James B. Beard

21ST ILLINOIS TURFGRASS CONFERENCE

DECEMBER 16-18, 1980

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ILLINOIS TURFGRASS FOUNDATION

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This publication was compiled and edited by Thomas W. Fermanian Assistant Professor of Horticulture, University of Illinois at Urbana-Champaign.

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Donald P. Nowotny

Good landscaping in a property attracts both buyers and tenants. One of the most obvious ways in which landscaping pays off is that it enhances the market value of the property. Another consideration is corporate image; the desire to be accepted by neighbors often motivates a company to create a beautifully landscaped plant or office building. Furthermore, landscaping can be an employee-recruiting asset, particularly if the landscape plan provides areas for employees to enjoy a relaxing picnic lunch by a pond, or on the lawn.

Landscaping can be used to conceal as well as enhance. For many of today's corporate structures in the suburbs, a large parking lot is a necessity. Parking lots are seldom beautiful, but they can be effectively screened and made to blend with the land plan by the use of border plantings and trees within the lot itself. Mounds in parking lot islands can screen the lot from the building. Clusters of trees and shrubs with the use of mounds will soften the view if not totally conceal the vehicles in the parking lot.

Landscaping should not be an afterthought, something tacked on after everything else has been completed. The companies that have done the best job with the landscape are those that employed a landscape architect from the very beginning.

In specific situations, a landscape architect can suggest ways to save money. On some jobs, thousands of pounds of earth must be moved to prepare the site for construction. Often this soil is hauled away to another location at great cost. The landscape architect may recommend that the surplus fill be used to contour the site, creating mounds. Thus functional problems are solved, the site becomes visually interesting, and the client is saved the cost of moving the soil off the site.

Water is another element that can add interest to the overall landscape design. Often, storm water detention and retention basins are planned and dug without consideration to their appearance or their maintenance. However, although these basins are primarily functional, they can be designed to be visually pleasing. Also, if they are laid out and contoured properly, they can be maintained more easily. Lakes can, therefore, serve as detention for storm water, and can also be aesthetic features of the site.

Even a mature environment can be created immediately. Some companies spend thousands of dollars to plant many 30-foot trees with rootballs weighing up to 12 tons on their grounds. It takes special equipment and talent to handle these large plants.

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Although many clients think of the first cost of initial design and the installation, they should also be concerned with the ongoing cost of maintenance. The beautiful lawn that looks so inviting will have to be mowed, watered, and fed. Shrubs and trees that make such a visual impact will need pruning, watering, and spraying. If maintenance is not kept in mind when a company and its landscape architect/contractor draw up the landscape plans, the client may be faced with high costs to keep up the original appearance; if not, the landscaping may deteriorate. In fact, poor planning can lead to deterioration despite high maintenance costs. An initial low cost landscape plan could lead to a high maintenance cost, and a plan with a high initial cost can prove to be relatively inexpensive to maintain.

There are certain elements of maintenance that are affected by the physical characteristics or design of the site, including natural or manmade contours, water bodies, parking areas, walkways, and the size and location of structures. The steeper a contour, the more prone it is to erosion. If the slope is greater than three to one, it becomes hard to mow. The flatter the site, the easier it is to maintain. But this does not mean a site should be level. Contours are desirable for aesthetic reasons, for greater privacy, and for drainage. So a compromise may be needed to determine the size, extent, and slope of contours on an industrial site.

Trees in parking lots are a major maintenance problem because of root rot from too much water. Most parking lots are made of asphalt. When the lot is new, all the water drains off, but cracking inevitably develops. Rain water soaks through the cracks, percolates through the gravel, and then collects along the compacted clay base because it cannot soak through any further. If a tree is planted in a parking lot island, the hole dug for the tree punctures this compacted layer of clay; thus the tree hole, in effect, becomes a basin in which the water collects and remains, since the clay is impenetrable. Consequently, the trees die because of too much water. The way to avoid this problem is to build mounds or planters that keep the roots so high that water does not collect in the hole. It costs more to plant this way, but since it avoids having to replace the tree, it is worth the extra money.

Most plant materials require four things; water, feeding, pruning (including mowing or trimming), and occasional insect and disease control. Lawns may be less expensive to install than trees, but they require considerably more maintenance to look good. They need mowing once a week (in some cases as frequently as every three days), watering, feeding four or more times a year, and periodic applications of weed and disease control. Trees are the most expensive plant material to install, but they require the least care once they are established.

Regardless of the plant material used, one point should be kept in mind: the first two years are the most critical in establishing the landscape. Therefore, the highest degree of maintenance is required during this period. It is very important to select plants that are horticulturally appropriate; that is, suited to the climate, soil, and particular location.

Whether a building is new or old, good landscaping can enhance its marketability, improve the compatibility of the building to its surroundings, contribute to energy savings, improve working conditions and productivity, and cement good community relations.

THE SEASONAL ROOT RESPONSES OF *POA ANNUA* AND CREEPING BENTGRASS UNDER PUTTING GREEN CONDITIONS

K.J. Karnok and R.T. Kucharski

The control of annual bluegrass (*Poa annua*) on golf course fairways and greens has been of significant interest to turfgrass researchers throughout the United States for many years. Unfortunately, after considerable time and effort, there is not much more known about the successful control of this grass species now than three decades ago. It is true that under certain conditions, including geographic location and varied management practices, high populations of *Poa annua* can be reduced or avoided; however, eight- to ten-year-old golf courses located in cool, humid regions generally contain high percentages of *Poa annua*.

Without question, under optimum conditions *Poa annua* provides one of the finest playing surfaces possible. However, serious problems arise when conditions turn from the optimal to suboptimal. High and low temperatures as well as drought can be devastating to *Poa annua*. The fact that *Poa annua* can provide an excellent playing surface has raised the question of trying to culture the species. In other words, management programs that encourage optimal health and vigor and in turn improve the tolerance of the species to environmental stresses need to be developed. Researchers at Ohio State University (OSU) agree with this concept. However, before cultural studies involving fertility, irrigation, and cultivation could be initiated, it was felt that much about the normal growth and behavior of *Poa annua* had to be investigated. A search of the scientific and semitechnical literature brought to light many articles on *Poa annua*. One particularly good publication highly recommended to all golf course superintendents was written by Beard et al. in 1978. Although much has been written about the species, it was clear that very little was known about its normal growth behavior, particularly its roots, under actual field conditions. Since detailed information was lacking, it was deemed necessary to examine the seasonal growth responses (in roots and shoots) of *Poa annua* under field conditions.

To facilitate the continuous monitoring of *Poa annua* growth under field conditions, construction of a rhizotron began in the summer of 1977. A rhizotron is an underground root observation laboratory that allows the investigator to observe root growth through glass windows. The primary advantage of such a facility is that it provides nondestructive measurement of the root system under field conditions through the entire year. The rhizotron at OSU consists of 30 observation cells located in the observation walkway (Fig. 1). At the end of the walkway is an instrument room which houses instrumentation for monitoring air, soil, leaf, and canopy temperatures, relative humidity, wind direction, wind speed, and solar radiation. Adjacent to the instrument room is a water reservoir room used in conjunction with the lysimeter portion of the facility. The lysimeter allows water use rates to be determined concurrently with root observations.

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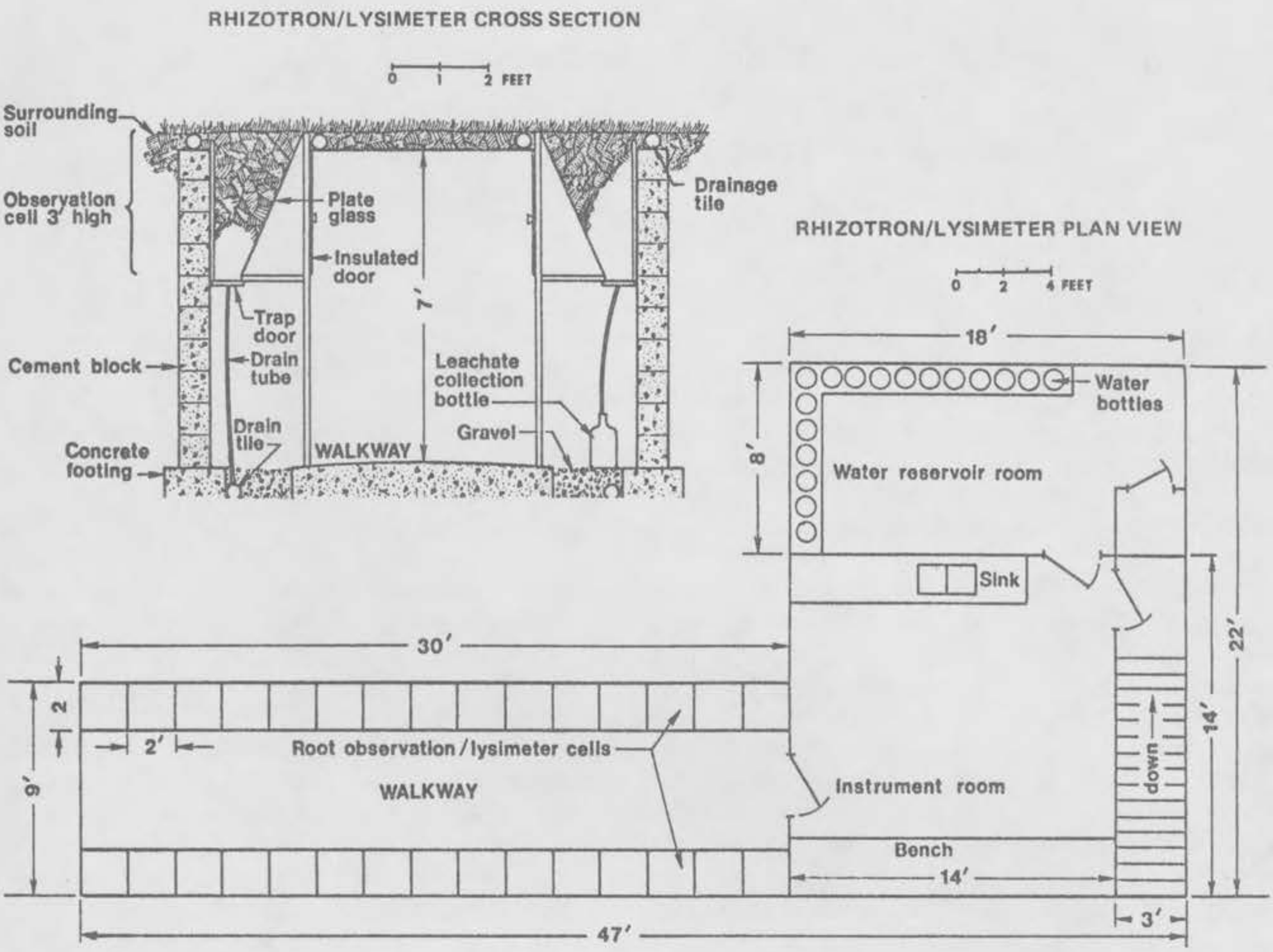

Figure 1. Rhizotron/Lysimeter.

POA ANNUA AND CREEPING BENTGRASS ROOTING STUDY

Although the total growth behavior of *Poa annua* was initially the primary objective, it was also considered important to monitor the root responses of its close counterpart, creeping bentgrass. Therefore, in the fall of 1978 sprigs of Penncross and *Poa annua* were removed from a golf green in northern Ohio and transplanted into flats in a greenhouse. The plant material was increased to complete sod covers by the following spring. On July 13, 1979, the sod pieces were removed from the greenhouse and placed on the rhizotron observation cells. Each observation cell contained a washed quartz sand having a pH of 6.6. Mowing height throughout the study was maintained at 3/16 inch. The turf received five pounds of actual nitrogen per 1000 square feet throughout the growing season. A preventative fungicide program was used as well as sufficient irrigation to prevent wilt.

OBSERVATIONS ON SEASONAL ROOTING GROWTH

Almost immediately following the placement of sod on the rhizotron cells, dramatic rooting differences were noted between the two species. Through the first summer, the bentgrass showed much more active rooting than the *Poa annua* (Fig. 2). Active rooting (new initiations and growth) for both species was reduced significantly in the last fifteen days of August. Throughout the remainder of the first growing season, Penncross showed as much as five times more active rooting than *Poa annua*. It is interesting to note the almost total cessation of *Poa annua* root

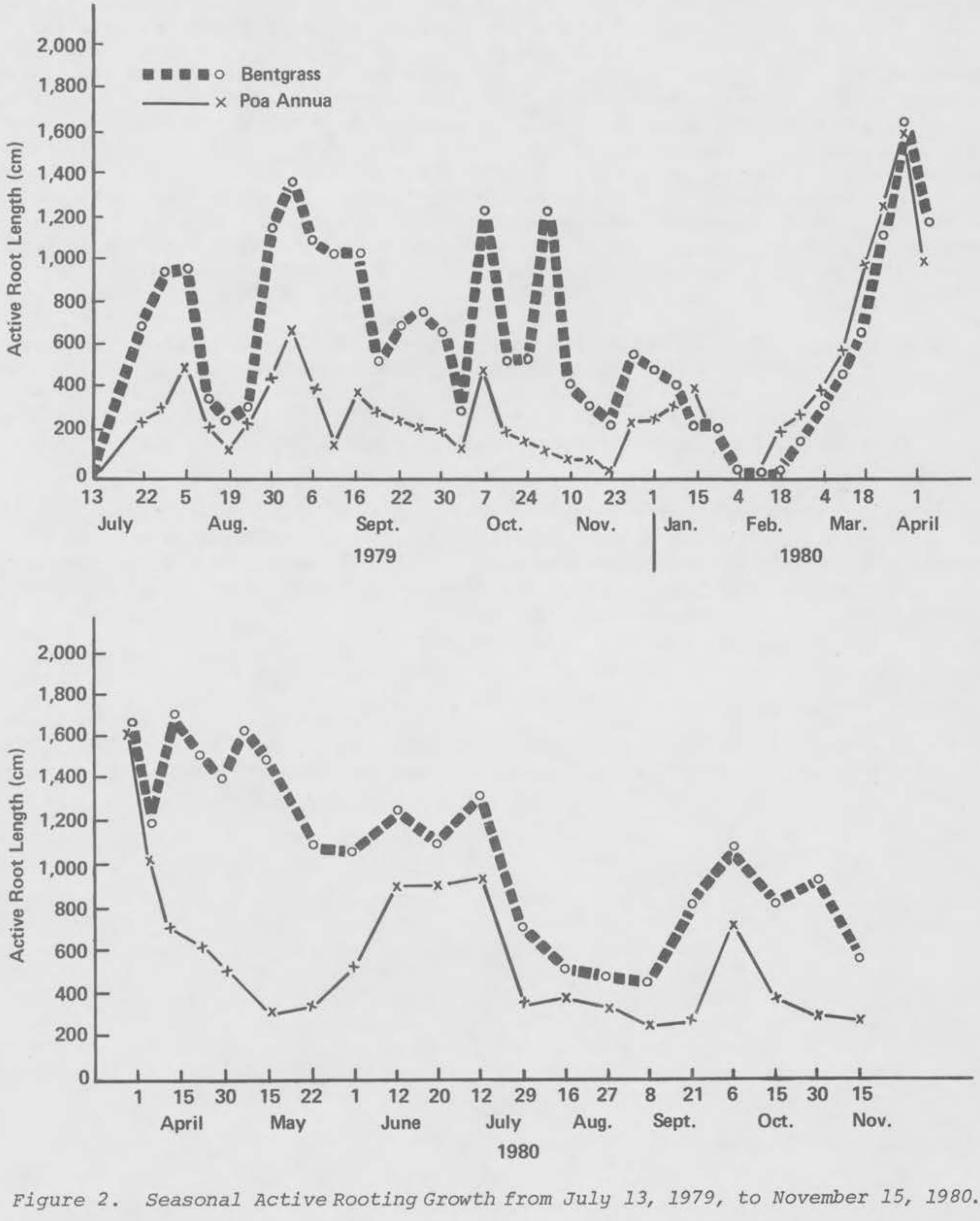

Figure 2. Seasonal Active Rooting Growth from July 13, 1979, to November 15, 1980.

growth at the November 23 observation. This decline in *Poa annua* rooting, occurring between October 15 and November 23, preceded that observed for Penncross by almost three weeks. Similar, but even more striking, is the dramatic reduction of active rooting by *Poa annua* in the spring, from approximately April 1 through May 15. This reduction in *Poa annua* rooting coincided with the appearance of seed head formation. Apparently the plant was using all available carbohydrates (food reserves) for seed formation rather than for initiation and growth of new roots. Although significant root behavior differences occurred during the first fifteen months of this study, there were no significant differences in the turf quality of the aerial parts of the two species. Furthermore, even though *Poa annua* exhibited a less extensive root system than Penncross, no significant loss of turf occurred. This fact can in part be explained by the preventative fungicide program and the relatively mild summers of 1979 and 1980.

When studying the seasonal active rooting graphs of the two species, the many implications are obvious. By knowing the behavior and relative activity of the root system of a turfgrass species at any given point in the growing season, the turfgrass manager is better able to select the cultural practice (fertilization, cultivation, pesticides, etc.) that will encourage the maximum health and vigor of his turfgrass.

It should be pointed out that the rooting responses presented in Figure 2 do not represent a full two years' data. It is generally accepted that a minimum of two years' data be recorded before firm conclusions are drawn. Therefore, the rooting response of *Poa annua* and creeping bentgrass at OSU will be continued at least one more year in order to be more valid.

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HEAT STRESS AND COOL SEASON GRASSES

David J. Wehner

In much of Illinois, the summer of 1980 was characterized by high temperatures and an absence of rainfall. These conditions made it difficult to grow high quality turf. The purpose of this presentation is to discuss the effects of heat stress on cool season grasses, and to suggest management practices that will help reduce the possibility of heat injury to the turfgrass stand. Although drought stress frequently combines with heat stress to damage the turf, this discussion will concentrate on heat stress.

It is important in a presentation on heat stress to recall the optimum temperature for the growth of cool season grasses. According to Beard (1973), the optimum temperature for the short growth of cool season grasses lies within the range 60-70°F, while optimum root growth occurs at soil temperatures of 50-60°F. When the soil or air temperatures deviate from these optima, there is, first, a reduction in growth, and then, when extreme temperatures are reached, possible injury or death to the plant.

The terms *stress*, *strain*, *indirect heat injury*, and *direct heat injury* are used by scientists to characterize the exposure and response of plants to high temperatures. Stress is an external factor acting on the plant. The most common plant stresses are heat or high temperature, drought, and cold or low temperature. When a stress acts on the plant and produces a change in its metabolism, the change is called a *strain*. The strain may be temporary if the stress on the plant is of brief duration or low intensity. If a stress of sufficient magnitude affects the plant, the strain may not disappear when the stress is removed, and thus the plant is injured permanently.

Indirect heat injury occurs when the plant is exposed to long periods of moderately high temperature (85-110°F). The injury is considered indirect because the damage results from the disruption of a necessary plant process, causing a buildup of a toxic substance in the plant cell or some other type of complication. Long exposure to high temperature reduces the rate of root initiation and growth. Also, the plant might use its food supply faster than that it produces by photosynthesis. Unfortunately, the plant may not show a distinct visible symptom to tell the manager that there are problems. The turf is simply weakened, and may be damaged more easily by disease, traffic, or other stress.

Direct injury occurs when the plant is exposed to high temperatures (above 110°F) for short periods of time (30 minutes or less). In this case, the heat destroys proteins, enzymes, or other constituents in the plant cells, and injury or death occurs immediately. An example of such an injury would be the brown spots that occur on the turf when a car is parked and the catalytic converter or muffler radiates high heat. The injury occurring on annual bluegrass during hot weather is probably direct.

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The relative importance of direct and indirect injury in turfgrass culture is not known. The two types of injury have a dose-time relationship. In work done in the 1920s with beets, it was found that an exposure of 104°F resulted in death of the beets after 25 hours, while an exposure of 140° resulted in death after only 40 seconds.

While indirect injury occurs during prolonged spells of high temperatures such as we had last summer, direct injury can occur any time the plant stops transpiring. Transpiration is the process by which heat is dissipated through the vaporization of water. When transpiration stops because of dry conditions or at midday when there may be a temporary water deficit, the temperature of the plant can rise to dangerous levels. The rate of transpiration can also be slowed when there is high atmospheric humidity. Scientists have found that plants can stand much higher temperatures when the humidity is low.

The susceptibility of turf plants to heat stress depends on their age, the management they have received, and the environment to which they are being exposed. The turfgrass manager has control over the fertilization, irrigation, and mowing the plants receive. There are several factors the turf manager should consider regarding heat stress and injury in cool season turfgrasses.

