, then, is bright, despite some problems. The future looks both exciting and challenging. **LM**