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Turfgrass Advances in the 21st Century

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Prior to a crystal ball gaze into the next millennium it is important to have a proper perspective as to the major turfgrass advances that have occurred during the last century. Point in fact, most technical advances have occurred since 1945 as summarized in the following table.

Evolution of Turfgrass Advances Since 1945.

Time period	Key areas of research emphases and achievements
1945–55	• Selective broadleaf weed control: phenoxy-herbicides.
	• Insecticides developed for efficacy and persistence.
1950–60	• Equipment: powered coring, slicing, spiking, and vertical cutting machines.
	• Mowing practices—heights and frequencies specific to species.
	• Culture of turfgrass communities: mixtures and blends.
1955–65	• Post- and pre-emergence grassy weed control through selective herbicides.
	• Turf-type fertilizer ratios and formulations.
	• Warm-season cultivar development: bermudagrasses and zoysiagrasses.
1960–70	• Root zone modification, Perched-Hydration Method.
	• Turfgrass establishment techniques, improved mulching methods.
1965–75	• Cool-season cultivar development: Kentucky bluegrasses, perennial ryegrasses, and tall fescues.
	• Sod production cultural practices and specialty equipment.
1970–80	• New disease characterizations, plus systemic fungicides.
	• New nutritional practices, emphasizing potassium and iron plus autumn fertilization.
1975–85	• Turfgrasses stress tolerance enhancement: cold, heat, drought, wear, and shade.
	• Plant growth inhibitor advances.
1985–95	• Cultural practices and cultivars that conserve water, energy, and nutrient resources.
	• Prediction modeling for ET and pests.

As shown in the table, there have been dramatic advances in the science of turfgrass management during the 20th century. Equally dramatic changes will occur in the 21st century as well. The following sections on turfgrass advances for the 21st century involve a considerable amount of crystal ball gazing, which is a high risk endeavor. Some may prove correct and some innovations will not be mentioned. This is to be expected. The main focus is to stimulate the thought processes of our readership as to what changes may occur and how these changes may affect their own professional activities.

New Turfgrass Species and Cultivars

There will be a number of new species introduced for turfgrass use in North America. Most will be low maintenance turf-

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grass species. Examples include such warm-season turfgrasses from southeast Asia as sarangoongrass (*Digitaria didactyla*) and tropical carpetgrass (*Axonopus compressus*). Cool-season turfgrasses that may emerge include Idaho bentgrass (*Agrostis idahoensis*) and tufted hairgrass (*Deschampsia caespitose*). In addition, multiple cultivars of such species as kikuyugrass (*Pennisetum clandestinum*) and seashore paspalum (*Paspalum vaginatum*) may become available. There will be other turfgrass species that will receive attention and be introduced into various parts of the world as we become more and more a global community.

Concerning new turfgrass cultivars, the greatest need is improved resistance and/or tolerance to environmental stresses such as drought, heat, cold, wear, and shade. To date turfgrass breeders have emphasized turfgrass characteristics and resistances to certain pests. There is a great need to refocus attention on developing improved stress tolerant cultivars, which will in turn result in healthier, stronger plants that will be even less prone to a broad range of weed, disease, and insect pests, thereby reducing the pesticide need.

Transgenic turfgrass cultivars will play a very important role in the 21st century, similar to what is developing in medical applications, pharmaceuticals, and food crops. Currently, there is a significant activist movement focused on blocking this advance in food crops. At one time the horse enthusiasts put up great resistance to the introduction of the automobile. These advances are of the magnitude that will eventually come to the fore. The approach most probably will be through proper labeling to offer choices for the end user and through appropriate safety research and development of these new transgenic materials. These new cultivars will possess internal resistance to the major diseases and insects, which will significantly reduce the need for pesticide use. There also are genes already developed that provide enhanced rooting and drought resistance. Other genes allow seed germination at very low soil temperatures or impart foliage color modification, with many more types of genes yet to be identified.