SYRINGING. When a light application of water is made to the turfgrass stand, the practice is called syringing. The benefit of syringing is that it prevents midday water stress, which can reduce transpiration. In research done at Michigan State, it was found that syringing a bentgrass putting green at 11:00 A.M. helped reduce the afternoon temperature of the grass by 10°F compared to an area that had not been syringed. Syringing should be practiced with caution in areas of very high humidity. Since transpiration is slowed by high humidity, the additional water applied during syringing may not help, and in some cases it will promote disease activity.

PROXIMITY OF STREETS AND BUILDINGS. Turfgrasses exposed to high heat loads because of such proximity should be watched for signs of heat stress. If these areas are under high maintenance, syringing may be necessary to help lower the temperature of the turfgrass stand. Landscaping materials should be placed so that air flow to these areas is not impaired.

FERTILIZATION AND IRRIGATION. The turfgrass manager should try to keep the turf hardy by avoiding excessive feeding and watering. In research done at the University of Maryland, the temperature required to improve plant maintained in lush conditions was 4°F lower than that required to injure plants maintained in hardy conditions. There are no set rules regarding the amount of nitrogen that will cause a drastic reduction in heat tolerance. Use the minimum amount of nitrogen needed to provide the quality of turf you desire. Also, irrigate deeply but infrequently. Turfgrass stands should not be kept constantly wet.

HEAT TOLERANT SPECIES AND CULTIVARS. There are differences in the heat tolerance of the turfgrass species. Tall fescue and creeping bentgrass are more heat tolerant than Kentucky bluegrass that in turn is more heat tolerant than annual bluegrass, perennial ryegrass, and fine fescue. Consideration should be given to using some of the new tall fescues instead of bluegrass. They are more heat and drought tolerant than bluegrass and produce a higher quality turf than Kentucky 31 tall fesuce. Not much information is available regarding the relative heat tolerance of cultivars within a given species. I am sure this will be an area of research receiving more attention in the future.

The turfgrass manager must be aware of all the inputs which affect the quality of the turfgrass stand. As mentioned earlier, fertilization and irrigation practices influence the heat tolerance of turfgrasses. Moreover, mowing practices and pesticide usage, by affecting the rooting depth and thatch accumulation in the stand, are indirectly related to heat tolerance. It is easy to see that there are complex interactions at work. By keeping informed of the latest research results, the turf manager can make sound decisions regarding management practices affecting the stress tolerance of turfgrass.

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THE USE OF ALTERNATIVE FUELS IN AGRICULTURE

J.C. Siemens

Alternative or synthetic fuels are liquids and gases than can be readily substituted in most cases for conventional oil products and natural gas. These fuels can be derived from coal, heavy oil, oil sands, oil shale, and from agricultural products. In this report I will briefly comment on the world and U.S. energy situation, and discuss the potential for the production and use of alternative fuels from agricultural products.

At present, the world energy demand from all sources is equivalent to 100 million barrels of oil per day. By the year 2000, this demand is expected to grow at the approximate rate of 2-1/2 percent per year. Demand is expected to reach nearly 130 million barrels per day of oil equivalent by 1990, and, in the following decade, to exceed 160 million barrels per day. By that time, the United States' share of the total energy demand will decline from the current 41 percent to about 31 percent; and, in the same period, the energy from conventional oil is projected to decline from 54 percent of the total in 1978 to about 37 percent. However, oil will continue to supply significantly more of the world's energy needs than any other fuel. It is also projected that the fossil fuels together, oil, natural gas, and coal, which account for about 90 percent of the energy used in the world today, will account for 77 percent of the world's energy by the turn of the century. Although synthetic fuels are expected to become significant in meeting the world's energy needs in the early 1990s, their production is subject to many uncertainties. By the year 2000 they are projected to provide approximately 9 million barrels per day; that is, between four to six percent of the world's energy supply.

It is relevant at this point to review briefly the U.S. energy demand and sources. In 1947, we produced almost all the oil used in the U.S., and imports were but a trickle. Until 1970, in fact, we were producing more oil annually than many experts in past years had predicted. One expert, however, has been predicting since the 1950s that never again will we produce as much oil as in 1970. The last nine years have shown how correct he was. In 1970 we produced 9.6 million barrels of oil per day to meet 77 percent of our energy requirements. In 1980 our production declined to 6.7 million, a quantity that satisfied 50 to 52 percent of our needs.

Oil imports, on the other hand, have increased steadily until only recently. In 1965 we imported only 9 percent of our oil. As our appetite for oil continued to increase, so did our imports. By 1970--the year we produced the most oil domestically--we imported 23 percent of our demand. A small dip in demand and in imports followed the 1973-74 oil embargo, but then oil demand and imports again increased. In 1977 we imported 48 percent of our oil; it is only now that we are seeing some decrease in oil imports because of conservation, and because of the situation in the Middle East.

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The pattern of fuel consumption in the U.S. is significant. Of the portable fuels--gasoline, diesel fuel, jet fuel, and LP gas--about 40 percent is used in automobiles. Trucks, using both gasoline and diesel fuel, add another 20 percent to the highway use of motor fuels. Thus about 60 percent of the portable fuels used in this country are consumed in vehicles on our streets and highways.

Agriculture uses about 2-1/2 percent of our country's total energy, which includes, roughly, 4 percent of the nation's portable fuel. On-highway vehicles used in agriculture consume the oil equivalent of 225 thousand barrels per day, compared to 260 thousand barrels per day for off-highway vehicles. Other major fuel inputs to U.S. agriculture include the manufacture of chemicals (such as fertilizers and pesticides) that uses about the same amount of energy as off-highway vehicles in agriculture. The manufacture of chemicals primarily uses natural gas directed mainly at the production of nitrogen fertilizer.

In Illinois agriculture, 45 percent of the total energy is channeled into fertilizers, and 48 percent is used for all other crop production activities. Only 7 percent is used for livestock production. The major fuels used on farms for Illinois crop production are gasoline, diesel fuel, and LP gas. Tillage (including planting) uses the most energy: 31 percent. The amount of energy used in trucks, pickups, and autos is surprisingly high, totaling 36 percent. On-farm drying, primarily corn, represents 18 percent of the energy used. This percentage would be much higher, perhaps double, if the energy used to dry corn commercially (off-farm) were included.

I have briefly discussed the energy supply and demand situation to point out that agriculture is not an island in the total U.S. energy picture. After all, U.S. agriculture uses just 2-1/2 percent of the nation's total energy, and about 4 percent of its portable fuel. This consumption is almost insignificant compared to the 40 percent used in our personal automobiles, and over 60 percent used totally on our streets and highways. It is evident that we must consider alternative fuels to meet our needs, not only in agriculture, but in the nation as a whole.

I would like to share with you some perspectives on the possibilities of substituting, on a national basis, some agricultural products for petroleum-based portable fuels. Ethanol is one such possibility. If we gave up eating, stopped feeding our animals, and used all the corn, wheat, and grain sorghum for making alcohol, the ethanol produced would replace only 14 percent of the gasoline used in 1978. The total soybean crop, if turned to oil, would equal 17 percent of all the diesel fuel used last year. Both these percentages are significant, but obviously we cannot justify the use of such a high percentage of our grain and soybean crops for producing portable fuels, especially for cars and trucks. Other vegetable oils are being researched for use as diesel fuel substitutes. Unfortunately, there are currently no other biomass-based energy sources with the potential of contributing even a fraction of the remaining portable fuel requirements to the national energy supply.

Despite the discouraging statistics, is still worthwhile to consider the production of portable fuels in the United States. The most widely publicized and used fuel, ethanol alcohol, is produced from the conversion of corn to alcohol. Ethanol has about 85,000 BTUs per gallon, while gasoline has 124,000, and diesel fuel 140,000 BTUs. The octane number of ethanol is higher than that of gasoline. The octane number is not an appropriate property of diesel fuel, which is characterized by a cetane number. Typically, diesel fuel has a cetane number of 50, while the cetane number of ethanol is zero. Ethanol requires much more heat to vaporize, compared to gasoline or diesel fuel. Overall, the properties of ethanol make it a much better gasoline substitute than a diesel fuel substitute.

Ethanol can be used in gasoline (spark ignition) engines. The best known and most widely used alcohol fuel today is gasohol, a blend of 90 percent unleaded gasoline and 10 percent ethanol. The ethanol must be 200 proof to be mixed with gasoline, or the two will not blend uniformly. Ethanol can, however, be used without blending in spark ignition engines designed to burn gasoline if some engine modifications are made. Unfortunately, ethanol cannot be used in diesel engines because manufacturers believe it decreases engine life and can cause catastrophic failure. Since most farm machines are powered with diesel engines, ethanol cannot provide fuel for most agricultural machinery. Where it can be used, however, ethanol should still be considered as a viable, though partial, alternative to conventional oil products and natural gas. It cannot completely meet our energy needs, but it certainly can contribute in part to solving our fuel-related problems.

AMMONIA VOLATILIZATION FROM TURFGRASS STANDS

W.A. Torello, D.J. Wehner, and A.J. Turgeon

The gaseous loss of nitrogen by the process of ammonia (NH_3) volatilization after applications of nitrogen fertilizers can be extensive, depending upon soil and environmental conditions. Past research has shown that soil pH, cation exchange capacity, temperature, moisture level, and the type of ammonium fertilizer applied, all affect the rate of nitrogen loss from soils as volatile NH_3. In general, soils having high pH levels (calcareous), elevated temperatures, low cation exchange capacities, and an increased potential for rapid moisture loss are candidates for large losses of applied N through NH_3 volatilization. The soils of central Illinois do not fall into this category yet; Nelson et al. (2) have shown NH_3-N losses to be more than 24 percent in urea-treated turf having an extensive thatch layer. However, these results may have been overestimated due to the nature of the systems used for the analysis of NH_3 volatilization.

A Turf Microecosystem has been developed at the University of Illinois to study the fate of agricultural chemicals applied to turf. This Turf Microecosystem is a more complex and, hence, a more accurate system to measure NH_3 volatilization than those systems previously used. The Turf Microecosystem has been described in detail by Branham and Turgeon (1).

The primary objectives of this study were to use the Turf Microecosystems to compare NH_3-N losses from turf following fertilizer applications of sulfur-coated urea (SCU), urea, isobutylidene diurea (IBDU), ureaformaldehyde (UF), Formolene, FLUF (Flowable Liquid Ureaformaldehyde), and NH_4NO_3. Secondary objectives were to evaluate the effects of rate of application, mode of application, and thatch on NH_3 volatilization from turf.

Comparisons of NH_3 volatilized from turf after applications of seven nitrogen fertilizers at various rates of N-application are shown in Table 1. Even at an unrealistic rate of N-application (6.0 lb.N/1000 sq. ft.), NH_4NO_3, UF, SCU, and IBDU lost insignificant amounts of N as NH_3. The effects of rate of application are evident when comparing NH_3-N losses from urea applied at the 6.0 lb.N and 1.0 lb.N application rate. Formolene and FLUF lost 3.6 and 4.0 percent of applied N as NH_3 respectively. In general, these and other treatments of fertilizer applied at the 1.0 lb.N rate exhibited very low levels of NH_3 volatilization. These results are in sharp contrast to those obtained by Nelson et al. (2) for turf grown on central Illinois soils.

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The effects of mode of application and thatch are shown in Table 2. When a urea solution (1.0 lb.N/1000 sq. ft.) was sprayed onto turf, NH_3 volatilization was greater than it was in prilled urea applications. Liquid applications of urea to turf having a layer of thatch showed slightly decreased NH_3-N losses compared with applications to turf without a thatch layer. However, liquid application of urea was still shown to increase NH_3-N losses over prilled applications.

Nitrogen losses from turf by NH_3 volatilization do occur in central Illinois, but to a rather limited extent. Soils in this region are, for the most part, not calcareous in nature and do not possess high pH levels that enhance the NH_3 volatilization process. Further research into the mechanisms of NH_3 volatilization from turf grown in soils having a neutral to acidic pH level is ongoing at the University of Illinois.

Table 1. Comparison of Ammonia Volatilization From Turf After Application of Seven Different Nitrogen Fertilizers at Various Rates of Application

Treatment	Rate of application (lb.N/1000 sq. ft.)	Mean ($\bar{X}$) percent N volatilized
Urea	1.0	1.6
Urea	6.0	8.6
SCU	1.0	1.4
SCU	6.0	2.3
NH_4NO_3	6.0	0.1
IBDU	6.0	0.01
UF	6.0	0.01
FLUF	1.0	4.6
Formolene	1.0	3.4
Formolene	2.0	4.0

Table 2. The Effects of Mode of Application and Thatch on Ammonia Volatilization From Turf After Liquid or Prilled Urea Applications[a]

Treatment	Rate of application (lb.N/1000 sq. ft.)	Mean ($\bar{X}$) percent N volatilized
Thatched turf		
Liquid urea	1.0	2.8
Prilled urea	1.0	1.7
No thatch		
Liquid urea	1.0	4.6
Prilled urea	1.0	1.6

[a]1.0 lb.N/1000 sq. ft.

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INSECT PEST UPDATE

Roscoe Randell

Insect activity in managed turfgrass during 1980 varied very little from that of the past five years. There were no new outbreaks of insect pests, but damage occurred from many turf insects that had appeared in other years.

GOLF TURF INSECTS. Black turfgrass *ataenius* grubs damaged fairways and areas around greens on a few courses in the Chicago area. Grubs appeared in damaged *Poa annua* in early July. Treatments with diazinon, Proxol or Dylox, and ethoprop controlled this insect. There was no second-generation infestation in late August.

Black cutworms appeared on greens in May and decreased with the next two generations through the summer. When applied on a monthly schedule, Dursban and Proxol controlled these insects.

Annual white grubs hatched in July and appeared in damaging numbers in August on fairways in the central section of the state. Preventive and rescue treatments of Proxol, Dylox, and diazinon gave satisfactory control generally three weeks after treatment.

LAWN TURF INSECTS. Annual white grub numbers did not reach the damaging levels they did in 1979 because of extremely dry soil conditions during the egglaying period of early July. Granular applied diazinon performed better than sprays where irrigation was impossible or delayed. However, there were instances where diazinon did not control annual white grub populations even when properly applied.

Greenbug infestations did not cause as much damage as in 1979. Bluegrass billbugs appeared again in DuPage County in August as grubs and adult snout beetles. In other states where this insect is a problem, Dursban is applied in April or August. Sod webworm increased through the second generation in late July with moderately high numbers of healthy webworms overwintering into 1981.

INSECT CONTROL TRIALS. Insecticide treatments were applied in 1979 to a Kentucky bluegrass sod area that exhibited a high number of annual white grubs, *Cyclocephala immaculata*. Granular formulations of bendiocarb (Fican), Amaze, trichlorfon, and diazinon were applied. Sprays containing bendiocarb, trichlorfon, diazinon, USCF-2, carbaryl (Sevin), and a combination of carbaryl (Sevin) plus chlorpyrifos (Dursban) were also used. The insecticides were applied on August 21 to plots ten feet by ten feet. There were four replicates for each insecticide treatment. Plots were irrigated before and immediately after application.

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Approximate grub counts were made after 3 weeks, but a detailed count was not made until on October 12 and 13 (Table 1). All insecticide treatments except carbaryl alone, controlled annual white grubs. Chlorpyrifos has not been effective in past years when applied alone, but when combined at reduced rates with carbaryl, it has performed effectively.

In 1980, the 1979 plots treated with Oftanol (Amaze) were free of grubs (Table 2). All other plots had a moderate grub population. Sevin plus Dursban combinations as well as Oftanol performed well in tests for grub control on a golf course fairway in 1980 (Table 3).

Table 1. 1979 White Grub Control

Plot size: 10 X 10 ft. - 4 replicates
Treatment date: August 21
Evaluation dates: October 12, and 13
Insecticides applied and irrigated

Treatment	Rate a.i./acre	Control grubs/sq. ft.
Bendiocarb (Ficam) 2.5G	2	3
Bendiocarb (Ficam) 50WP	2	3
Amaze 5G	2	3-6
Trichlorfon (Dylox) 80SP	8	3
Trichlorfon (Dylox) 5G	8	3
Diazinon 14G	5	3
Diazinon 4E	5	3
UCSF-2 (Sevin) 80S	8	35-45
Sevin and Dursban 80S + 4E	4 + 2	3
Untreated	---	40-45

Table 2. 1980 Annual White Grub Control

Resampling of 1979 grub control plots
Applied: August, 1979

Treatment	Rep.	Grubs/sq. ft. 10/19/79	Grubs/sq. ft. 10/19/80
Oftanol	1	3	0
	2	6	0
	3	4	0
	4	4	0
Untreated	1	44	18
	2	40	17
	3	45	20
	4	41	16

Table 3. 1980 Annual White Grub Control

Insecticides applied: September 12
Precount of grubs = 25 to 28 per square foot
4 replications of 100 square feet plots for each treatment

Treatment	Rate a.i./acre	Live grubs/sq. ft. 9/22	10/3
Dursban 2E + Sevin 80S	2 + 4	3.8	1.0
Oftanol	2	6.5	0.0
Untreated	---	25.0	26.0

THE EFFECTS OF FUNGICIDES ON REDUCING DEVELOPMENT OF LEAF SPOT AND MELTING-OUT ON KENTUCKY BLUEGRASS IN 1980

M. C. Hirrel, M. C. Shurtleff, and G. L. Fagiolo

To date, the study of turfgrass epidemiology has been confined to a few rating dates at certain times during the season in an attempt to determine when chemical control will be most effective. Such critical point models are useful in timing chemical sprays, but they do little to evaluate disease progress and how chemical applications can act to reduce the rate of disease development. This year, the weather from the latter part of March to the first of May was conducive to the development of leaf spot and melting-out epidemics on bluegrass incited by *Helminthosporium vagans* and other species. The purpose of this study was to observe how different fungicides in combination, and with different timings, affected the development of this disease from the leaf blight to the crown rot stage.

To evaluate and chart the course of a melting-out epidemic over an eight-week period, a qualitative visual rating of color, stand density, and disease severity over a 152.5 cm^2 (25 square feet) plot was correlated with a quantitative estimate of the amount of disease present through numbers of leaf lesions in a 5 cm^2 (2 square inches) area. A randomized complete block design of 20 treatments, 19 fungicides, and one untreated check with four replications was used. The timing of fungicide treatments was either 3 sprays at 2-week intervals, or 2 sprays at 3-week intervals. The first spray application was made the week of April 14 following the first mowing season, and the last spray was applied the week of May 19.

Differences in disease severity began after May 19 (on which date ratings ranged from 0.60-1.10), and were first noticed on May 28. Disease severity continued to increase until June 6, and for most treatments had declined to below the May 28 rating by June 12 (Table 1). Fungicide treatments could be divided into three basic groups, based on the disease severity index of the plots compared to the untreated checks on the same rating date. At the height of the epidemic, between May 28 and June 6, Group I treatments had little or no effect on reducing disease severity compared to the check. Group II treatments for the most part reduced disease severity; however, it was the Group III treatments that consistently reduced disease severity for the duration of the epidemic. The rate of infection and disease development was calculated for each group, and further describes the amount of disease control attributed to fungicide treatment. Infection rate for Group I and the check was 0.148 and 0.138, respectively; for Group II, the rate was 0.078, and for Group III, it was 0.042. [The procedure for this calculation was based on that used by J.E. Van der Plank in *Plant Diseases: Epidemics and Control* (New York: Academic Press, 1963), p. 21. According to him, the infection rate (r) for foliar diseases develops by a continuous compound interest-like growth curve:

$$r = \frac{2.3}{t_2 - t_1}\left(\log \frac{X_2}{1-X_2} - \log \frac{X_1}{1-X_1}\right),$$ where t and t are rating dates and X is the disease severity rating at t_2 and X_1 is the disease rating at t_1.]

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Table 1. Disease Severity Ratings of Helminthosporium Melting-out and Leaf Spot on Kentucky Bluegrass Following Fungicide Treatments

Treatment	Mean melting-out leaf spot severity index[a] May 28	June 6	June 12
Check (untreated)	2.85	4.20	3.25
Group I. Disease severity similar or slightly lower than the check			
Bayleton 25% WP 2 oz, 3S, 2W[b]	4.50	4.40	3.40
Acti-dione RZ, 0.5 oz, 2S 3W	3.65	4.25	2.00
Baleton 1 oz; Acti-dione TGF 0.5 oz, 3S 2W	3.42	2.84*	2.05
Acti-dione TGF, 2.1% WP 1 oz, 3S 2W	3.05	2.45*	1.55
Bayleton, 25% WP 4 oz, 3S 2W	2.90	2.60*	3.20
Bayleton 0.5 oz; Daconil 3 oz,[c] 3S 2W	2.00	1.30*	4.75
Acti-dione RZ 0.5 oz; Acti-dione TGF 0.34 oz, 3S 2W	2.20	2.40*	3.05
Group II. Disease severity often lower than the check			
Acti-dione RZ 0.5 oz; Acti-dione TGF 0.34 oz, 2S 4W	2.85	3.00*	1.25*
Bayleton 2 oz; Dyrene 8 oz, 3S 2W	1.50*	1.15*	1.55
Daconil 2787 3 oz,[c] 3S 2W	1.45*	2.55*	2.00
Acti-dione RZ 0.5 oz; Acti-dione TGF 0.34 oz, 3S 2W	2.15	2.70*	1.30*
Bayleton 1.0 oz; Acti-dione TGF 0.34 oz, 3S 2W	1.81*	2.38*	1.76
Group III. Disease severity consistently lower than the check			
Acti-dione TGF 0.34 oz; Daconil 1.5 oz,[c] 3S 2W	1.70*	1.00*	0.80*
Tersan LSR, 80% WP, 4 oz 3S 2W	1.60*	2.20*	0.90*
Acti-dione TGF 0.5 oz; Daconil 1.5 oz,[c] 3S 2W	1.40*	1.90*	0.80*
Chipco 26019 1 oz; Tersan LSR 3 oz, [illegible] 2W	1.20*	1.40*	0.75*
Dyrene, 50% WP 8 oz, 3S 2W	1.05*	1.15*	0.85*
Chipco 26019, 50% WP 2 oz, 3S 2W	0.85*	0.65*	0.65*
Chipco 26019, 50% WP 4 oz, 3S 2W	0.60*	1.00*	0.20*

*Treatment means differ from the check at the 5% level of significance.

[a]Rating scale 0-5 with 0 = no disease, and 5 = severe melting-out over 50% of 152.5 cm^2 (25 square feet) turf plot.

[b]S = number of sprays; W = number of weeks between sprays.

[c]Daconil should have been used at the 6 oz. rate rather than 3 oz. to be equivalent to Dyrene at 8 oz.

Table 2. Amount of Helminthosporium Leaf Spot Lesions in a 5 cm^2 Area of Turfgrass

Treatment	Mean lesion numbers/5 cm^2, rating date					
	May			June		
	15	21	26	6	12	18
Check (untreated)	2.85	4.20	3.25	1.85	2.20	3.45
Group I.[a]						
Bayleton 25% WP 2 oz, 3S 2W[b]	4.50	4.40	3.40	2.63	2.20	3.40
Acti-dione RZ, 0.5 oz, 2S 3W	3.65	4.25	2.00*	1.90	2.25	3.05
Bayleton 1 oz; Acti-dione TGF 0.5 oz, 3S 2W	3.42	2.84	2.05*	1.90	2.25	3.05
Acti-dione TGF, 2.1% WP 1 oz, 3S 2W	3.05	2.50*	1.55*	1.65	2.10	0.90*
Bayleton, 25% WP 4 oz, 3S 2W	2.90	2.60*	3.20	2.45	2.40	2.80
Bayleton 0.5 oz; Daconil 3 oz,[c] 3S 2W	2.00	1.45	4.75	1.90	1.45*	2.50
Acti-dione RZ 0.5 oz; Acti-dione TGF 0.34 oz, 3S 2W	2.05	2.40*	3.05	1.80	1.65	1.80*
Group II.						
Acti-dione RZ 0.5 oz; Acti-dione TGF 0.34 oz, 2S 4W	2.85	2.90	1.25*	1.10*	1.40*	2.95
Acti-dione RZ 0.5 oz; Acti-dione TGF 0.34 oz, 3S 3W	2.15	2.70*	1.20*	1.65	2.05	1.80*
Bayleton 1.0 oz; Acti-dione TGF 0.34 oz, 3S 2W	3.42	2.84	2.05*	1.90	2.25	3.05
Bayleton 2 oz; Dyrene 8 oz, 3S 2W	1.50*	1.15*	1.55*	1.45	1.50	2.10*
Daconil 2787 3 oz,[c] 3S 2W	1.45*	2.30*	2.00*	1.50	2.10	1.60*
Group III.						
Acti-dione TGF 0.34 oz; Daconil 1.5 oz,[c] 3S 2W	1.75*	1.00*	0.80*	1.10*	2.25	2.10*
Tersan LSR, 80% WP, 4 oz, 3S 2W	1.65*	1.20*	0.90*	2.60	2.35	2.30*
Acti-dione TGF 0.5 oz; Daconil 1.5 oz,[c] 3S 2W	1.40*	1.90*	0.80*	1.70	1.75	1.65*
Chipco 26019 1 oz; Tersan LSR 3 oz, 3S 2W	1.20*	1.40*	0.75*	2.10	1.05*	2.00*
Dyrene, 50% WP 8 oz, 3S 2W	1.05*	1.15*	0.85*	1.45	1.15*	1.70*
Chipco 26019, 50% WP 2 oz, 3S 2W	0.85*	0.65*	0.65*	1.05*	0.90*	1.30*
Chipco 26019, 50% WP 2 oz, 3S 2W	0.60*	0.65*	0.65*	0.55*	0.70*	0.60*

*Treatment means differ from check at 5% level of significance.
[a]Treatments grouped according to disease severity index (Table 1).
[b]S = number of sprays; W = number of weeks between sprays.
[c]Daconil should have been used at the 6 oz. rate rather than 3 oz. to be equivalent to Dyrene at 8 oz.

Disease severity ratings were in close agreement with lesion numbers in 5 cm^2 of turfgrass (Table 2). Difference in lesion numbers could be detected nearly 14 days before differences in disease severity and, in general, the increase and decline in lesion numbers preceded a similar curve for disease severity by 7 to 10 days. During May, the check and Group I treatments had nearly twice as many lesions per 15 cm^2 of turf as the Group II treatments, and three to four times as many as the Group III treatments. In June, however, the differences in lesion number decreased. For the check and Group I treatments, the decrease was one-third to one-half the numbers present in May. With Group II the decrease was one-fourth to one-third the numbers observed in May, but there was little or no difference in lesion numbers between May and June for treatments in Group III. Thus, the effect of the Group III fungicides is one of reducing lesion numbers--a fact that correlates with a disease severity index that is low.

A more thorough analysis of the epidemic was not possible due to an abrupt change in weather conditions. High temperatures in June and July, and low rainfall stalled, then decreased the leaf spot phase of the epidemic to the point where disease severity and lesion numbers were poorly correlated. The crown deaths did not take place in many of the treatments until the onset of the drought period. Changing weather conditions may also explain why the leaf spot phase failed to develop again in late summer. Such conditions make it difficult to separate symptoms associated with disease from those associated with drought. Results from data collected from mid to late spring suggest that (1) certain fungicides alone or in combination will effectively reduce the onset and development of *Helminthosporium* leaf spot; and (2) the development of a leaf spot epidemic can be observed earlier if lesion counts rather than disease severity ratings are made. Thus, by choosing the proper fungicide or fungicide combination and knowing the developmental stage of the disease, we can make timely spray applications and thereby more effectively control turfgrass diseases and reduce the cost of disease management.

SOLID STATE CONTROL SYSTEMS FOR LARGE TURF IRRIGATION

Paul F. Granger

The newest step in revolutionizing the irrigation industry is the introduction of the solid state automatic controller for large turf sprinkler systems. Today I will be talking about the four most predominant of these solid state systems. All four were introduced a little over a year ago. The four systems are the VCS 39500 by Royal Coach, the Maxi Control System by Rainbird, and the Vari-Time III and MPC System by the Toro Company. All of these systems incorporate the precision timing of solid state and the elimination of electromechanical parts. We will be talking about the components and features of each of these systems starting with Royal Coach's VCS 39500.

The Royal Coach VCS 39500 is a central satellite system requiring four communication wires between the central and field terminals. The central consists of two pieces. The first unit is a video terminal with a standard typewriter keyboard that is placed on a desktop. The second unit is the computer itself that can be fixed to the wall or to the desk. All programming is done through a question-and-answer format on the video screen. Programming can also be accomplished from the field controller.

The VCS 39500 has six separate fourteen-day programs with an independent syringe program separate from the six schedules. The syringe program is capable of syringing from one minute to fifty-nine minutes in one-minute increments. The central can be programmed for twelve separate start times, and has an automatic rechargeable battery that will retain the program for up to twelve hours in case of power failure.

The VCS 39500 is capable of having 99 irrigation groups with a maximum of 4800 electric two-watt solenoid valves. The field controller consists of four modules of six stations each. These modules can be operated all at one time, or each module can be assigned to a separate irrigation group. Each of the twenty-four stations can either be timed from 0 to 60 minutes in one-minute increments, or from 1 to 9 hours in one hour increments. The field satellite can be operated independently, manually, semiautomatically, or automatically. The controller may also be omitted from the central and turned off. Power for the field controllers may come from separate power sources. Each controller comes equipped with a built-in rechargeable battery for program retention and is available in either a wall or pedestal mount. At the present time there is one system in the state of Illinois: Olympia Fields Country Club is in the process of having it installed.

The next system to be discussed is the Maxi Computer Control System by Rainbird, which consists of three basic parts: the Maxi Computer Controller that is used for entering all programming for the system; the MTW Output Module, used as an interface between the field remote control valves and the computer controller; and the decoder of a selected channel that activates and allows power to be

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applied to the solenoid of the remote control valve. This system eliminates all field controllers, but does allow field operation through the use of a portable operator.

The Maxi Computer Controller features an on/off switch; a run, dry run, and program switch; an automatic, semiautomatic and manual mode of operation; and an operation keyboard and programming keyboard that use two lighted message screens. The Maxi Computer Controller is capable of operating eight MTW Output Modules, each having up to four encoders controlling twenty-eight stations. The Maxi System thus has a total limit of 896 stations. A rechargeable battery will maintain the program for four to six hours should there be a power failure.

The MTW Output Module can have from one to four encoders, each with a capacity of twenty-eight stations and an indicating light to show status. A memory switch is provided for each encoder. This switch in the *off* position will be illuminated when the station is in operation, while in the *on* position the light will come on when the valve is actuated and stay on until it is reset. The switch provides a means of verifying the following morning which stations went on, and which did not.

Each encoder of the MTW Output Module has its own two-wire path. So if four encoders are used on each of two MTW Output modules, a total of sixteen wires would come out of the central location to connect to different areas of the golf course. These wires go directly to the decoders assigned to that encoder of the MTW Module. There are two types of decoders: a fixed channel nonprogrammable decoder and a programmable decoder. The decoders are watertight and can be either directly buried, or placed in a valve box. The decoder board has quick disconnection to cap for easy maintenance.

The Maxi Control System is a step-schedule orientation as opposed to the conventional program-station orientation of other controllers. It is capable of holding ninety-nine different schedules at any one time. Each schedule in turn can hold up to ninety-nine individual steps of information within it. All schedules can be operated independently, in any combination or simultaneously, or linked to another schedule. A maximum of five stations can be operated at one time per encoder. Time for each station can be set from one second to ninety-nine days with absolute accuracy.

The Maxi Control System has random scheduling that allows stations to be operated in any sequence desired. Any station can be incorporated in as many schedules as desired, and can be repeated within that schedule any time and as often as desired. Any individual schedule may be repeated from one to ninety-eight times. Any schedule can be monitored to show time scheduled and time left to go, and this can be modified on a one-time basis with the station returning to the original program on the next operation. Any schedule can be put on hold or interrupted at any time, and the water budgeting feature allows any schedule to individually be increased or decreased in operating time from 0 percent to 999 percent of what was originally scheduled. At present, there are no installations of the Maxi Control System in the state.

The Toro Vari-Time III is comprised of a central controller that initiates command to field satellites. The central controller consists of two modules: the central programmer module and the central syringe module. The central programmer module consists of six central syringe communication switches that are either in the *up* or *on* position for programming or running, or the *down* position for off.

Along with these switches is a keyboard for all data entry; a rain switch indicator and reset button; an output monitor switch that interrupts the signal to the field; a display board indicating time and day; and a *cancel all* button that cancels all activity for satellites and returns them to the off position. An internal battery protects against memory loss, and the central programmer has an indicator light to show when the battery is low and needs replacement.

The second module on the central consists of six separate control syringe modules. Each of these control modules consists of a ten-position 0 through 9-minute syringe timer; a one-time manual start to the satellites for program 1 and program 2, and for syringe 1 and syringe 2; and a *cancel* button for that particular central module. The VT III Central/Syringe module display is a seven-digit L.E.D. The first five digits show the time of the next start time. The sixth digit tells which program (1 or 2) this start time is for; and the last digit is a light to indicate if it is an active day or if the start time is set for a syringe program.

Each central unit is capable of being programmed with thirty independent start times per day of the fourteen-day program. Some of these start times can be used to repeat a particular program. Each of the six central modules is capable of controlling twelve satellites, and each of the satellites is capable of handling twelve stations for a total of 864 stations. The central control unit need only be attached to the satellites by one pulse wire. The 110-volt power may be supplied to the central and the satellites from separate power sources.

The satellite for the VT III is capable of handling twelve stations and comes mounted either as a single or double controller. The satellites can control either electric valves through wires connected from the controller to the head or valve solenoid, or hydraulic valves through the use of a 24-volt electric to the normally open hydraulic converter. All station timing is programmed at the satellite's locations.

The VT III satellite has the ability to operate by itself separate from the central controller, through the central itself, or to be turned off. It has a multimanual feature allowing you to select up to six stations that you would like to run at one time on a manual basis.

The station time-totalizer feature allows for the display of the total programmed station run time for program 1 or 2. This time appears in hours or minutes. An internal battery protects against memory loss during power outages. The day of the week changes at 6:00 A.M. The central select function allows you to select at the satellite itself the central module that will command that particular satellite. A display at the satellite indicates the station number, the station run time and the program. This display is shown only during operation or programming, although the display button can be pushed at the satellite to give the previous information.

Currently there are eleven Vari-Time III Systems installed and operating in the state of Illinois. They are located at the following places: Beverly Country Club, Hinsdale Golf Club, Idlewilde Country Club, Riverside Golf Club, The Indian Hill Club, Oakbrook Municipal Club, Villa Olivia Country Club, Jacksonville Country Club, Bunker Hills Golf Club, Golf Mohr Golf Club, and Mill Creek Country Club. Three systems are sold and on order for the coming year.

The last and final system we will be discussing is the Toro MPC. The MPC modulating pressure control and automatic control system for large turf irrigation is comprised of a central programmer, a pump and pressure control package, and a cycler for each valve or valve-in-head sprinkler in the irrigation system. Unlike conventional control systems, the MPC System requires no wire or tubing from the controller to the valves. Communication is made through the piping of the system by varying the water pressure to turn sprinklers on and off in an operator-selected program.

The MPC programmer provides the flexibility of irrigation and syringe-control for water usage at maximum efficiency. The thirty-nine stations allow for proper separation of areas requiring individual operating procedures. The keyboard entry system provides easy programming of multiple programs through solid state microprocessor technology.

A different water cycle may be programmed for each day of the fourteen-day period. The water cycle may be started at any time of the day with as many as six start times per day available. The thirty-nine stations may be set for 0, 3, 6, 10, 15, 20, 25, 30, 40, and 60 minutes for the irrigation mode, and 0 to 9 minutes for the syringe in one-minute increments. Syringe functions include dew or frost removal, and heat stress relief. A *reset* or *cancel* program that cancels irrigation or syringe programs and returns the system to a *standby/off* position may be initiated at any time.

All switching from station to station is done through the pump-control system, the pipe in the system, and the cycler. When the system pressure is dropped to 60 pounds per square inch, the cycler at the head ratchets one position to station 1; after a short delay, the system pressure is dropped to 40 pounds per square inch. If the cycler and central have been set to *activate* line pressure will be increased to normal operating pressure. When this operation is complete, the system pressure is dropped again to 60 psi; the cyclers advance to station 2, and the pressure drops to 40 psi. Again, if the controller and cycler have been set, the system pressure will be raised to operating pressure. When the entire program is complete, the system pressure is dropped to 20 psi and all cyclers reset to zero.

The MPC controller and pump controls come in a skid-mounted package that is fitted into the pumphouse system. The MPC controller has 39 stations with both irrigation and syringe modes of operation. It features a programming lock switch to lock in the program and to prevent mistakes from being made by inadvertantly hitting the keyboard. It has indicator lights to show day and stations on a program. The MPC is capable of fourteen programs with six start times per day per program. In the *observe* mode, the total program can be shown for review.

The controller is mounted on the pump control package consisting of an automatic pump panel, a hydraulic panel with three-way solenoids, and regulators to control pressure. A bypass valve to dump water and lower pressure is incorporated with a regulating valve to control system pressure. A pressure tank to read control pressure and remove surges is mounted on the skid. At the moment there is one system in the state of Illinois, installed at Nordic Hills Country Club.

We now have four modern and up-to-date control systems to help us advance our industry in Illinois. Our ultimate goal for each of these systems is the same: to meet the needs of our end-users--the golf course superintendents.

FUSARIUM BLIGHT—A LITTLE UNDERSTANDING AND A LOT OF IGNORANCE

H. Cole, Jr., and P.L. Sanders

INTRODUCTION

Fusarium blight is a severe midsummer disease of Kentucky bluegrass *(Poa pratensis)* on golf course fairways, home lawns, and other recreational areas. Kentucky bluegrass possesses excellent resistance to some diseases, vigor of growth and recovery, and excellent play characteristics. Unfortunately, many of the varieties currently planted are very susceptible to Fusarium blight, and, because of their widespread use, damage to fairway turf is often substantial in midsummer. The disease is also an important concern of the sod production industry, causing increasing problems not only in the production fields, but also on the customer's site.

Fusarium blight was first described by Couch and Bedford (11), who observed it on Merion Kentucky bluegrass in southeastern Pennsylvania. During 1960, 1961, and 1963, the disease became an epidemic on bluegrass and bentgrass stands in Ohio, New York, New Jersey, Delaware, Maryland, and the District of Columbia (11). Bean (1) observed a similar disease on Merion bluegrass lawns in the Washington, D.C., area. Subirats and Self (33) described Fusarium blight on centipede grass in Alabama, and Bell (4) reported a Fusarium disease of zoysia.

UNDERSTANDING FUSARIUM BLIGHT--A CHRONICLE OF FAILURE

Ever since Couch and Bedford (11) first described Fusarium blight, a great deal of research has been undertaken in order to understand this disease. Much of this extensive research to date has led to contradictory conclusions. Many aspects remain unexplained, including, for example, the role that the Fusarium fungus plays in the development of the field symptoms. At this time it is not possible to say with confidence what organisms and environmental factors may be involved in the induction of Fusarium blight.

A major shortcoming is that although potentially pathogenic *Fusarium* spp. are regularly isolated from turfgrass showing symptoms of Fusarium blight, no one has been able to induce the field "frog-eye" or "dead ring" symptom by inoculating turfgrass with these Fusaria. In addition, the experimental fungicide, triadimefon, which provides complete suppression of the field symptoms of Fusarium blight, exhibits lack of fungitoxicity to *Fusarium* spp. when isolated

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from diseased turfgrass (24). Neither has fungitoxicity to these pathogens been demonstrated in bioassays of Kentucky bluegrass treated with triadimefon. Fungitoxicity of triadimefon to other turfgrass pathogens was readily demonstrable through both these techniques. Thus, one can reach the peculiar conclusion that Fusaria do not incite the field symptom, and that the chemical suppressing the field symptom does not control the pathogen(s). These results, however, more probably indicate that *Fusarium* spp. are pathogenic within the unexplained biotic or environmental complex that produces the field symptoms of Fusarium blight.

The literature indicates that the majority of the Fusarium blight outbreaks are associated with moisture stress. Research on related diseases may be drawn upon to explain several of the puzzling aspects of moisture stress and disease development. The works of Cook and Papendick (10), and Papendick and Cook (23) regarding water stress in wheat and soil water potential, and the effects of these factors on colonization of soil organic matter and host plants by *Fusarium* spp. may be particularly relevant to an understanding of Fusarium blight. In these investigations high nitrogen fertilization increased moisture stress within wheat plants, accentuating colonization by *Fusarium* spp. The increased internal water stress probably was not due to a direct nutritional effect, but rather to indirect effects produced by larger root systems that increased water extraction from the soil, and greater leaf areas that increased transpiration. We believe this may occur with Kentucky bluegrass.