Some day is it possible that professionals may be growing turfgrasses that are basically red or yellow in color? One might call this a "Star Turf" concept, which is a spin off of the popular term Star Wars.

Pest Management

The amount of pesticide usage can be expected to decline (1) as better turfgrass cultural practices are developed, (2) as more sophisticated techniques such as physiological modifiers and enhancers are introduced and their use becomes widespread, and (3) as turfgrass cultivars are developed with resistances to a wider array of pest disease and insect problems. The transgenic cultivar techniques will provide the most rapid advances in this regard.

By the same token, there will be a need for certain pesticides to properly manage turfgrasses to meet the functional, recreational, and aesthetic needs of people living in densely populated urban areas. There will be continued emphasis on integrated pest management (IPM) practices, including more sophisticated scouting techniques and the development of computer-based prediction models for individual disease and insects that are derived from the monitoring of key microenvironment parameters.

Future pesticides will be more target-pest specific. There will be an increase in spot treatment of key problem areas rather than broad-area treatment. Finally, there will be an increased requirement for documenting of scouting activities on which pesticide use decisions are based, as well as documenting the specific procedures followed and materials used on a given turfgrass area.

Weeds. Weeds have been the number one problem in turfgrasses. Actually, 90% of the potential weed problems are controlled through proper mowing and the use of adapted turfgrass species. The development of more stress tolerant and pest insect and disease resistant cultivars will result in dense, persistent turf stands that will provide increased competitiveness against the encroachment of weeds. Most probably there will be an increase in the corrective treatment of weed problems relative to preventive applications. A survey of key research scientists raises serious questions as to just how effective the new biological weed controls, such as certain bacteria, will be in the control of turfgrass weeds.

Finally a "Star Turf" perspective. This could involve the development of a herbicide applicator that moves across the turf area with forward monitoring devices that identify the particular weeds in the plant community. By onboard computer models the appropriate pesticide and rate will be selected, and subsequently the specific area onto which the herbicide treatment is to be made is automatically controlled. Impossible?

Diseases and Insects. It is likely that some significant new species of both pest diseases and insects will arise in the 21st century. In addition, target-specific pesticides will be developed that affect only the causal fungal pathogen or insect pest of concern. Emphasis will be placed on curative rather than preventive pest control solutions. Transgenic turfgrass cultivars with resistance to the major pest diseases and insects will be a key advance during the 21st century.

It is the consensus of knowledgeable turfgrass pathologists and entomologists that biological techniques for the control of either insects or diseases will not approach the success rate achieved with chemical materials. In the case of diseases, a limited degree of control will be achieved for certain foliar pathogens, but control of soil-borne causal pathogens of patch diseases is highly unlikely. By the same token, a limited degree of control can be anticipated for foliar-feeding insect species, such as cutworms and armyworms, via sustained applications at frequent intervals. However, there is little potential for the control of soil-inhabiting, root-chewing insects. Thus, the biological control approaches may be used if the customer or end user will accept partial control with noticeable turf damage and/or the pest problems in a specific area are limited to certain foliar active disease or insects of minimal severity.

Concerning a "Star Turf" development, what about a miniaturized monitoring unit located on key representative turfgrass

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FEATURE ARTICLE

Sod Webworms in Fairways and Putting Greens

Daniel A. Potter

Ordinarily when insect damage shows up in creeping bentgrass putting greens, we assume that cutworms are at fault. **This past summer, though, sod webworms reached outbreak levels on fairways and putting greens of many golf courses in the eastern half of the United States.**

Sod webworms are the larvae of small, buff-colored "lawn-moths" that often hover over turf while laying eggs at dusk. The larvae make silk-webbed tunnels in the thatch and soil, about the diameter of the stem of a golf tee. At night, they chew down the grass, leaving small sunken trails in the turf. In creeping bentgrass, the damage can look like some strange patch disease. The damage is compounded when flocks of foraging birds pull up tufts of grass to get at the larvae. Sod webworms don't form webs over the turf surface—those small patches of webbing made visible on the surface of greens and fairways by dew are the work of small, harmless spiders. A soap flush (2 tablespoons [30 mL]) of lemon-scented liquid dishwashing detergent in 2 gal (7.6 L) of water poured or sprinkled over 1.0 yd^2 (0.8 m^2) of turf will bring the small spotted caterpillars to the surface in 10 to 20 minutes. They don't come boiling out of the ground like cutworms and armyworms do.