The occurrence of the "frog-eye' or "dead ring" field symptom and the sharp delineation of the infection center borders remains unexplained. Rather than shifting gradually from healthy grass to severely blighted grass, this transition often occurs over a very short distance. One tiller may be dead and the next one apparently healthy, thus producing a very distinct "dead spot" on the turf. If water stress is critical in disease development, then an attempt must be made to explain why, in a very short distance, one tiller should be under water stress and an adjacent one apparently free from such stress. This symptom has never been observed in a greenhouse or a growth chamber. Soil moisture availability, as affected by proliferation of soil (fairy ring - basidiomycete) fungi, may influence the disease development pattern in the field, especially the "frog-eye" symptom. Shantz and Piemeisel (25) in their paper on fairy ring development, reported that in the actual ring portion, soil moisture levels were lower, and that water percolation rates were reduced when compared with the ring interior or exterior. "Hard dry spot" associated with fungal proliferation has long been observed on bentgrass greens by golf course superintendents. Other factors may contribute to soil and plant moisture stress from place to place in a turf area; however, the radial expansion pattern of Basidiomycete fungi in soil, and the hydrophobic nature of Basidiomycete mycelium and by-products (17) would seem to present one explanation for the "dead ring" and "frog-eye" symptom.

Growth chamber studies indicate that bentgrass is most susceptible to Fusarium blight, while field observations suggest that the disease is primarily a problem of bluegrass. Turfgrass management practices may explain this discrepancy. Traditionally, bentgrass is grown under adequate, or often excessive irrigation. On the other hand, bluegrass fairways are traditionally kept "dry" to minimize invasion by undesirable grasses. This difference in irrigation practices may explain the absence of Fusarium blight in most bentgrass areas.

A HISTORY OF CONTROL RESEARCH

Because of the regular association of Fusarium blight with hot, dry environments, Bean (3) has recommended heavy watering for disease suppression. Research evidence (13) suggests that although adequate irrigation suppresses Fusarium blight, it encourages invasion of quality bluegrass turf by annual bluegrass *(Poa annua)* and other weed grasses.

Funk (15) has pointed out that Kentucky bluegrass cultivars originating in areas with cool, moist summers are often severely damaged by the disease; he has suggested that Fusarium blight resistance is to be found in "southern turftype" bluegrass cultivars that are heat and drought tolerant. He states that these cultivars should do well in the southern transition zone of bluegrass adaptation where Fusarium blight is most damaging. He also suggests the overseeding of turftype ryegrasses into blighted bluegrass stands, adding the caution that improved resistance to *Pythium* and *Rhizoctonia* is needed for good summer performance of ryegrass in regions where summer heat stress and humidity are excessive.

In addition to the "plant-oriented" control approach of resistant Kentucky bluegrass cultivars, Turgeon (34) has suggested an "environmental-oriented" approach that avoids excessive nitrogen fertilization during spring, provides adequate moisture for turfgrass survival during stress periods through irrigation, employs appropriate cultivation practices to control thatch and alleviate soil compaction, and applies effective fungicides.

In the period from 1966 through 1976, many chemical control experiments were conducted. During the early part of this period, most work (1, 3, 11) involved the contact fungicides such as mancozeb (Dithane M-45), thiram-organic mercury (Tersan OM), anilazine (Dyrene), Difolatan, chlorothalonil (Daconil), and others. Although a partial level of control was obtained in a few instances, the level of disease suppression was not satisfactory for practical use. For example, Bean et al. (3) presented the results of a series of fungicide experiments conducted during 1965 and 1966. A single application of hydrated lime (11 kg/93 m^2) reduced Fusarium blight fourfold, and Tersan OM applied in weekly sprays provided significant disease suppression. On the other hand, Difolatan, Dyrene, Dithane M-45, Daconil 2787, and Panogen turf fungicide provided no significant benefit. In spite of favorable small plot results, however, neither hydrated lime nor Tersan OM achieved commercial success. Applications of hydrated lime (1 kg/mo/93 m^2) were found by Cole and Sanders *(unpublished data)* to increase significantly the incidence of Fusarium blight.

Soil fumigation as a method to control Fusarium blight was tested by Cutwright and Harrison (12). In fall 1966, sod was stripped from a test area that had been severely blighted; replicated plots were fumigated with three soil fumigants; and the area was seeded with Merion Kentucky bluegrass two weeks after fumigation. Only a few scattered Fusarium-blighted areas developed in the experimental area during the following summer. The disease ratings for 1968, however, indicated that none of the treatments effectively controlled the disease over even a short two-year period.

The introduction of systemic fungicides provided the first highly effective chemical treatment. Cutwright and Harrison (12) in 1970 reported excellent control of Fusarium blight with weekly preventive sprays of benomyl. Muse (20) reported control of Fusarium blight with thiophanate methyl and benomyl when they were applied as drenches, and Fulton et al. (14) obtained suppression of the disease with presymptom application of foliar sprays of triarimol and benomyl, followed by a drenching water irrigation. Vargas and Laughlin (35) reported excellent control of the disease with regular preventive applications of benomyl as a drench (foliar sprays were not effective), but no control with Dithane M-45 or thiabendazole, regardless of mode of application. In the ensuing years, various researchers (5, 8, 9, 16, 18, 22, 30, 31, 35) have obtained successful control of Fusarium blight through preventive and curative applications of benzimidazoles, triarimol (EL 273), and fenarimol (EL 222). However, in 1975 and 1976, control failures were reported with benzimidazole-derivative fungicides due to apparent pathogen resistance to the fungicides (7, 32).

During the 1977 and 1978 growing seasons, excellent control of Fusarium blight was obtained with the experimental fungicides, triadimefon (Bayleton) (6, 19, 21), CGA 64251 (19, 21, 26), DPX 4424 (26), and iprodione (26019) (6, 26, 29). In-depth studies with triadimefon (BC 6447) (24) and iprodione (27, 28) demonstrated no petri dish toxicity to *Fusarium* spp. Iprodione was found to increase sporulation of *Fusarium* spp. in the laboratory and to increase the number of Fusarium propagules in treated field soil (27, 28).

CONTROL THROUGH THE EYES OF A RESEARCHER

At present a satisfactory control system for suppression of Fusarium blight is not yet available. Practical research aimed at identifying control measures is seriously hampered by the lack of conclusive information about disease development. The lack of an effective inoculation technique makes it impossible to determine whether the Fusaria that are regularly isolated from bluegrass showing symptoms of Fusarium blight, are indeed the causal pathogens. We have in the past assumed that Fusarium fungi were the causal agents when in fact we have had no basis to draw such a conclusion. Thus, at present, we have no sure information about causal fungi, nor how, where, or if they damage grass, and why some grasses are resistant to the disease. Without such essential basic knowledge, control decisions have limited basis in hard facts, and are often similar to the search for a cure for human cancer.

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THE ISOLATION OF A TOXIN FROM SPRING DEAD SPOT AREAS IN BERMUDAGRASS TURF

T. W. Fermanian, R. M. Ahring, and W. W. Huffine

INTRODUCTION

Spring dead spot (SDS) is a disease of bermudagrass (*Cynodon* L.C. Rich.) characterized by the appearance of small circular areas of dead grass that are first noticed as the grass breaks dormancy in the spring. According to Wadsworth and Young (1960), these necrotic areas remain devoid of bermudagrass throughout the next year or two. Weeds, however, readily invade and persist in the dead areas. The selectivity of the SDS environment could be the key to the selective biological control of bermudagrass. Since the spots normally do not increase in size through the period of active bermudagrass growth, the restriction of bermudagrass development by an active pathogen is questionable (Wadsworth, 1966). However, the presence of a fungus-produced toxin is very possible. If a toxin is produced only during active pathogen growth, it would appear that the toxin is very resistant to degradation, and will, possibly, persist for the entire season! Leaching of the toxin is minimal (Kozelnicky, 1974; Wadsworth, 1966), a fact supported by the lack of pronounced downhill movement of SDS on sloped turfs (Wadsworth, 1966). The potential value in isolating and identifying the toxin(s), if present in SDS soils, is that it would be possible then to: (1) develop effective control measures, and (2) synthesize and produce the toxin for selective control of bermudagrass.

Restriction of bermudagrass to a limited area is usually a persistent problem. The rapid lateral spread of bermudagrass stolons and rhizomes allows the turf to eventually grow beyond its intended borders. At present, only cultivation and nonselective herbicides are available for bermudagrass control. Cultivation is usually the most effective control of bermudagrass, but its effect is shortlived. The application of nonselective herbicides severely limits the use of the area treated, whereas control by a natural toxin of bermudagrass would not.

This research was initiated to investigate the possibility of a SDS-related toxin, regardless of the mechanism of production, and to characterize any isolated toxin.

MATERIALS AND METHODS

Collection of SDS Soil

The initial phase of this investigation was to collect soil from SDS areas. This soil was used in all the subsequent soil extractions. All collections were made between April 26, 1979, and May 21, 1979. Despite the severe winter of 1978-1979, the incidence of SDS was minimal. Therefore, very few sites were available for the collection of SDS samples. These samples were obtained from eight sites

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located on three golf courses and two home lawns. The location, site, soil texture, and herbicides applied to the site within two months prior to the sampling date are listed in Table 1.

A 10 cm golf course green hole-cutter was used to extract all soil samples. Three cores were lifted from each dead spot and adjacent healthy turf. After removal from the hole-cutter, each core was divided into four parts. First, all thatch was removed from the top of the core. The remaining soil was then divided as follows: 0 to 3 cm, 3 to 6 cm, and 6 to 9 cm. Any remaining soil was discarded.

Table 1. Site Location, Soil Texture, and Preemergence Herbicide Applied to SDS Soil Samples

Location	Site	Soil texture	Preemergence herbicide
Southern Hills Country Club	Eighteenth fairway	Loam	Benefin[a]
Southern Hills Country Club	Twelfth rough	Loam	None
Southern Hills Country Club	Sixteenth fairway	Loam	Benefin
Ponca City Country Club	Tenth fairway	Silt loam	None
Ponca City Country Club	Seventeenth green apron	Sandy loam	Benefin
Cushing	Home lawn	----	Benefin
Cushing Country Club	Fourteenth fairway	Loam	None
Stillwater	Home lawn	Loam	Benefin

[a]N-butyl-N-ethyl-α-α-α-trifluoro-2,6 dinitro-p-toluidine

Preliminary Tests

Several preliminary tests were conducted to evaluate the soils for toxin activity. A split-plot design with a factorial arrangement of sites, SDS and check (non-SDS soil samples from adjacent areas) and depth with four replications was used for the study. The main plots were sites and subplots, and the four depth fractions of each sample were as follows: thatch, soil surface to 3 cm; 3 to 6 cm; and 6 to 9 cm.

The soil from each subplot (soil depth) was placed in 5 cm square peat pots. Twenty-five hulled seeds of an experimental bermudagrass hybrid, Guymon X 10978b, were placed in the top 5 mm of soil. Guymon X 10978b was selected for the experiment because it exhibited excellent seedling vigor in previous work (Fermanian, 1978). Seedling emergence counts were made at 10, 35, and 70 days after seeding.

Soil Extracts and Bioassays

Several soil extracts with water, 95 percent ethanol, and 80 percent methanol were made by leaching the soil-core and soil-core depth samples for 24 hours, by filtering the leachate, and by concentrating the leachate (extract) under vacuum. The entire extraction and bioassay procedure common to all three solvents, but using methanol as the example, is given below.

The soil samples, approximately 400 g each, were mixed with an equal volume of an 80 percent methanol solution (w/v). After being shaken for approximately 1 minute, the mixtures were allowed to stand for 24 hours. To remove suspended soil particles, the mixtures were filtered several times by vacuum through "Whatman" No. 31 filter paper, followed by flash evaporation at 60° C to remove the methanol. After evaporation of the methanol, the remaining aqueous solution was cooled and refrigerated until used in the bioassay.

The SDS extracts were diluted with distilled water to make final concentrations of 25 and 50 percent of the original, a dilution ratio of 1:4 and 1:1. The undiluted, non-SDS soil extract, distilled water, a 0.5 percent methanol solution, and a 1 percent methanol solution were used as controls. Six ml of each methanol extract dilution, of non-SDS soil extract, and of control solution were each used to moisten two layers of paper substrate cut to fit in individual, covered, germination boxes each 7 x 7 x 2.5 cm. Fifty seeds of bermudagrass (Guymon X 10978b), or of lettuce (*Lactuca sativa* L. Mesa 659) were then added to each box. Germination boxes were arranged in a randomized block design with four replications. The boxes were placed in a 20-30° C alternate, 8 hours light at 30° C, and 16 hours darkness at 20° C germination environment. Germination counts for the lettuce seeds were made three days later. The boxes containing bermudagrass seedlings were evaluated for germination percentages, shoot lengths, and root lengths at the end of 7 days.

A second methanol extraction was made of a SDS soil sampled from a Stillwater home lawn. A 3-6 cm fraction of SDS soil was also studied. All extraction procedures and bioassay treatments were the same as outlined previously. Evaluations of plant growth were also the same as those for the first study except that the root length of the lettuce seedlings was also recorded.

A third and more detailed methanol extract experiment followed these initial studies. The preparation and extraction of the soil samples in this experiment were the same as for the previous experiments. However, a major change in the design was made. Only bermudagrass seed (Guymon X 10978b) was used in the assay. The germination boxes were arranged in a split-unit design with four replications. The main units consisted of a factorial arrangement of extracts from SDS and non-SDS soil samples from four locations. The extracts from the four depth fractions of each sample were the subunits. All germination boxes were placed in the germinator on the same date. Seven days later each box was evaluated for the percentage of germination, seedling, and root length.

RESULTS

Preliminary Tests

SDS soils were assayed for effects on seed germination and growth of bermudagrass seedlings on three different dates, and each evaluation provided similar results. Data collected 10 days after seeding indicated a general enhancement of germination in SDS soil (Table 2).

In five of the seven sites assayed, germination in SDS soil was higher than the check soil, and from one site the increase was significant. Unlike Kozelnicky's (1974) previous findings, this stimulated growth in SDS soil persisted for up to

Table 2. Germination and Growth of Bermudagrass Seedlings Grown 10 Days in SDS and Non-SDS Soil from Seven Sites

Location	Site	SDS soil	Non-SDS soil
		Percentage of seed germination	
Cushing CC	#14 Fairway	41[a]	32
Cushing	Home lawn	17	10
Ponca City CC	#10 Fairway	27	22
Ponca City CC	#17 Fairway	25	27
Southern Hills CC	#12 Fairway	24	19
Southern Hills CC	#18 Fairway	35	8
Stillwater	Home lawn	28	29

[a]LSD 0.05 = 11.03

70 days. Some differences in germination and growth of bermudagrass in different soil sample depths and their interactions were found. These differences, however, are meaningless without the establishment of SDS toxic effects first.

Methanol Extract Bioassays

The initial bioassay of the methanol extract showed significant differences in means of extract assay treatment in all areas evaluated. Lettuce seed germination (Fig. 1) and both shoot (Fig. 2) and root lengths of bermudagrass seedlings had highly significant mean differences. Out of a possible 200 lettuce seeds, only two germinated in the undiluted extract from SDS soil. Bermudagrass seed germination was also significantly reduced in the undiluted SDS extract, as compared to the non-SDS soil extract (Fig. 1). The germination of bermudagrass seed grown in water and 0.5 percent methanol, however, was not significantly different from that found in the undiluted extract.

The mean shoot lengths of bermudagrass seedlings for extracts as determined by the analysis of variance were significant when tested by Duncan's Multiple Range test (DMRT). The length of seedling shoots on undiluted SDS extracts were significantly shorter than in any other substrate treatment group. It should be noted also that the seedling shoot lengths in the methanol solutions were significantly longer than those in any other treatment (Fig. 2).

Evaluation of the bermudagrass seedling root length data by DMRT showed differences similar to those found for shoot lengths. Seedlings grown in substrate moistened with the undiluted SDS extract had significantly shorter roots than any other substrate treatment group. The seedlings grown in the methanol solutions again had the longest length, a fact suggesting that methanol residues were not the inhibitory factor depicted by the test results.

Studies utilizing the second methanol soil extracts were analyzed as a randomized block experiment. Unlike the first extract bioassay, lettuce seed germination in the control soil extract was not significantly different than the germination in the undiluted SDS extract. There were, however, significant differences in lettuce seed germination among the control soil extract, undiluted SDS extract, the 50 percent SDS extract, and all the other extracts. When tested by DMRT, the lettuce root length means showed similar groupings as the germination means. Again, there was no significant difference in root lengths between lettuce grown in the undiluted SDS extract from soil at either depth, or from the control soil extract. It should be noted that the lettuce seedling roots in water were significantly longer than the roots of any other group.

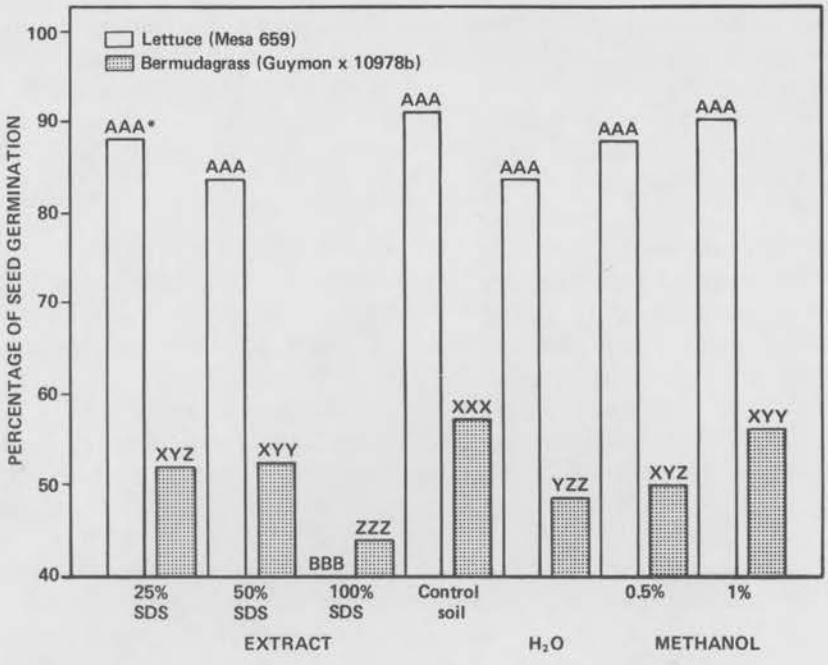


Figure 1. Mean seed germination of lettuce or bermudagrass on substrate moistened with the methanol extracts of SDS and non-SDS soil.

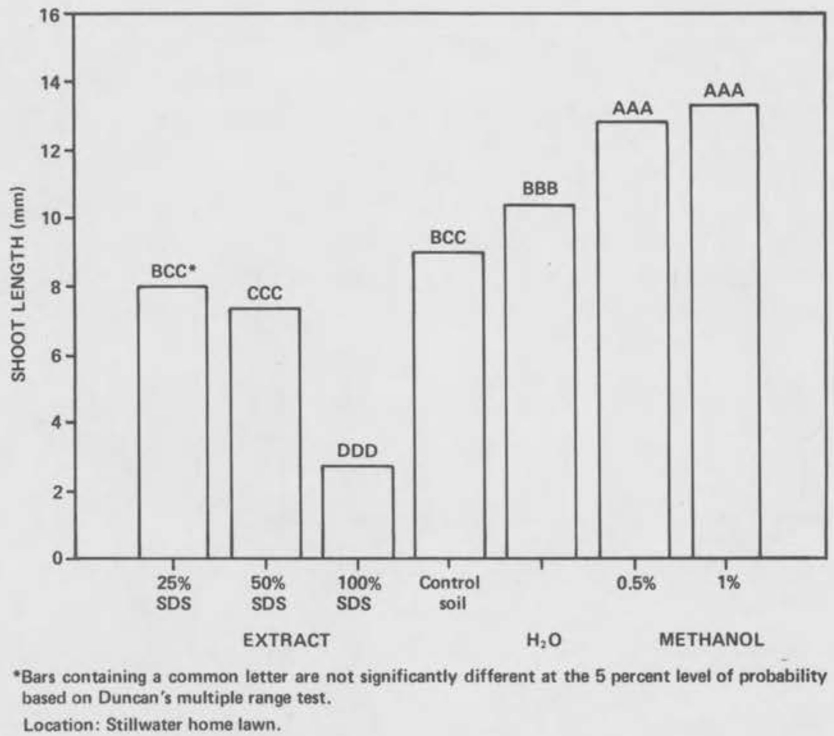
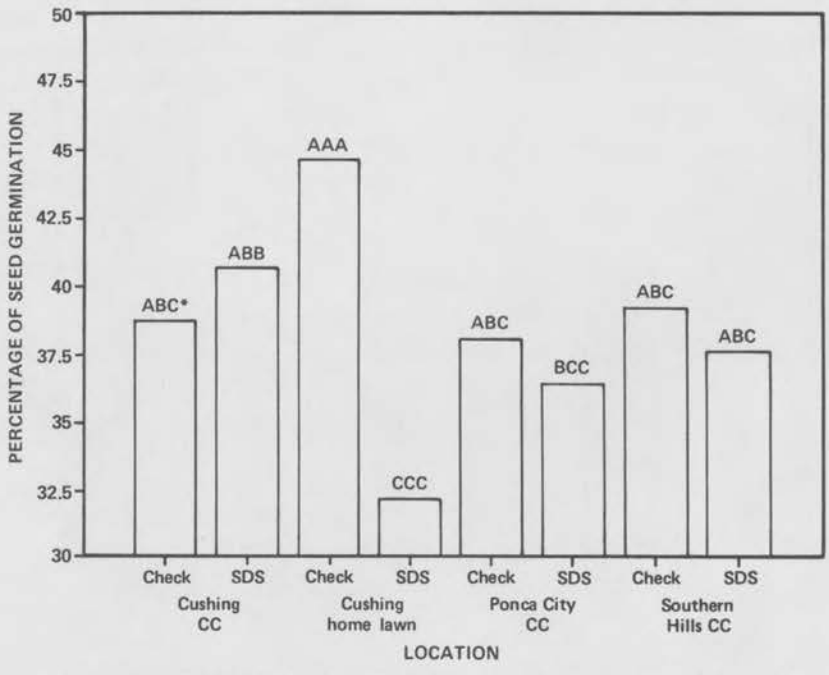


Figure 2. Mean shoot length of bermudagrass seedlings germinated on substrate moistened with the methanol extracts of SDS and non-SDS soil.

The greatest evidence of the presence of SDS toxin in the second methanol extract came from the analysis of bermudagrass seed germination means. The undiluted SDS extract of both soil depths significantly lowered the germination percentages in comparison to the control. Bermudagrass seedlings on water-moistened substrate had the longest shoot and root lengths; therefore, all extracts showed some degree of reduction in shoot and root length.

The third methanol extract bioassay was analyzed in two parts in the following order: (1) The total experiment was analyzed as a split-plot design such that main plots were a factorial arrangement of extract type and sample location. (2) The data for each location were analyzed separately as a split-plot design, with the main plots consisting of the source of extract (SDS or non-SDS soil). Before the entire analysis could be computed, a regression equation had to be formulated to determine the subplot values. Approximate values for germination, shoot length, and root length for both the non-SDS Cushing home lawn soil, the thatch sample, and the Cushing Country Club SDS thatch samples were selected from a regression line for each replication. These values were used in all analyses of variance to provide a balanced design. Eight degrees of freedom were subtracted from the subplot error term. This procedure was necessary because thatch was not present at the time of sampling at these two sites. A significant F-value ($P<0.05$) was found for the type X location interaction. These interaction means were tested by DMRT and are shown in Figure 3.



*Bars containing a common letter are not significantly different at the 5 percent level of probability based on Duncan's multiple range test.

Figure 3. Mean seed germination of bermudagrass on substrate moistened with methanol extracts of SDS and non-SDS soil.

Although much overlapping of means occurred, one clear separation should be noted. The bermudagrass seeds in SDS extracts from the home lawn in Cushing had significantly lower germination than the bermudagrass in non-SDS soil extracts from the same site.

No significant differences in seedling shoot lengths were found between SDS and non-SDS soil extracts from the same location, except from Southern Hills Country Club, where seedling shoot lengths were greater in the SDS soil. Significant differences in shoot lengths between different extracts among locations, however, did occur. The analysis of variance for root lengths of bermudagrass seedlings showed a significant F-value ($P<0.05$) for the location X type interaction. Significant differences in root length means were also found between SDS and non-SDS soil in the same locations for Cushing Country Club, Cushing home lawn, and the Ponca City Country Club. The Ponca City and Cushing Country Club locations, however, showed greater seedling root length in the SDS extract.

The analyses of variance for bermudagrass seed germination, shoot length, and root length in the third methanol extracts, showed significant F-values for depth, depth X type, depth X location, and depth X location X type interactions. Interpretations of this analysis will not be attempted. A more valid interpretation can be made by examining the analysis of variance by location. Because no significant differences in germination, shoot length, and root length means among location X type interactions were found for the Cushing and Southern Hills Country Club locations, the analysis of variance for these sites will not be discussed.

The analyses of variance of the soil extract from the Ponca City Country Club showed, with few exceptions, no significant F-values for all groups of means. The exceptions, however, had greater values for the SDS extract than for the control soil extract. No significant differences in bermudagrass seed germination for depth X type interaction means from the Cushing home lawn location were observed. For both seedling shoot length and root length, the 0-3 and 3-6 cm depth extracts of SDS soil had significantly lower values than the extracts from corresponding depths of non-SDS soil.

DISCUSSION

No conclusive evidence for toxin activity was found in the soil with ethanol and water extract bioassays. In the soil bioassay, a significant increase in germination and growth occurred in the SDS soil from several locations.

Significant differences in lettuce or bermudagrass seed germination between non-SDS and SDS soil extracts were observed in all three methanol extract bioassays. Diluted SDS extract enhanced the germination and growth of either test species. Bermudagrass seedlings that did germinate on substrate moistened with the SDS extract often had greatly reduced shoot and roots. No significant differences in germination were observed among subsample depths at any location and experiment. The toxic activity however, was greatest in the 0-3 and 3-6 cm fractions. Since neither the SDS nor non-SDS soil thatch subsample was available at either the Stillwater or Cushing home lawn locations, information on toxin activity for this fraction is lacking.

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ENHANCING THE GERMINATION OF KENTUCKY BLUEGRASS

H.L. Portz, D.Y. Yeam, and J.J. Murray

Kentucky bluegrass is the major cool season turfgrass for the northern half of the United States. It has excellent turfgrass quality in the fall and early spring, but may experience summer doldrums, such as thinning by disease, and summer dormancy. It is subject to possible frost-heaving when established in late fall. Also, of the cool season turfgrasses, it is the slowest in germination, usually taking between two and three weeks for field germination where ryegrasses germinate in one week. As shown in Table 1, cultivars of Kentucky bluegrass vary in speed and percentage of germination.

Table 1. Germination of Kentucky Bluegrass Cultivars in Petri Dishes†

Cultivar	Percentage of germination 8 days	16 days
Fylking	69	92
Baron	51	91
Kenblue	54	87
Victa (new)	15	83
Adelphi	34	82
Majestic	61	81
Enmundi	42	77
Merion*	35	76
Bristol	40	72
Rugby	35	67
Windsor	25	67
Trenton	21	48
Vantage (new)*	11	39
Ram	7	35
Victa (old)	1	32
Parade*	2	25
Vantage (old)*	2	8

†At 20° C, light (12-12).
*Selected for further research.

From the seventeen cultivars, four were selected for further study. Research with zoysiagrass seed has shown the advantages of a KOH scarification and light treatment to enhance germination. The objective of this research, therefore, was

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to determine if the percentage and rate of germination of inherently slow germinating or old seed of Kentucky bluegrass cultivars can also be increased by scarification with KOH and light treatment.

SEED TREATMENTS

Seed treatments were conducted according to the following plan:

1. KOH scarification
   --0 to 35 percent water solution
   --0 to 24 minutes duration

2. Light treatment
   --200 Einstein's/m^2/second
   --0 to 72 hour duration

3. Dried 3 to 6 hours

4. Stored at 0° to 4° C for minimun of one week

5. Seeds germinated in petri dishes or paper pots at 15° to 25° C in dark or in light with diurnal fluctuation of 12 hours light and 12 hours dark (12-$\overline{12}$).

RESULTS AND DISCUSSION

An initial trial in the greenhouse showed good results from a 15 percent KOH scarification for 8 minutes on Parade Kentucky bluegrass as compared with the control. The four old and new seed lots selected were scarified with 15, 25, and 35 percent KOH solutions for 0, 2, 8, 16, and 24 minutes. Results for one new seed lot of Vantage Kentucky bluegrass are shown in Table 2. A 25 percent concentration for 16 minutes gave a germination of 78 percent in ten days after seeding as compared to 27 percent for the untreated control. Although the germination for an old seed lot of Vantage was only 41 percent in twenty days, it was significantly better than the 16 percent for the control (Table 3).

Table 2. Percentage of Germination 10 Days After Seeding of KOH-treated New Vantage Seed†

	KOH concentration (%)*		
Scarification	15	25	35
Minutes	Percentage of germination		
Control	26 f	27 f	27 f
2	40 e	44 e	39 e
8	67 bc	64 bc	59 cd
16	69 bc	78 a	75 ab
24	16 fg	10 g	51 de

†At 20° C, light (12-12), in petri dishes.
*Means followed by the same letters are not significantly different at the 5 percent level as indicated by Duncan's Multiple Range Test.

Table 3. Percentage of Germination 20 Days After Seeding of KOH-treated Old Vantage Seed†

Scarification	KOH concentration (%) 15	25	34
Minutes	Percentage of germination		
Control	15 fg	16 fg	15 fg
2	14 fg	21 def	17 ef
8	24 cde	32 abc	28 bcd
16	40 a	41 a	39 a
24	7 g	17 ef	34 ab

†At 20° C, light (12-12), in petri dishes.

Further testing of all seed lots indicated that a 30 percent KOH concentration for 12 minutes at 15° C gave the highest germination. KOH at 30 percent plus light treatments of 24 (KL24), 48 (KL48), and 72 (KL72) hours were compared to KOH treatment only (KD) and control. The seeds for the latter were germinated in the dark at 15° C in petri dishes. The best germination for the four seed lots was from the 24-hour light treatment shown in Table 4. When KL24-treated seeds were seeded in pots, germination in 15 days of all four seed lots was dramatically increased over the control (Table 5). After 25 days, the untreated control seed was gradually catching up, but was still only slightly over one-half the germination of treated seed.

Table 4. Germination 10 Days After Seeding of Scarified (30 Percent KOH for 12 min.) and Light-treated Seed of Four Kentucky Bluegrass Seed Lots†

Treatment*	Old Vantage	New Vantage	Old Parade	Merion
	Percentage of germination			
KL24	31 a	73 a	39 a	67 a
KL48	30 a	70 a	30 b	60 a
KD	25 ab	48 b	8 d	32 c
KL72	23 b	49 b	21 c	45 b
Control	3 c	21 c	7 d	31 c

†At 15° C, in dark, in petri dishes.
*KD=KOH, no light; KL(24,48,72)=KOH and hours of light treatment.

Table 5. Germination 15 and 25 Days After Seeding of KL24-treated Seed of Four Kentucky Bluegrass Seed Lots†

	Days after seeding			
	15		25	
Seed lot	KL24	Control	KL24	Control
New Vantage	58	10	76	48
Old Vantage	37	8	42	18
Old Parade	34	9	50	26
Merion	50	11	75	48

†At 25° C, in light, in pots.

In July, treated and untreated Kentucky bluegrass seeds of three cultivars were seeded in the field at the USDA-Beltsville Center in Maryland. Seedling plants at 35 days and the percentage of groundcover in 52 days are shown in Table 6. Despite the extremely hot July and August period, a 78 percent groundcover in 52 days was achieved with the KL24 seed. An explanation of the lower seedling count and groundcover for KD seed as compared to the control is difficult; perhaps there was some injury to the embryo as a result of scarification. And, because this nonlight treated seed was delayed in germination until normal sunlight could reach the seed, the hot soil temperatures adversely affected germination.

Table 6. Plants/Unit Area and Percentage of Groundcover of Treated Kentucky Bluegrass Seed

Treatment	Number of plants/0.1m^2 in 35 days	Percentage of groundcover in 52 days
KL24	916 a	78 a
Control	722 b	61 b
KD	548 c	41 c

USDA-B fied test; means of 3 cultivars, 3 replications.

CONCLUSION

In conclusion, the percentage and rate of seed germination in selected Kentucky bluegrass cultivars can be significantly increased by scarification with KOH (30 percent concentration for 12 minutes) followed by light irradiation for 24 hours. Thus, older seed lots might be utilized, or slow-germinating cultivars could be established more rapidly and successfully when seeded under less than ideal conditions such as those prevailing in late fall or late spring. The treatment could be conveniently performed with hydroseeding.

ESTABLISHING ZOYSIAGRASS FROM SEED

D.Y. Yeam, H.L. Portz, and J.J. Murray

Zoysiagrass (*Zoysia japonica* Steud.) is well adapted to the transition zone of the United States, but its use has been limited mostly because of difficulties in establishing it. This presentation briefly covers the recent research efforts to establish zoysiagrass by seed rather than by vegetative methods such as sodding, plugging, and stolonizing. Except for full sodding, all these methods are relatively slow, so that it takes from one to three years to establish a complete cover.

The other alternative--the use of seed--has proved more successful. In Korea, Dr. Yu, Dr. Yeam, and others have been seeding zoysiagrass for a number of years. The handseeding of small plots, and the hydroseeding of golf courses and roadsides is now a regular practice. If seeding is possible in Korea, it should certainly be possible in the United States.

Because of dormancy factors, only 5 to 10 percent of untreated seeds germinate in 10 to 15 days, and 30 percent in 6 to 8 weeks. Forbes and Ferguson (1) first recognized that intact seeds of zoysiagrass did not germinate, but that mechanical hulling and sulfuric acid treatment resulted in both increased speed and percentage of germination. In early work in the 1950s at USDA, Beltsville, plant breeders such as Grau, Ferguson, and Forbes utilized seed in space plantings for outcrossing and hybridization to develop new cultivars such as 'Meyer' and 'Emerald'. Seed germination, however, was always low, even with dehulling or acid scarification. The slow, erratic germination of 50 to 60 percent of the seed was not adequate for commercial use.

Dr. Yeam and his co-workers in Korea have developed a technique for breaking this seed dormancy. It consists of two steps: (1) to treat seed with a potassium hydroxide solution: 30 percent KOH or NaOH for 25 minutes; and (2) to give a light treatment for 36 to 48 hours. Results show germination of over 90 percent in 7 days.

SEED ESTABLISHMENT EXPERIMENTS

Treated and untreated seeds were imported from Korea. Dr. Yeam personally brought considerable untreated seed with him on his sabbatical to Southern Illinois University at Carbondale, and USDA-Beltsville. The objectives of the research were as follows:

1. to determine the best seeding rates, seed treatment, and seeding method in a prepared seed bed;
2. to compare seeding versus plugging into an existing sod;

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3. to determine effective herbicide treatments;
4. to determine practical methods for hydroseeding.

The two locations for the seeding rate and method experiments were at Southern Illinois University at Carbondale (SIU-C), and at the USDA, Beltsville (USDA-B).

PROCEDURE AND RESULTS

Seeding Rate and Seeding Method Experiments

Scarified and light-treated Korean zoysiagrass seeds (SL) at the rate of 1/4, 1/2, 3/4, 1, 1 1/2, and 2 lb. per 1000 sq. ft. were drop seeded, lightly raked, and rolled with a Brillion seeder-roller. Irrigation was used as needed to keep soil surface moist. A preemergence herbicide, siduron, at 8 lb. a.i./acre, and a postemergence treatment of 2,4-D/dicamba at 0.8 and 0.25 lb. a.i./acre were applied. Weekly mowing at 1 1/4 inches was begun at six weeks. Results of the six seeding rates are shown in Table 1. The 2 lb. seeding rate gave a significantly higher groundcover at USDA-B in 3 weeks, and at SIU-C in 5 weeks. In 5 weeks at SIU-C, the 3/4 lb. rate and above gave over 80 percent groundcover. By 12 weeks, however, even the 1/4 lb. rate gave over 86 percent groundcover.

Table 1. Seeding Rates for SL Seed and Resulting Groundcover at Two Locations in 1980

Seeding rate		Groundcover		
		USDA-B	SIU-C	
m^2	1000 sq. ft.	3 weeks	5 weeks	12 weeks
g	lb.	Percentage of groundcover		
1.25	1/4	40.0 b*	68.3 b	86.7 a
2.50	1/2	58.3 b	70.0 ab	88.3 a
3.75	3/4	68.3 ab	81.7 ab	88.3 a
5.00	1	71.7 ab	80.0 ab	90.0 a
7.25	1 1/2	83.3 ab	83.3 ab	90.0 a
10.00	2	91.7 a	86.7 a	90.0 a

*Means within columns followed by the same letter are not significantly different at the 5 percent level as determined by Duncan's multiple range test.

In the seed treatment and seeding method experiment, weed control, irrigation, and mowing were similar to the seeding rate experiment. The percentage of groundcover from a uniform seeding rate of 1 1/2 lb. per 1000 sq. ft. using seed that was untreated (U), scarified only (S), and scarified and light-treated (SL), is shown in Table 2. SL seed showed the highest percentage of groundcover with Brillion-rolled (BR) and seed-rolled (SR) seeding methods at both locations. Nonlight treated seeds (S) were slower to emerge when Brillion-rolled, and especially when drilled (RS) as compared to smooth-rolled, because of soil coverage and consequent light exclusion. At 12 weeks at SIU-C, the U seed had significantly lower groundcover than S or SL seed, but there was no difference in the seeding method.

Table 2. Seed Treatments, Seeding Methods, and Resulting Groundcover of Zoysiagrass at Two Locations in 1980

Seed treatment	Seeding method	Groundcover USDA-B 3 weeks	Groundcover SIU-C 5 weeks	Groundcover SIU-C 12 weeks
		Percentage of Groundcover		
U	BR	3.0 b	6.7 e	51.7 b
U	SR	2.0 b	5.0 e	48.3 b
U	RS	3.0 b	8.3 e	51.7 b
S	BR	51.7 a	48.3 b	88.3 a
S	SR	58.3 a	70.0 a	90.0 a
S	RS	7.0 b	25.0 cd	81.7 a
SL	BR	66.7 a	78.3 a	91.7 a
SL	SR	56.7 a	80.0 a	85.0 a
SL	RS	6.0 b	36.7 bc	81.7 a

U= untreated; S= scarified; SL= scarified and light-treated;
BR= Brillion-rolled; SR= smooth-rolled; RS= Roger's seeder.

Seeding Versus Plugging Into an Existing Sod

Two methods of seeding, drilling with a Roger's seeder, and broadcast seeding followed by verticutting, were compared to plugging into existing sods of tall fescue and Kentucky bluegrass. Although a number of chemicals were used to suppress grass growth, no zoysiagrass seedlings could be found. Only the zoysiagrass plugs persisted.

Methods of Propagation and Weed Control

Plugs and stolons of 'Meyer' zoysiagrass and treated Korean seed (SL) were established and treated with several pre- and postemergence herbicides. Weed control by the different herbicides and phytotoxicity to zoysiagrass seedlings are shown in Table 3. The best weed control resulted from a combination of siduron and simazine; however, the phytotoxicity to seedling zoysiagrass was greatest. Only siduron was acceptable as a preemergence weed control. Groundcover with all three propagation methods is shown in Table 4. Treated Korean seed at 1 1/2 lb. per 1000 sq. ft. with siduron gave a groundcover of 90 percent as compared to 80 percent for stolonized 'Meyer' and 78 percent for plugged 'Meyer'. Simazine was the best preemergence herbicide for plugged and stolonized zoysiagrass. When no weed control was used, plugging was the only propagation method giving over 50 percent groundcover.

*Table 3. Effect of Herbicides on Establishment of Zoysiagrass by Seed**

Herbicide treatment	lb. a.i./acre	Weed control † Broadleaf	Weed control † Grassy	Turfgrass ‡ growth
Siduron	10.00	5.9	8.2	4.8
Simazine	0.75	8.9	8.9	1.5
Siduron/simazine	8.00/0.50	9.0	9.0	1.3
DCPA	10.00	6.9	7.5	2.2
MSMA + 2, 4-D/dicamba	1.00 (2x) 0.75/0.25	8.5	3.2	3.5
Check		3.5	1.9	3.2

*Planted 18 June 1980.
†Rating of 9 = Complete weed control; 1 = no control.
Average of four ratings, July 1 - July 22.
‡Rating of 9 = no phytotoxicity and good growth; 1 = no growth.

*Table 4. Herbicide Treatments and Propagation Methods for Establishing Zoysiagrass in a Prepared Seedbed at Carbondale, Illinois**

Herbicide treatment	Percentage of groundcover on 2 Oct. (15 weeks) Seeded	Stolonized	Plugged
Siduron	90.0 a	80.0 a	78.3 ab
Simazine	1.7 e	75.0 a	83.3 a
Siduron/simazine	5.0 de	68.3 a	73.3 abc
DCPA	10.0 de	38.3 b	51.7 d
MSMA +2, 4-D/dicamba	61.7 b	65.0 a	65.0 bcd
Check	22.7 c	36.7 b	55.0 cd

*18 June 1980.

Hydroseeding

Two roadside banks in Southern Illinois were hydroseeded in 1980. Turf fiber and siduron were applied with SL seed. Initial germination of seed was good on one bank receiving supplemental irrigation for one week. After 3 weeks, however, the hot weather and lack of rainfall left only a few seedlings in ditch areas. The other hydroseeding location without any follow-up irrigation showed no viable seedlings.