I believe that the recent outbreaks of sod webworms in bentgrass fairways and putting greens were drought-related. Our problems in Kentucky seemed to be mainly from the bluegrass webworm (*Parapediasia teterella*) a ubiquitous species that normally is more abundant in roughs. Like most webworms, it has several generations per growing season. By mid- to late summer, the turf in nonirrigated roughs had become so dry that the moths were forced to lay their eggs in irrigated turf. As summer progressed, the population became increasingly concentrated on fairways and greens.

Sod webworms are fairly easy to control. **Pyrethroids are fast and effective, and offer the advantage of very low use rates and low toxicity to mammals, although pyrethroids are very toxic to fish.** In our tests, pyrethroids such as bifenthrin (Talstar), cyfluthrin (Tempo), deltamethrin (DeltaGard), and lambda-cyhalothrin (Scimitar) typically provide better than 95% control within one day. Organophosphates or carbamates such as acephate (Orthene), bendiocarb (Turcam), carbaryl (Sevin), chlorpyrifos (Dursban), and trichlorfon (Dylox) also work well. We've also had good success with the sprayable formulations of halofenozide (Mach 2) and spinosad (Conserve), two of the newer, reduced-risk insecticides.

Use liquid applications when treating for sod webworms, and postpone irrigation at least overnight. Treatments can be applied when damage begins to build up, or timed by watching the moth flights which precede each of the two to four successive generations or broods. Eggs hatch in about a week, so **timing applications for 2 weeks or so after peak moth activity will coincide with feeding of the young larvae.** Gempler's (tel. 1-800-382-8473) markets inexpensive kits containing sticky traps and lures with the sex pheromone of the bluegrass webworm. These traps attract only the harmless male moths from relatively short distances away. By placing one or more traps in low-lying trees or shrubs near infested areas, you can monitor the moth flight for spray timing, and also get a feel for where the highest levels of that species may occur.

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sites that contains computer-based prediction models with the findings derived from the sensing of key microenvironmental factors? The results are then transmitted to a central operations facility where the responsible individual can monitor the potential for various turfgrass disease and insect pests to occur in the upcoming few days or weeks, as well as suggested turfgrass cultural practices which should be considered within the particular environmental conditions relative to projected turfgrass shoot and root growth activity.

Energy and Water Conservation

Energy. Recent energy prices in the United States have minimized the concern about energy costs, that were an issue during the 1970s. However, high energy costs will reoccur during the 21st century, particularly as related to gasoline-powered internal-combustion engines. The conservation of energy should be a priority. Thus, it is important to give appropriate consideration and action to (a) energy efficient vehicles and machines,

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(b) efficient vehicle routings, (c) low-pressure irrigation systems and energy-efficient pumping stations, (d) turfgrass cultivars with slow vertical leaf extension rates to reduce the mowing frequency, and (e) use of recycling approaches where appropriate. These are just some of the many efforts that can be made to conserve energy.

Water. While energy will most probably be available, although at a higher cost, this may not be true for water in terms of turfgrass use. In some arid regions water use for turfgrasses may be severely restricted, and in certain semi-arid regions it may be available but at a very high cost, including the purchase of reclaimed water. Water conservation should be an ongoing priority in turfgrass maintenance including (a) the need to develop improved, efficient irrigation systems in terms of both operational hardware, and controllers, as well as the design itself, (b) increased use of evapotranspiration prediction models, typically involving the modified Penman equation, (c) increased role for reclaimed water, (d) the development of turfgrass cultivars with even lower evapotranspiration rates and enhanced root systems for dehydration avoidance, (e) development of improved drought resistant turfgrass species and cultivars, and (f) increased use of water harvesting techniques in the original design and construction of turf sites. These are only a few of the many approaches that will be employed increasingly in an effort to conserve our valuable water resource.