CONCLUSION

1. Dormancy of zoysiagrass seed can be broken by scarification and light treatment resulting in over 90 percent germination.
2. A seeding rate of 3/4 lb. per 1000 sq. ft. of scarified and light-treated Korean seed gave an adequate groundcover of 88 percent in 12 weeks.
3. Surface seeding and rolling with a Brillion seeder or smooth-rolled seeding gave better stands in 5 weeks than did drilling with a Roger's seeder.
4. Seeding into a tall fescue or Kentucky bluegrass sod was not successful in 1980.

5. Siduron was the only preemergence herbicide useful for seed establishment, whereas siduron and simazine separately and in combination gave good results with stolonizing and plugging.
6. Hydroseeding is potentially a good commercial method for establishing zoysiagrass on roadside banks, but was unsuccessful in 1980 without follow-up irrigation.

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CONTROLLED-RELEASE PREEMERGENCE HERBICIDE FORMULATIONS FOR THE CONTROL OF CRABGRASS IN TURF

David R. Chalmers, H.J. Hopen, and A.J. Turgeon

Commercial formulations of preemergence herbicides are applied to turf in a readily bioavailable form, free to react with environmental components of the turfgrass ecosystem. Biologically active herbicides can be depleted from the environment in a number of ways (such as volatilization, sorption by organic matter, adsorption by plants, and chemical, photochemical, and microbial degradation) resulting in reduced periods of weed control. This often necessitates the use of repeated applications of the herbicide to achieve effective weed control. A possible alternate method of extending herbicide activity is to regulate the bioavailability of the active ingredient through the use of controlled-release preemergence herbicide formulations.

Formulations used for these studies were provided by the USDA formulation chemist, B. Shasha, from the Northern Regional Research Center in Peoria, Illinois. The control-release carrier under study is starch xanthide (sx), a granular material made from corn starch. The starch xanthide formulation physically encapsulates the herbicide within a granular porous matrix. Release of the active ingredient occurs through diffusion and decomposition of the matrix.

The 1980 studies include a continuation of field studies initiated in 1979 that had included: (a) a comparison of relative performance of six sx-benefin formulations, and (b) evaluation of different combinations of starch xanthide (sx) and commercial formulations (cf) of benefin. A greenhouse comparison of sx-benefin was also included in 1980.

FIELD STUDIES:

All plots measured 5 x 6 ft. for all experiments and contained each treatment plus control in three replications. The turf was a Kenblue-type Kentucky bluegrass maintained at a mowing height of 1.0 inch, fertilized with a 10-6-4 ($N:P_2O_5:K_2O$) water soluble fertilizer and irrigated as needed to prevent wilt. The plot area was overseeded twice with large crabgrass to ensure weed pressure on Dec. 1, 1979 (0.5 lb./1000 sq. ft.), and April 26, 1980 (1.0 lb./1000 sq. ft.). Herbicide formulations were applied to all studies on May 1, 1980, and watered in. Rates of benefin per acre varied with the study and are included in the following tables. Data were collected periodically during the season for evaluations of phytotoxicity and weed control.

GREENHOUSE STUDY:

Four different sx-benefin formulations were compared with the chemical formulation at 2 and 4 lb./acre rates on two soil types (a Plainfield sand, and a

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Flanagan silt loam) to evaluate controlled-release characteristics.

Treatments were surface applied once (9/29/80) to soil or sand contained in 4 inch (dia.) plastic pots arranged in a randomized complete block design with five replications. Starch xanthide compounds contained approximately 2 percent benefin and were of a 20-40 mesh particle size. Chemical formulation of benefin was a specially formulated 0.5 percent G. Treatments were immediately watered following application.

Large crabgrass feed (approximately 20 percent viable) was sown (100 seeds per pot) at intervals of 1, 21, 42, and 63 days following herbicide treatment. All pots were kept moist by a mist system operating for 15 seconds every 10 minutes for two to three hours a day. Greenhouse temperatures ranged from 70°-80°F at the conclusion.

Data were collected on the basis of the number of crabgrass plants that would develop to the two-leaf stage and beyond. Raw data were subjected to an analysis of variance for each seeding date, and treatment means were compared using Duncan's multiple range comparison test. Data are expressed as percent control of crabgrass based on the untreated check.

RESULTS: FIELD STUDIES

All formulations produced acceptable control of large crabgrass without injury to the desired turf (Table 1). Control, however, did not appreciably differ among the six sx-benefin formulations tested (Table 2).

When different combinations of sx-benefin were combined with cf-benefin, only the 2 lb./acre treatments produced differences in control (Table 2). Control obtained from 2 lb. treatments was greatest when benefin was applied as cf, indicating that while sx-benefin may give good control of crabgrass, it does not have an advantage over the cf under these experimental conditions.

RESULTS: GREENHOUSE (TABLE 3)

There were no significant differences between treatments at the 4 lb./acre rates on either sand or soil media at any date. The following discussion will be concerned with 2 lb./acre treatments.

All compounds gave excellent control of the initial seeding on both sand and soil. When crabgrass was seeded after 21 days, all sx-compounds on sand and 3 sx-compounds (H_2O_2-0.30; Iron-0.30; H_2O_2-0.17) on soil resulted in significantly greater control than the chemical formulation. This advantage over the cf on sand was maintained for all sx-compounds at seeding date 42 and two sx-compounds (Iron 0.17; iron 0.30) at seeding date 63. On soil the benefit obtained from the sx-types over the cf disappeared at seeding dates of 42 and 63 days after application. Control obtained from cf treatments did not differ with media.

Results indicate that starch xanthide formulations of benefin can extend the effective period of control beyond that obtained with the commercial formulation. This advantage, however, is more pronounced on sand rather than soil media.

Table 1. Comparison of Relative Performance of Different Starch Xanthide Formulations for the Control of Crabgrass in Kentucky Bluegrass Turf

Starch xanthide herbicide formulation Polymer	Crosslinking agent	Degree of substitution	Percentage of active ingredient	Percentage of crabgrass 10/2
Acid modified flour			2	3.2 a*
Corn starch	$Fe_2(SO_4)_3$	0.3	2	2.7 a
Corn starch	$Fe(SO_4)_3$	0.17	2	1.7 a
Corn starch	H_2O_2	0.3	2	1.5 a
Corn starch	H_2O_2	0.17	2	1.8 a
Corn starch	H_2O_2	0.17	7	4.2 a
Untreated check	----	----	----	44.2 a
2 lb./acre				9.2 A
4 lb./acre				7.7 A

*Values with a letter in common do not differ significantly at the 5 percent level as determined by Duncan's multiple range test.

Table 2. Evaluation of Different Combinations of Starch Xanthide (sx) and Commercial Formulations (cf) of Benefin for Crabgrass Control in Kentucky Bluegrass Turf

Total benefin applied (lb./acre)	Carrier application rates (lb./acre)		Percentage of crabgrass			
	cf	sx	8/12	8/27	9/9	10/2
4	4	0	0.3 a*	0.7 a	0.7 a	0.7 a
4	3	1	0.7 a	0.7 a	1.0 ab	0.0 a
4	2	2	1.0 a	2.0 ab	0.7 a	0.7 a
4	1	3	0.7 a	2.0 ab	3.0 ab	2.3 abc
4	0	4	0.0 a	1.0 ab	1.3 ab	1.3 a
3	3	0	1.0 a	1.0 ab	1.0 ab	0.7 a
3	2.25	0.75	1.3 a	1.3 ab	2.0 ab	2.0 abc
3	1.5	1.5	0.7 a	0.7 a	1.0 ab	0.7 a
3	0.75	2.25	1.7 a	2.3 ab	1.7 ab	0.7 a
3	0	3	2.3 a	3.0 ab	5.0 ab	2.3 abc
2	2	0	3.0 a	1.0 ab	0.7 a	0.3 a
2	1.5	0.5	2.3 a	3.7 ab	3.0 ab	3.0 abc
2	1	1	3.0 a	3.7 ab	5.3 b	5.3 c
2	0.5	1.5	1.0 a	1.3 ab	1.7 ab	1.7 ab
2	0	2	3.7 a	5.0 a	5.0 ab	5.0 bc
Untreated check			30 b	33.3 c	33.3 c	38.3 d

*Values with a letter in common do not differ significantly at the 5 percent level as determined by Duncan's multiple range test.

Table 3. Percent Control of Crabgrass Seeded After Four Postapplication Periods Following Application of Two Rates of Five Preemergence Herbicide Formulations of Benefin to Two Soil Types

		sx Formulation		Postapplication period before seeding (days)			
Rate (lb./acre)	Media	Crosslinking agent	Degree of substitution	1	21	42	63
				Percentage of control†			
2 lb.	Sand	Iron	- 0.30	98 a*	100 a	81 ab	73 abc
		Iron	- 0.17	100 a	92 a	81 ab	87 ab
		H_2O_2	- 0.30	100 a	98 a	86 ab	58 abcd
		H_2O_2	- 0.17	100 a	97 a	72 ab	45 cd
		cf		98 a	63 c	33 d	36 d
	Soil	Iron	- 0.30	100 a	90 a	64 bcd	10 cd
		Iron	- 0.17	100 a	68 bc	45 d	0 cd
		H_2O_2	- 0.30	100 a	96 a	66 bcd	24 bcd
		H_2O_2	- 0.17	100 a	88 ab	51 cd	0 d
		cf		98 a	60 c	43 d	19 cd
4 lb.	Sand	Iron	- 0.30	100 a	100 a	98 a	93 a
		Iron	- 0.17	100 a	100 a	100 a	87 ab
		H_2O_2	- 0.30	100 a	100 a	98 a	93 a
		H_2O_2	- 0.17	100 a	98 a	98 a	91 a
		cf		100 a	98 a	67 abc	69 abcd
	Soil	Iron	- 0.30	100 a	100 a	85 ab	57 abc
		Iron	- 0.17	100 a	100 a	81 ab	33 abcd
		H_2O_2	- 0.30	100 a	100 a	95 a	81 ab
		H_2O_2	- 0.17	100 a	92 a	75 abc	29 abcd
		cf		100 a	94 a	83 ab	39 abcd

†Data based on the percentage of crabgrass in the untreated check controlled by treatment.

*Values with a letter in common do not differ significantly at the 5 percent level as determined by Duncan's multiple range test.

NEMATODES--A NEW ILLINOIS TURFGRASS PROBLEM?

T.A. Melton III and M.C. Shurtleff

Nematodes are present in all soils and comprise the largest group of multicelluar animals on earth. For several reasons, however, they have only recently become recognized and studied. Firstly, they are microscopic (0.4-3 mm long), translucent, and live in the soil. Secondly, they generally reduce vigor but rarely kill their plant host. Thirdly, most plant observations have focused on the shoots rather than the roots.

Most research on plant-parasitic nematodes has been concerned with food-producing crops, and therefore, the importance of nematodes on turfgrasses has not been well established. When relatively low numbers of certain species feed on specific turfgrasses, a great deal of damage may occur. However, some nematodes can reach high population levels (several thousand per pint of soil) and never seriously damage the turf. Yet understanding nematodes and their relationships to turfgrass is essential in implementing a nematode management program aimed at growing high quality turf.

BASIC NEMATODE MORPHOLOGY

Nematodes are microscopic roundworms, generally 0.4-3 mm in length and 30-100 µm in diameter, during some stage of their life cycle. The adult females of root-knot *(Meloidogyne* spp.*)* nematodes are pyriform or pear-shaped.

Most nematodes have well developed digestive and reproductive systems. From anterior to posterior, the digestive system is composed of the oral opening, the stylet, the esophagus, the intestine, and the anal or cloacal opening. Possession of a stylet separates plant parasites from nonparasitic forms. The stylet is a hollow spearlike structure in the head region used to excrete digestive enzymes into the plant tissue in addition to probing, penetrating, and feeding on the root cells.

The reproductive system varies considerably from species to species. In general, the female reproductive system is composed of a vulva, vagina, oviduct regions, and ovaries. Males generally possess a spicule (copulatory organ), cloaca, *vas deferens*, seminal vesicle, and testes.

NEMATODE LIFE CYCLES AND TYPES OF PARASITISM

Most nematodes have six stages of development (Figure 1). An adult female releases eggs into the soil. The first stage juvenile (J_1) develops within the egg. The J_1 molts, becoming the second stage juvenile (J_2). The J_2 hatches from the egg, and in order to survive, must find a food source within a few days. Three more molts lead to the adult stage. The sex of the nematode is usually determined during the third or fourth juvenile stage. Variations in the life cycle are related to differences in the types of parasitism.

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Plant-parasitic nematodes are obligate parasites living only as parasites. Generally they are classified as endoparasitic or ectoparasitic. Endoparasites enter the root to feed. Sedentary endoparasites, such as root-knot, enter the root as in their second stage, and select a feeding site where the females remain through maturity. Migratory endoparasites, such as root-lesion, enter the root at any stage during their life cycle and feed at several sites, killing groups of cells.

Ectoparasites feed at the root surface by extending their stylet or entire head region into the root tissue. Sedentary ectoparasites, such as ring *(Criconemoides* or *Macroposthonia)*, rarely move from an area once feeding begins. Migratory ectoparasites, including stunt *(Tylenchorhenchus)*, spiral *(Helicotylenchus)* and stubby-root *(Trichodorus* or *Paratrichodorus)*, "graze" or feed at several locations on the root.

TYPES OF NEMATODE DAMAGE

Nematode damage to turfgrass varies depending on the nematode and other stresses involved. The root-knot nematode alters the grass physiology by secreting certain enzymes that induce giant cell formation at the feeding sites. These giant cells act as metabolic sinks, "attracting" energy-rich metabolites that are consumed by the nematode.

Some nematodes inhibit root growth. The stubby-root nematode, for example, feeds at the root tips where a combination of enzymes and mechanical damage is thought to reduce cell multiplication resulting in a "stubby root" appearance. Many nematodes cause necrotic lesions (dead areas) in grass roots. These lesions are produced by feeding processes, or by the nematode entering the roots. The most obvious lesion is caused by the root-lesion nematode. The lesions, often enlarged as microorganisms, invade and multiply in the wounds.

Nematodes have been shown to increase the amount of disease on certain plants. Disease complexes often produce a synergistic effect that devastates the host. Soil fungi, such as species of *Fusarium, Rhizoctonia* and *Pythium*, are common pathogens of turfgrasses found in disease complexes with nematodes in other plants. It is likely that such complexes occur on turfgrasses. The interaction of nematode and fungus is due to mechanical damage to the root and to physiological changes that may lower the disease resistance of a plant. The fungus may also affect the nematode. For example, *Fusarium* has been shown to increase the reproduction of certain nematode species.

POPULATION DYNAMICS

Nematode populations fluctuate with both time and space. Knowledge of the shifts in population sizes is necessary to properly diagnose and control nematode problems. Population changes vary according to the nematode species, and most populations increase immediately after a period favorable to turfgrass growth. Populations often peak in June and again in the late fall. Sampling should, therefore, be avoided in midsummer or during the winter. Although population levels may increase when environmental conditions are favorable, symptoms may not appear until later when the turfgrass is under some stress.

Nematode distribution in space also depends on the type involved, although most species cluster in small areas. Most parasitic nematodes that attack turfgrass roots are concentrated in the top 10 cm of soil. Within a nematode-damaged area, the highest numbers of nematodes are found at the margins rather than in the center of the area, because the healthy roots that have not been fed upon are a better food source. Soil should be tested for nematodes on a regular basis, particularly at the margins of suspected areas to a depth of 10 cm, following vigorous turf growth.

Nematodes are spread via infested soil, water, and plant material, primarily by man. They rarely move more than eight inches through soil on their own power in one growing season.

SYMPTOMS

Altering host physiology, inhibiting root growth, or causing root necrosis disrupts nutrient and water uptake, and translocation by the grass plant. The end result is the typical above-ground symptoms caused by nematodes. Such symptoms are *not* indicative of nematode problems. The latter vary considerably with environmental conditions and are easily confused with insect, disease, nutrient and moisture stresses, pesticide injury, a thick thatch, or other turfgrass problems.

Nematode damage may include chlorosis, dying back of the grass blades, gradual reduction in vigor, sensitivity to stress, and a gradual thinning of the turf. Chlorosis and thinning occur in spots due to the clustered distribution of nematodes. Symptoms are most obvious during periods of moisture and temperature stress.

THRESHOLD LEVELS

An economic threshold for individual species of parasitic nematodes is very complex, and a tremendous amount of data must be collected and assimilated before one can be properly established. At present, economic thresholds are not well defined. In Illinois, our threshold levels are based upon experience and research.

Better thresholds are being established on crops such as soybeans and corn. Nematodes may reduce the grain yield on these crops without any above-ground symptoms ever appearing. With turfgrasses we are principally concerned with appearance and vigor. Since the expression of symptoms varies with the level of different stresses, theoretical thresholds should also be variable. The problem, however, is that damage may occur at one population level at one time but not at another. Thus, turf nematode samples should be analyzed in pairs consisting of a sample from a suspect area and one from a "healthy" area. This allows comparison of nematode numbers as well as data to help establish threshold levels. A nematode problem can only be diagnosed by a qualified nematologist in a well-equipped laboratory. In Illinois, such facilities can only be found at the University of Illinois Plant Clinic at Urbana. Thresholds given in Table 1 are used as rough guidelines in making chemical or other recommendations.

CONTROL PRACTICES

Although resistant turf varieties would be beneficial in the control of nematodes, little research has been done in this area. The two basic control strategies are as follows:

1. Reducing the initial population. This strategy can only be accomplished prior to planting. Tactics include ensuring that stolons or sprigs, soil, and equipment are free of parasitic nematodes. Sprigs and stolons have been freed of nematodes by hot water treatments (120° F - 125° F for 45 minutes). The soil mix for greens and tees can be treated with

methyl bromide or a similar fumigant. Grading and planting equipment should be thoroughly washed or steamed before use.

2. Minimizing the population increase of nematodes. This strategy will reduce the damage to the turfgrass roots. Cultural practices for achieving this goal include proper use of fertilizers, the use of only sterile soil amendments and clean equipment, and good turf management, including proper irrigation practices. A deep, healthy root system can withstand a much higher level of nematodes than can a shallow root system.

Chemical control of nematodes can be accomplished with fumigants or contact nematicides formulated as granulars or liquids, but should only be practiced when such a recommendation is made by a reputable nematologist. Whichever method is selected, application should be made when the temperature is 60° F or above to ensure that a high percentage of the nematodes are not in the resistant egg stage.

Fenamiphos (Nemacur) and ethoprop (Mocap) are two nematicides registered for use on established golf turf. Fenamiphos probably gives the most consistent results with the least chance of chemical damage to the turf. Nematicides should be watered in with 0.5-1 inches of water as *soon* after application as possible. A strip-test will often indicate whether a nematicide application will induce a response from the turf.

CONCLUSION

Nematode problems on turfgrass are not new to Illinois. Problems appear to be most serious in about four-year cycles, or when grass is placed under severe environmental stress.

Periodic sampling for nematodes and sound turf management practices will help to keep this problem a minor one. When populations of nematodes suddenly increase, nematicides are available that will elicit a favorable growth response from the turfgrass.

Table 1. Nematode Thresholds on Turfgrass

Nematode	Threshold*
Stunt	50-60
Spiral	70+
Ring	70+
Lance	50-60

*Population levels of nematodes that warrant control measures/100 cc of soil.

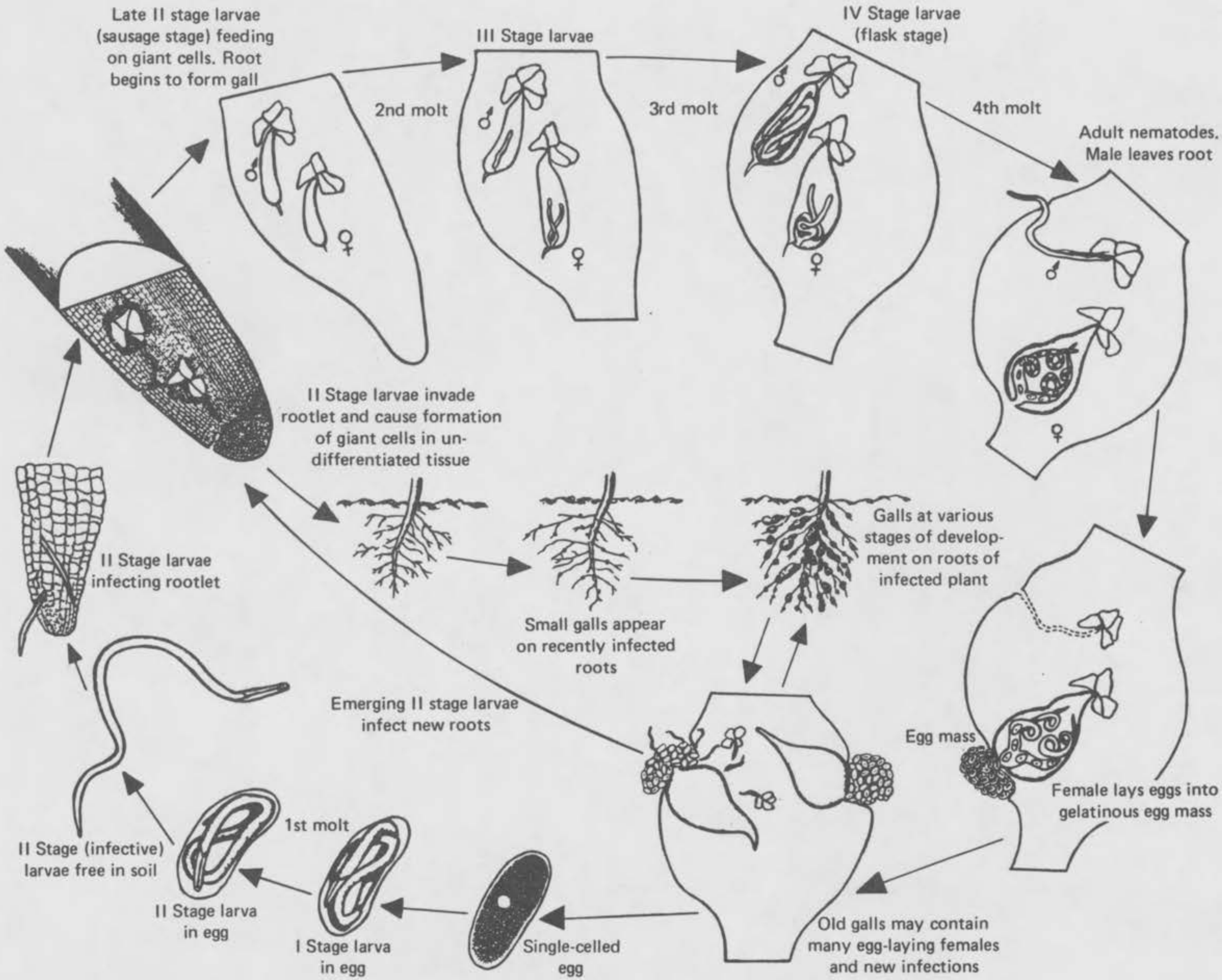

Figure 1. Disease cycle of root-knot caused by nematodes of the genus Meloidogyne. [*Modified from G.N. Agrios, Plant Pathology (New York: Academic Press, 1969), p. 629.*]

WHAT WE'VE SEEN IN 1980

Stanley J. Zontek

Turfwise, 1980 was not a kind year for many turfgrass managers. Extremes were the order of the day: extremes in periods of heat and humidity; in the amount of rainfall that fell (or didn't fall); in diseases and insects; and in storms that ran through many areas causing tree and structural damage. This was the year many golf courses suffered, and in our travels as agronomists for the Turf Advisory Service of the U.S.G.A. Green Section, we saw just about all of the extremes. The major problems we observed this season are as follows:

DISEASES. This was a very active year for disease, and most of the golf courses that we saw had used over their budgeted amounts for fungicides. The stresses came, and stayed, and the longer it remained hot and humid, especially where thunderstorms rumbled through, the worse some hot weather diseases became. The one particularly frustrating disease of note this year was the decline of Toronto or C-15 in the Chicago area. As no specific cause for this problem has yet been positively identified, all we can say is that it is a disease of weak turf. (The grass at putting green height was infected, but the same grass at the collar height of cut, shows no disease symptoms!) The U.S. Golf Association Green Section, in cooperation with the G.C.S.A.A. and Chicago District Golf Association, is actively researching this problem with an outstanding team of scientists headed by Dr. Houston B. Couch. We are hopeful that the causal agent and a control will be available soon.

INSECTS. Scattered areas experienced damage due to the white grub stage of Japanese beetles, European Chafer, and the black *Ataenius* beetle. As usual, sod webworms and cutworms caused their normal amount of damage. However, overshadowing all of these insect problems was the damage done to putting green turfgrass by nematodes. Nematodes are nonsegmented roundworms with the longest species barely visible to the naked eye, and with the majority of nematodes being microscopic. Nematodes seldom kill grass outright. Their mode of action is to feed on the grass roots, and thus cause stunting, knots, and lesions. They therefore reduce the health and vigor of turf in general. In conjunction with the other stresses experienced this year, the nematodes were one other factor that helped the turf succumb. Fortunately, tests for nematodes are relatively easy and economical to perform, and they are available through the University of Illinois Plant Clinic at St. Mary's Road, Urbana, IL 61801. Furthermore, nematicides are readily available in the market. Therefore, if your grass simply does not respond as it should during the summer, consider having a test run for nematodes just to be sure these microscopic parasites aren't giving you unseen problems.

WEEDS. The adage is so true that "the best weed control is a thick turf." This season saw the turf thinning early with the result that weeds, especially crabgrass, were more of a problem than in recent memory. Indeed, most preemergence herbicides gave less than adequate control for any number of reasons that are not necessarily the fault of the product. On greens, the handpicking of crabgrass

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still is a good way to help these so important-to-play areas stay clean. Don't overlook this point! Golfers can forget many things, but crabgrass in putting greens seems to be a particularly sore point. So be on a good preemergence control program using split applications of herbicides when appropriate; then again where necessary, consider following up with a postemergence chemical program, and if some weeds still develop through this chemical barrage, seriously consider hand weeding. It's slow, painstaking work, but it truly is the final step in the control of crabgrass on putting greens.

RAINFALL. Some portions of the north central region received too much rainfall, whereas other areas experienced serious drought conditions. In the drought areas this season, deficiencies in the courses' irrigation and/or water storage and supply systems certainly showed up. It seems that every area of the country is susceptible to a drought similar to the one experienced this year. Therefore, it behooves the golf course superintendent and his club to have *both* a good irrigation system to distribute water *and*, perhaps even more importantly, enough water in storage and recharge to reliably supply enough water to the golf course to survive any drought period. Throughout the eastern half of the United States, we saw golf courses running out of water for irrigation or severely restricted in the use of water, especially from municipal water sources. The use of potable water for turfgrass irrigation will always be an area of concern, but even more so as our fresh water resources in the future are stretched. It may be a good idea to study your supply and distribution systems now, and begin a program to upgrade either, or both, and to look toward alternate sources of water, including sewerage effluent. Having a good water supply and the irrigation system to supply it is very important today, and will even be more so in the future.

WILT. Both wet and dry wilt were scattered problems this season. *Poa annua*, as always, was the turf that wilted the most severely. Wilt is caused by a combination of factors, but suffice it to say that any turf will be stronger and less susceptible to wilt if it has a deep, fibrous rooting system, with soil that is loose, open, and aerated; if it is protected by a good fungicide spray program (especially *Poa annua*); if it is on a low to moderate balanced fertility program as per soil test recommendations, and is properly irrigated.

TRAFFIC. Simple observation as well as figures released by the National Golf Foundation indicate that the number of rounds of golf, overall, is increasing after a period of slight decline and stagnation. Perhaps the cost of gasoline is keeping the golfers closer to home! In any case, increased traffic is both a blessing and a problem. Increased revenue is a necessity for almost every golf course, but the problems of wear, tear, and compaction to the grass and soils require constant effort to combat, whether through extra aeration, overseeding, fertility, or by cart path installations.

SOIL PROBLEMS. The problems we have seen this year with soils is discussed at length in another portion of these proceedings. We refer you to them. Briefly, the soil in which the grass is growing must be managed properly. It is hoped that problems will be avoided in new constructions as the knowledge, specifications, and testing procedures become well known and available. Soil problems, short of reconstruction, can be managed to some degree through proper usage and control of aeration, topdressing, irrigation, pesticides, and fertilizer applications. Serious soil problems, particularly inadequate internal drainage, may require rebuilding. It all depends on how serious the soil problems are. As with anything, and particularly with soil problems, it is necessary to have the assistance of a good soil testing laboratory equipped for both chemical and physical soil analyses. Using these labs can only assist the turf manager in analyzing his soil-related problems to decide upon the best management program, and generally to do his job better.

In summary, 1980 was, overall, not a good year for many golf courses. Much turf was lost for a variety of reasons. If there was one positive aspect to this season, it was that shortcomings in the overall construction, equipment, budget, and management of the golf course came to light. Seeing and understanding these problems can give clubs an opportunity to correct them now, and, possibly, to avoid a recurrence of them in the future

TREES FOR THE GOLF COURSE

David J. Williams

A golf course is more than than tees, fairways, greens, and a clubhouse. It is a landscape entity that is unique, and, we hope, beautiful and challenging. Much of the uniqueness and beauty of a golf course come from its physical layout and natural features including hills, valleys, ponds, streams, and trees.

Golf course superintendents are experts at turf maintenance and care, but many of them lack knowledge about the selection, maintenance, and care of trees. The key to tree maintenance is proper species and cultivar selection for the intended design, and conditions at the growing site.

Many insect and disease problems can be avoided by selecting trees carefully. To select the right tree, you need to be familiar with the site conditions and pest problems common to particular areas, and to know what trees are best suited for the conditions and are least susceptible to major insect and disease pests. Suppose, for example, that apple scab and fire blight are prevalent among crab apple trees in an area. Since crab apple cultivars vary greatly in their susceptibility to these diseases, you can virtually eliminate both problems by selecting nonsusceptible or highly resistant cultivars. In general, try to make use of the variability in the plant kingdom.

Another good rule of thumb to follow is, "Don't fight the site." For example, if a planting site is located in a low area where drainage is a problem, select a tree such as bald cypress that is tolerant of wet conditions, rather than a tree such as sugar maple that requires well-drained soil. The best approach in selecting trees is to choose species native to the growing conditions of the intended planting site.

Table 1 contains a list of trees that are well suited for landscaping in Illinois, and rates these trees on environmental tolerance and landscaping attributes. Some trees commonly found in Illinois and their major insect and disease problems are shown in Table 2. Recommendations for their control can be obtained from the Cooperative Extension Circular 900 of the University of Illinois at Urbana-Champaign.

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Table 1. Environmental Tolerance and Ornamental Attributes of Landscape Trees in Illinois

	Height (feet)	Tolerant of: Different sites	High pH	Aerial salts	Drouth	Wet soil	Sun	Light shade	Landscape attributes: Flowers	Fruit	Autumn color	Ornamental bark	Rapid growth
Acer buergeranum	<30				X		X	X			X	X	
Acer campestre	30-50	X	X		X		X				X		
Acer ginnala	<30		X		X		X	X		X	X		X
Acer griseum	<30						X	X			X	X	
Acer platanoides	>50	X	X	X	X		X	X	X		X		X
Acer pseudoplatanus	30-50	X	X	X	X		X					X	X
Acer rubrum	>50	X				X	X	X	X		X	X	X
Acer saccharum	>50						X				X	X	
Acer tataricum	<30		X		X		X	X		X	X		X
Amelanchier arborea	<30						X	X	X	X	X	X	
Alnus cordata	30-50	X	X		X	X	X	X					X
Alnus glutinosa	30-50	X	X		X	X	X	X					X
Betula nigra	>50					X	X					X	X
Betula papyrifera	>50						X					X	X
Betula pendula	>50						X					X	X
Carpinus betulus	30-50	X	X		X		X	X				X	
Celtis laevigata	>50	X	X		X		X	X				X	X
Celtis occidentalis	>50	X	X	X	X	X	X	X					X
Cericidiphyllum japonicum	30-50						X				X	X	X
Cladrastis lutea	30-50			X	X		X		X		X	X	
Cornus florida	<30						X	X	X	X	X		
Cornus kousa	<30						X	X	X	X	X	X	
Cornus mas	<30	X	X		X		X	X	X	X		X	
Crataegus crusgalli 'inermis'	<30	X			X		X		X	X	X		
Crataegus phaenopyrum	<30	X			X		X		X	X	X		
Crataegus viridis 'Winter King'	<30	X			X		X		X	X		X	
Eucommia ulmoides	30-50		X		X		X						
Fraxinus americana	>50	X	X		X		X				X		X
Fraxinus excelsior 'Hessei'	>50		X		X		X						X

Table 1. (Continued)

	Height (feet)	Tolerant of: Different sites	High pH	Aerial salts	Drouth	Wet soil	Sun	Light shade	Landscape attributes: Flowers	Fruit	Autumn color	Ornamental bark	Rapid growth
Fraxinus nigra	30-50	X	X		X		X						X
Fraxinus pennsylvanica	>50	X	X		X	X	X	X			X		X
Fraxinus quadrangulata	>50		X		X		X				X		
Ginkgo biloba	>50	X	X	X	X		X				X		
Gleditsia triacanthos 'inermis'	30-50	X	X	X	X	X	X				X		X
Gymnocladus dioica	>50	X	X		X		X			X	X	X	
Halesia carolina	30-50						X	X	X	X		X	
Koelreutaria paniculata	30-50	X	X	X	X		X		X	X			X
Liquidambar styraciflua	>50					X	X			X	X		X
Magnolia acuminata	>50		X				X			X			X
Magnolia kobus var. *loebneri* 'Merrill'	<30						X	X	X			X	
Magnolia soulangiana	<30						X	X	X			X	
Malus sp.	<30	X			X		X	X	X	X	X		X
Metasequoia glyptostroboides	>50		X		X		X				X	X	X
Nyssa sylvatica	<50			X		X	X			X	X		
Ostrya virginiana	30-50						X	X			X	X	
Phellodendron amurense	30-50	X	X		X		X			X	X	X	
Platanus x acerifolia 'Bloodgood'	>50	X	X	X	X	X	X	X					X
Prunus sargentii	30-50						X		X		X	X	
Prunus serrulata 'Kwansan'	<30						X		X			X	
Pyrus calleryana 'Bradford'	30-50	X	X	X	X		X	X	X		X		
Quercus acutissima	30-50						X						
Quercus imbricaria	30-50						X						
Quercus macrocarpa	>50		X		X		X						
Quercus palustris	>50					X	X				X		X
Quercus phellos	>50					X	X						

Table 1. (Continued)

	Height (feet)	Tolerant of: Different sites	High pH	Aerial salts	Drouth	Wet soil	Sun	Light shade	Landscape attributes: Flowers	Fruit	Autumn color	Ornamental bark	Rapid growth
Quercus robur	>50	X	X		X		X						X
Quercus rubra	>50	X					X				X		X
Sorbus alnifolia	30-50		X				X		X	X	X	X	
Sorbus aucuparia	30-50						X		X	X			X
Sophora japonica	>50		X		X		X		X	X			X
Taxodium distichum	>50					X	X				X		X
Tilia x euchlora 'Redmond'	30-50	X	X		X		X		X				X
Tilia cordata	>50	X	X	X	X		X		X		X		
Tilia tomentosa	>50		X		X		X		X		X		
Ulmus parvifolia	30-50	X	X		X		X	X				X	X
Zelkova serrata	>50	X	X	X	X		X				X	X	X

Table 2. Common Trees and Their Insect and Disease Problems

Tree	Insect	Disease
Ash	Ash borer Ash flower gall mite Fall webworm	Anthracnose Leaf spots Cankers Ringspots, dieback
Birch	Bronze birch borer Birch leaf miner Oystershell scale	Cankers Fasciation Chlorosis (iron deficiency)
Crab apple	Aphids Borers San Jose scale Yellow-necked caterpillars	Scab Fire blight Rust Powdery mildew Leaf spot
Honeylocust	Mimosa webworm Leafhoppers Aphids Honeylocust mites	Kaskaskia cankers Ganoderma root rot
Juniper	Bagworms Mites	Rusts Phompsis tip blight
Magnolia	Magnolia scale Tuliptree scale	Leaf blight Leaf spots Cankers
Maple	Leaf galls Cottony maple scale Aphids Leafhoppers	Anthracnose Verticillium wilt Cankers Chlorosis (iron deficiency)
Oak	Leaf galls Twig galls Lecanium scale Leaf miners	Anthracnose Leaf blister Oak wilt Armillaria root rot Chlorosis (iron deficiency)
Pine	Pine needle scale Zimmerman pine moth European pine shoot moth Pine sawflies	Needle blight and casts Diplodia tip blight Sooty mold Pine wilt nematode Chlorosis (iron deficiency) Air pollution (O_3 + SO_4)
Spruce	Eastern spruce gall aphid Cooley spruce gall aphid Spider mites	Cytospora canker Diplodia tip blight
Tuliptree	Aphids	Sooty mold
Taxus	Black vine weevil Fletcher scale	

LAWN RENOVATION

Richard L. White

Optimum cultural and maintenance programs for lawns do not always keep turf quality from deteriorating. When deterioration does occur, lawn renovation offers a viable, effective, and relatively inexpensive alternative to continued normal turf care. There are several situations in which lawn renovation can, and should be considered.

The most obvious need for lawn renovation arises when extensive insect or disease damage occurs. In this extreme situation, lawn renovation is a substitute for total turf replacement, and thus becomes an additional, salable customer service.

Other situations where lawn renovation might be considered are less obvious. The question is not merely to produce turf, but rather to produce a more aesthetic turf. For example, perennial weedy grasses might severely limit the potential appearance of a turf area, and poor performing monoculture turfstands might benefit from the introduction of improved seed varieties. However, decisions to renovate must be made in conjunction with the customer.

Once the decision to renovate has been made, timing the change is important. For cultural and practical reasons, the most effective time in the Chicago area is between August 15 and October 1. The fall seeding eliminates many annual weed problems with the first frost. Fall renovation allows applications for annual grass preemergence and broadleaf weed control in the following year, and thus minimally disrupts a regular turf maintenance program. Fall renovations allow strong seed development before summer drought stress. Practically speaking, fall renovation helps us fill a low business activity period in tree care, and thus helps us better utilize personnel.

The mechanics of the lawn renovation that we use are listed below. All procedures are performed by existing personnel. For best results, these procedures should be carried out in two consecutive seasons.

1. *LAWNS WITHOUT PERENNIAL GRASS PROBLEMS:* Slit seed with a Jacobsen Seeder with the cutter blades set deeply enough to cut through the thatch and groove the soil approximately a quarter of an inch. Then sweep the thatch debris from the lawn.

2. *LAWNS WITH PERENNIAL GRASS PROBLEMS:* Apply Round-up at 3 quarts per acre two weeks prior to seeding. Spot treat the remaining vegetation after 10 days, and slit seed as above in another 4 days.

3. *SEED:* Use a blend of two improved ryegrasses and three improved bluegrass applied at 1.5 lb. per 1000 square feet.

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4. *PRODUCTION:* Use a two-member crew. One person runs the seeder while another sweeps and bags. Normally this team completes four 7 to 8 thousand square feet of lawn per day.

5. *FERTILIZER:* Apply 30-5-10 (50 percent SCU) at 1.5 lb. per 1000 square feet at the time of seeding and again in November.

6. *CUSTOMER EDUCATION:* When the seeding is completed, leave an informative letter with the bill. In the letter, outline the specifics of seed mixture, fertilizer, watering requirements, and performance expectations. This step is vital since the highest quality seed and workmanship will be impaired without the cultural support of the homeowner.

The results achieved with the above procedures are positive. Lawn renovation provides us with a viable additional customer service, and enables us to better utilize personnel. More importantly, lawn renovation offers a workable course of action in those formerly impossible situations where the normal cultural maintenance procedures were simply not bringing results. Now, in these situations, our staff can with new confidence discuss lawn renovation with a customer, who is generally eager to listen.

GOVERNMENT REGULATIONS AFFECTING THE LAWN CARE INDUSTRY

Robert Earley

If you want to know what government regulation in our industry is going to be like in the 1980s, here it is: it will be just more of what the 70s were like, only with more regulations, more pressure from environmental groups, more public concern, more worker concern, but, possibly, more pesticides being used. Some EPA people have said that because certain pesticides we use in this industry are being banned, they could be replaced by other pesticides, less effective to be sure, but used in larger quantities.

What effect will the change in administration have? Some say that if Jimmy Carter had remained in office, we would have had forced integrated pest management—IPM—in two years. If we are to believe what Ronald Reagan said during the campaign, there might be a slowdown. This seems to be true to some extent. But these things move slowly because these days there is a lot of momentum for environmental concerns. You might look for quicker changes on the state level where the enforcement is actually carried out. The fact remains that two weeks after the country elected a president who pledged to get government off the backs of the American people, that same government began enforcing what may be the most complicated set of regulations ever revised.

On turning to the RCRA—the Resource Conservation Recovery Act—we see that this act went into effect a little less than a year ago on November 19, 1980 to be exact. The law covers all businesses involved in hazardous waste generation, transportation, and disposal. EPA officials say that for the first time since the chemical revolution began after World War II, the government will know who is generating the wastes, who is transporting them, and how they are being disposed of. To put the regulations in place, the EPA requires all companies which generate, haul, or store wastes to notify the agency of their existence. Some 58,700 companies have done so, and they have been assigned identification numbers.