Cultural Practices

Like other aspects in growing turfgrasses the cultural practices also will have significant advances in the 21st century. These can be divided into the specialty areas of fertilization advances, physiological and growth regulation, computer-integrated agronomic applications, and matrix stabilization of high-sand, intensively-trafficked root zones. These four areas will be discussed in the following subsections.

Fertilization Advances. There will be continuing trends to lower nitrogen fertility levels, combined with higher rates of potassium and iron usage. The latter two will be especially important on intensively trafficked turfs.

There should be increased use of controlled-release fertilizer carriers, especially for nitrogen and potassium. In addition, there is further room for improvements in the types of controlled-release fertilizers available. While turfgrass science has led the entire fertilizer industry in the development of controlled-release fertilizers, we may still be only 50% advanced in achieving the ultimate product. Foliar fertilization will receive increased emphasis for environmentally sensitive areas.

Nutrient management plans will become important and may even be required by government legislation at some time in the future. This would be in addition to stringent requirements relative to recording and reporting fertilizer application practices.

Finally, regarding "Star Turf." A major advance in fertilizer applicators could be a forward-sensing device which determines the comparative need for nitrogen fertilizer. The radiation-based sensors would generate information that is fed into the onboard computer that determines and directs the amount of nitrogen fertilizer to be applied to any given micro-area, as the applicator device moves across the turf site. Yes this is possible, but when will it become economically and environmentally practical?

Physiological and Growth Regulation. Major advances in plant growth regulators have been achieved in the past two decades. However, there is much potential for further developments. Included are growth regulators that reduce the growth of individual plant morphological structures as well as differential effects at the interspecies level.

In addition, physiological regulators will be developed that are active in the enhancement of tillering, rooting, color, antisenescence, and stress tolerance such as heat, cold, and drought. These types of materials will probably be applied by a foliar method.

Computer-Integrated Agronomic Applications. Computers will play an increasingly definitive role in most phases of turfgrass culture. This will include automatically monitoring and processing both the atmospheric and soil microenvironmental perimeters that affect turfgrass growth as well as diseases, insects, and weeds. These types of site-specific information will be integrated by computers into prediction models to forecast (a) the timing and amount of irrigation needed, (b) the likelihood of specific disease, insect, or pest occurrences, and (c) the appropriate timing for specific cultural practices including fertilization, winter overseeding, and turf cultivation. From a mechanization standpoint, computers will play an increasing role, along with laser applications, in the operation of mowers, pesticide applicators, and fertilizer spreaders.

Root Zone Stabilization. Intensively trafficked turfs such as for sports fields, recreational areas, and park grounds will be subjected to greater soil compaction problems. Further advances will be made in the use of more permeable root zones, which will be stabilized by interlocking mesh matrices that provide not only stabilization of the permeable root zone, but also flexing self-cultivation activity and nutrient exchange sites.

Summary

The 21st century will offer many new challenges. Some individuals may view them as problems, while others see opportunities. There will be an increasing need for turfgrass managers with sound technical-based expertise who have both formal education in the agronomic-soil dimensions combined with real-world field experience. These turf managers will experience increased demands in terms of management skills, such as systems organization, personnel management, record keeping, cost control, and budgeting. It is not uncommon for many turf facilities to employ assistant turf managers. In the future, it may become more common to also have a business manager to support the overall operations of the turfgrass manager. The bottom line will be to maximize the cost efficiency of turf facilities while producing high quality functional turfs that are being subjected to ever increasing intensities of use.