Most lawn care companies can be exempt from the law. However, it appears that all lawn care companies have the *potential* to become hazardous waste generators. Pesticide spills or container mismanagement could put any lawn care firm into the category of a hazardous waste generator or a storer of hazardous wastes. To preclude possible fines and liability problems for owners and managers, it is deemed advisable for everybody to fully understand the regulations and even to register with EPA as a potential waste generator. Due to the very serious nature of this issue, the industry as a whole needs to give it very serious attention.

As an industry, we are very visible because we are out on lawns every day during the season. I believe that one of our most pressing concerns right now is to avoid negative publicity resulting from violation of RCRA regulations. Please do not assume this issue concerns someone else. Every lawn care businessman should address this matter immediately by investigating the law, reviewing current operations, and implementing policy that is carefully administered to preclude the

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condition of nonexempt status. Lawn care companies must comply with the regulations if nonexempt status cannot be maintained.

As mentioned earlier, the lawn care industry is possibly the most publicly visible user of the materials coming under the jurisdiction of RCRA. A single major violation could cause considerable long-term harm to the industry. Currently, compliance is not an impossible task. However, negligence could create public pressure to make the regulations tougher, a circumstance that might be both costly and difficult to accommodate.

Chemical industry experts say the 2,000 pages of rules took four years to draft, generated 100,000 pages of negative comments, and will impose an annual compliance burden on American industry of $1 billion and 5.2 million hours of labor. But no one expects newly elected President Ronald Reagan to push for their elimination because the new rules regulate what many believe to be the most serious environmental problem of the 80s, that of hazardous chemical wastes. Congress called for this national roadmap of toxic chemicals when it passed RCRA in 1976 and directed EPA to get some control of the 57 million tons of hazardous wastes produced annually in this country. The EPA says only 10 percent of that waste is being disposed of properly—a situation the new regulations are designed to correct by making chemical companies and other generators of waste liable.

Those of you who are members of the Professional Lawn Care Association of America (PLCAA) have, over the past few months, received considerable correspondence from PLCAA headquarters regarding RCRA regulations. EPA has established what it considers to be careful categorization of chemicals according to their potential for causing environmental and public harm if improperly handled. At present, the products you might be using that are categorized as acute hazardous wastes are 2,4-D, Lindane, Methoxychlor, PCNB, and Cy60N. Silver is on this list, and there may be other products too. The list will undoubtedly be expanded in time to include more materials, some of which now may be in use by the lawn care industry.

There are, however, several exemptions for most lawn care firms from the law as a whole. The exemptions regard amounts of waste generated or stored on a monthly basis by each location of a firm. If yours is a multiple location operation, the law regards each location as a separate entity.

A hazardous waste is any disposed-of material containing a listed chemical such as 2,4-D. This disposed-of material could be found in concentrated form as manufactured, in the residue of a container; in the sediment of a spray tank; or in the absorption material used to contain a spill that includes soil or any other absorbing agents.

Two main criteria—quantity and chemical concentration—are used to measure whether a hazardous waste is exempt or nonexempt. To determine if a liquid or solid waste is hazardous or nonhazardous, an extraction procedure test for toxicity (EP test) is used to determine the concentration of the hazardous waste pesticide in milligrams of material per liter. Listed acute hazardous wastes exceeding both the minimum concentration and weight limits are considered hazardous waste material, which is nonexempt.

We can be both a generator and storer of hazardous waste material. *Waste*, the key word, is defined as material that is disposed of and deposited in a sanitary landfill, or even at an unaccepted point of disposal. It does not include liquids or solids remaining in material left over and recycled back into our equipment and then used in regular operations if the recycling is accomplished within the specified time frame. Our two concerns, then, are generation and stor-storage.

If, within one month, a location generates a hazardous waste greater than the specified limit, it becomes nonexempt and is, therefore, subject to meeting the special disposal requirements of the law. Waste is defined in the following terms:

—2.2 lb. or more of any commercial, undiluted chemical product categorized as a hazardous or acute hazardous waste

—any hazardous waste chemical containers larger than 5.25 gallons that are not at least triple-rinsed

—22 lb. of inner liners (bags) of such containers per month

—220 lb. per month of any clean-up material (such as vermiculite or clay) used to contain a spill of a commercial, undiluted, hazardous waste chemical

—any liquid or solid hazardous waste in quantities greater than 2,200 lb. per month that exceeds permissible concentrations allowed by the EP toxicity test

Limits of accumulation are similar for storage. It makes sense that one should never allow locations to become storers of hazardous waste. Any chemical in the hazardous waste category is not designated as a waste material until it is categorized as needing disposal. When hazardous waste exists but is in exempt quantities, no permit is needed to have it disposed of in a sanitary landfill, although the carrier must know that the waste exists. Liquid or solid material entering a refuse container automatically become waste material. This material includes not only pesticide containers, but also sediment from trucks or other tanks.

Although the hazardous waste generated by most lawn care firms probably does not exceed the limits, we should never intentionally accumulate enough hazardous waste to break exemption laws. Each manager must know what the limits are and calculate whether or not the location has exceeded the limits.

Here are some suggested rules to follow to maintain nongenerator status:

1. Any commercial, undiluted pesticide should never be improperly disposed of whether it is or is not a hazardous waste material.

2. Containers should be disposed of in the following manner:

   a. Bags and boxes must be completely emptied before disposal.

   b. Liquid containers must be triple-rinsed with the rinse solution not being used in regular operations. Do not let empty containers accumulate, especially ones over 5.25 gallons. Remember, any size drums containing hazardous waste pesticides must be disposed of within 90 days.

c. Never let *any* material be allowed to reach a drain or sewer. Always recycle material to be used on lawns or landscape rather than dispose of it.

d. Drip pans must be utilized under all spigots or valves on any pesticide containers. The drippings must be added to a spray truck and disposed of in regular operations unless absorption material is used to collect the drippings, which should then be disposed of frequently enough to maintain exempt status.

e. Spills should be immediately contained. Absorption clean-up materials must be at or below exemption limits to avoid EPA notification.

You will not exceed limits if these procedures are followed. PLCAA will be publishing RCRA guidelines that will be available to both PLCAA members and nonmembers. Their offices are in Chicago. Another event that concerns the lawn care industry is the proposal to ban turf applications of Dursban and Diazinon. This proposal is currently being evaluated by the Department of Environmental Conservation (DEC) in New York, and will undoubtedly spark off a heated debate. We have to nip the proposal in the bud.

Citing recent examples of bird-kill on golf courses in Long Island and Westchester counties, a spokesman for the Wildlife Division of the DEC in New York attributed the deaths to both accidental and intentional poisoning of the birds with Diazinon, which is particularly toxic to species of black ducks and Canadian geese. The New York State Turfgrass Association is presently petitioning state legislators on the subject. The controversy is far from over, and the DEC has yet to make formal recommendations on limitations of insecticide use. They expect to file their report shortly, and you can be sure we'll keep an eye on it. Your association should do likewise.

On turning to 2,4-D, we find that recent tests revealing previously unrecognized contaminants in this widely used herbicide may result in a conditional ban of the chemical in Canada as early as the winter of 1980. Obviously, the discovery by *Agriculture Canada's* Food Production and Inspection branch would have disastrous effects on lawn care in Canada; and the U.S. could be next.

In Canada, officials told us that 2,4-D was reported to contain minute traces of dioxins. The most lethal variety, TCDD, was found in the previously banned herbicide, 2,4,5-T, but never in 2,4-D. Pressure from environmental groups charging that the chemical can cause cancer, birth defects, and deformities may push Canadian authorities to ban the herbicide. *Agriculture Canada* has not reported which dioxins are present in 2,4-D, or the toxicity levels, a shortage of information that might be behind much of the uninformed panic.

The panic is not limited to Canada. Recently in Madison, Wisconsin, there was a meeting held—a hearing—to discuss a ban of 2,4-D use in that city and its county. The people behind it want to ban 2,4-D in the whole state. There have also been referendums to ban 2,4-D in Oregon, California, and elsewhere.

There is a push in Florida for legislators to pass a law requiring the lawn care industry to provide a written guarantee to customers for 100 percent insect control. Pressure is being brought upon legislators who obviously don't understand our business. In Ohio, a bill was proposed that would have required a written notification 48 hours in advance to customers and neighbors when a pesticide was to be sprayed. I think that bill died in committee, but it would have been scary.

In other legislation that could affect our industry—two days after RCRA went into effect—the Federal Department of Transportation (DOT) enacted new amendments to its regulations on transport of hazardous materials. Old regulations covered only interstate transportation, and to be considered hazardous, a material had to be flammable. Now regulations are intrastate, and the material no longer has to be just flammable.

The key here is—does DOT consider us a transporter of hazardous materials? If you are using Dursban, Diazinon or 2,4-D, you would be carrying sufficient quantities in your tanks to make a report necessary. But don't everyone go rushing out and start questioning DOT, because it we make an issue out of it, they are going to notice us. PLCAA is checking it out and will make a report.

IPM—Integrated Pest Management—is another issue that concerns us. Most think this just means biological control—the avoidance of chemicals. That is not necessarily true. Some people have recommended dropping the word "control" from all of your literature and substituting the word "management." Most people think of "control" as meaning "eradication." "Management" is closer to meaning reducing pest problems to economic levels we can deal with. Our industry should influence the direction IPM is going to take. And make no mistake about it, we are definitely going to have to live with some form of IPM.

The best policy is to use a monitoring system when the applicators go out for a minimum check to see if the pest is there before they blast the lawn with a pesticide. Also, we'll be doing more spot treating, using proportioners to apply pesticides where needed.

Closed spray systems are already a reality in California. As one lawn care businessman told me, we will no longer be able to open our barrels, throw the pesticide into a bucket, carry the bucket over to the truck, slip and slide up the truck and dump it in. There will have to be a closed system of some type, where you simply take it from the container or some other labeled container, so that the applicators themselves are not handling the concentrate outside of the closed system. This will come within the next ten years, so it is something to be thinking about.

It is not all gloom and doom, though. As EPA restricts more chemicals, it probably will open up a whole new market for us—that of the homeowner who now applies his own pesticides. A 1972 survey shows over 30 million pounds of pesticides were used in the urban environment, and 80 percent of that quantity was applied by homeowners. If the homeowner becomes more and more restricted in what he can apply, a new market opens up for the professional applicator—the lawn care businessman.

So, even if we do get squeezed in some areas, our market might expand in other areas if we work within the system instead of against it. It could be to our advantage in the long run. To a great extent, we can be masters of our own destiny in the lawn care industry: by orchestrating laws that affect us, and by working through PLCAA and ITF to take an active role in influencing legislation. If we do not speak out, we deserve what we get.

LIQUID FERTILIZER MIXES FOR THE LAWN-CARE INDUSTRY

Robert W. Freske

In recent years, the most innovative, economical, and diversified measure adopted by the lawn care industry has been the use of liquid fertilizers. That just one drop of liquid can contain nitrogen, phosphate, potash, sulphur, iron, other micronutrients, and a wide array of pesticides is impressive. Moreover, virtually anyone can spray up to five acres a day with ease. The rate of application is 4 gallons per 1,000 sq. ft. in 45 seconds, and includes 1 to 1 1/2 lb. of nitrogen per 1,000 along with pesticides. During the summer months, applications of 3 gallons per 1,000 allow a tank full of product mix to go even farther.

Three methods of application are used in the Niles, Michigan area: dry application, cyclone spreading, and severe dusting. In a dry application, the applicator must tear open the bags, fill, and push a broadcast-like spreader. We refer to such an applicator as a "duster," and call our liquid applicator a "squirter." We used only liquid fertilizer in our area until we ran out of a liquid pesticide. Then we switched to a wettable powder and almost had mass mutiny. Our applicators complained, morale dropped, and we noticed a drop in acreage for the 4 or 5 days we were using a wettable powder. It was evident that liquids were easier to handle. Liquids can, for example, be loaded into 1,500-gallon three-wheelers for farm application. A nutrilawn would use a 900-gallon lawn spray truck; chemlawn, a 1200-gallon truck; perf-a-lawn, a 750-gallon truck; and amazing grass, a 500-gallon truck. For application to beans, a spray plane carrying 50 to 150 gallons is used. A Jeep station wagon holds several 55-gallon drums; a Buick sedan holds two 30-gallon drums in the back with the seats removed. The range of liquid lawn care operations is wide: from two 1,500-gallon polytanks having a 3-horsepower gas engine with a 1 1/2-inch pump, to a truck with a 12,000-gallon tank. Outside polytanks such as those used by Moyer & Sons in Philadelphia can hold 1,000 gallons with the discharge hose running into a building where the pump and meter are unloading and back to the outside where the lawn trucks are loaded. An outdoor cone tank and liquid mixer and a stainless steel tank can also be used.

Liquids are, therefore, more easily handled than other fertilizers. You can pump and meter from one tank or truck directly to another. Transportation is easier, even when you are using a 1,000-gallon nurse tank behind a pickup truck. Let us look, by way of contrast, at the Canadian ship *Algosoo*, which unloads, say, 22,000 tons of bagged fertilizer, namely, potash. The bulk has to be loaded by an expensive front-end loader into a dump truck that has to, in most cases, be unloaded onto a conveyor system into a building, and kept dry. In addition, the bagged fertilizers take up valuable inside storage space and may require an expensive fork lift for moving. Cleanup is another problem with bagged fertilizer because the bags are often broken and the contents spilled.

Another advantage of liquid lawn care is that it allows custom blending for the seasonal and regional needs of the manufacturer. In most areas in the upper

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midwest, the company will make four applications per year (early spring, late spring, summer, and fall). In the Detroit area, 7 to 9 applications are not uncommon, but with the high cost of fuel, some applicators are cutting back to 5 and 6 applications, using 6 to 8 gallons per square foot.

Initially, the suppliers of liquid lawn care will try to determine the amount of N-P-K required, and the source of nitrogen needed (i.e. urea, controlled-release nitrogen [formolene], or urea-ammonium, although this last is a 28 percent solution that is not actually recommended for turf). The average rate per application is 1 lb. of nitrogen with 1/4 lb. of phosphorous, and 1/2 lb. of potash per 1,000 square feet. A typical analysis is a 14-3-6.

Formulas for urea only are given below for 1 ton batches:

Urea liquor 23-0-0	1,139 lb.
P205 10-34-0	176
Potash 0-0-62	194
Water	491
Total	2,000 lb.

This makes up one ton of 14-3-6 liquid, using a 50 percent urea liquor instead of 46 percent urea (50 percent or 46 percent is 23-0-0).

With controlled-release nitrogen (formolene), the formula is as follows:

Urea Liquor 23-0-0	530 lb.
Formolene 30-0-0	467
P205 10-34-0	176
Potash 0-0-62	194
Water	633
Total	2,000 lb.

This formula is the same as the 14-3-6 analysis, except that half the nitrogen, (or 140 lb. N out of the 280 lb. N per ton), was derived from ureas (methylol/methylene) having a controlled-release potential. In all instances, the potash is muriate in a chlorine base.

The basic raw materials used in all liquid formulations are given below:

Urea liquor	23-0-0
Urea prilled or fines	46-0-0
Ammonium polyphosphate	10-34-0
Formolene (cont. rls. N)	30-0-2
Soluble potash	0-0-62
Sulphate of potash	0-0-51
Ammonium thiosulphate	12-0-0-26S
Water	

All the ingredients mentioned above are measured into a 5, 10, or 20-ton mixer capable of tremendous agitation. The agitation time is determined by the formulation being manufactured, and the mixture is monitored constantly via a control panel. The finished product is taken to a lab and tested for analysis, pH, and specific gravity to give an accurate weight per gallon. The product is then stored and ready for delivery to the lawn care company, or is pumped right into tankers for delivery.

A typical analysis of 16-2-6 with 50 percent of the nitrogen derived from formolene is as follows:

Urea 46-0-0	340 lb.
Potash 0-0-62	180
Formolene 30-0-2	500
Poly 10-34-0	120
Water	860
Weight 10 lb./gal.	2,000 lb.

At 28 gallons per acre, the analysis of 16-2-6 can be broken down thus:

200 gal./ton
1 lb. N/1,000 sq. ft.
1.6 lb. N/gal.
28 gal./acre
7.14 acres/ton

We see, therefore, that at 10 lb. per gallon, there are 200 gallons per ton of product. Each gallon contains 1.6 lb. N, and it would take 28 gallons of 16-2-6 to apply 1 lb. of N per acre: 43,560 sq. ft. divided by 1.6 lb. N = 27.225 gallons. We always go to the next highest gallon. The breakdown can be summarized as follows for 16-2-6 at 28 gal./acre:

4 gal./1,000 sq. ft.
175 gal./acre
-28 gal. 16-2-6
147 gal. water/acre

At 4 gallons per 100 square feet we would use 175 gallons of product per acre, i.e., 28 gallons of 16-2-6 concentrate, and 147 gallons of water. (4 gal. per 1,000 x 43.560 sq. ft. = 174.24 gal./acre or rounding to the next highest gallon, 175 gal./acre).

For 16-0-4 with 60 percent Formolene, the breakdown is as follows:

Urea 46-0-0	300 lb.
Potash 0-0-62	120
Formolene 30-0-2	650
Water	930
10 lb./gal.	2,000 lb.

This formulation was a summer mixture meant primarily for southern Michigan as far east as Detroit and Port Huron, and northern Indiana, roughly from Valparaiso to Fort Wayne.

The breakdown for 16-0-4 at 28 gallons per acre is identical to that for 16-2-6. Here again, for 4 gallons per 1,000 square feet, we would apply 175 gallons of the product to the acre, and of that, 28 gallons would consist of 16-0-4 concentrate, and 147 gallons of water.

The formula for 20-5-10 with 50 percent Formolene is given below:

Urea 46-0-0	370 lb.
Potash 0-0-62	300
Formolene 30-0-2	670
Poly 10-34-0	290
ATS 12-0-0-26S	---
Water 370	370
10 lb./gal.	2,000 lb.

The breakdown at 22 gallons per acre would be as follows:

400 lb. N/ton
200 gal./ton
1 lb. N/1,000 sq. ft.
2 lb. N/gal.
22 gal./acre
9 acres/ton

Here we have a change. With four extra units of nitrogen, we apply only 22 gallons per acre to get 1 lb. N per 1,000 square feet. Notice the change per gallon for the nitrogen content, i.e., from 1.6 lb. N per gallon in the 16-0-4 formula (see table for 16-2-6, which is identical) to 2.0 lb. N per gallon in the 20-5-10 formula. A further breakdown of 20-5-10 at 22 gallons per acre is given below:

4 gal./1,000 sq. ft.
175 gal./acre
-22 gal. 20-5-10
153 gal. water/acre

We still want to apply 4 gallons per 100 square feet, and we still would use 175 gallons per acre, but only 22 gallons of 20-5-10, and 153 gallons water.

The following comparison with 20-5-10 dry fertilizer is worth noting:

400 lb. N/ton
2,000 lb./ton
1 lb. N/1,000 sq. ft.
4.4 50-lb. bags
220 lb./acre
9 acres/ton

We still have 400 lb. of N per ton, and we still want to apply 1 lb. N per 1,000 square feet. We know that each fifty-pound bag contains 10 lb. N, and at 43,560 sq. ft. per acre we would need 4.4 fifty-pound bags, or 220 lb. of bagged fertilizer per acre. 1 ton would still cover 9 acres.

Ammonium thiosulfate 102-0-0-26S is a relatively new fertilizer, and is being used quite extensively in agriculture. We will be hearing more about the use of this product in liquid lawn fertilizers. An example of the breakdown of 20-5-10/4S with 12-0-0-26S and 50 percent formolene follows:

Urea 46-0-0	290 lb.
Potash 0-0-62	325
Formolene 30-0-2	670
Poly 10-34-0	295
ATS 12-00-26S	310
Water	110
10 lb./gal.	2,000 lb.

Thus a typical formula using Ammonium thiosulphate 12-0-0-26S has a 1 to 5 ratio, 1 lb. of sulfur to 5 lb. of nitrogen. In this formula there would only be about 37 lb. of nitrogen in ammonia form per ton; spreading that ton in liquid form over 9 acres surely should not cause any *phytotoxicity* problems. Other liquid lawn fertilizers manufactured and used in the liquid lawn care industry in our area are 30-0-2, 15-5-5, 23-0-0, 18-0-6, 18-2-6, 12-4-4. They always contain higher nitrogen, low or no phosphate, and moderate potash.

Is it easy to handle liquid lawn fertilizers? Yes, we believe it is. Just put the discharge hose or nozzle into the hatch of the nurse tank or truck. Set the meter and punch the ticket at 000 for accurate gallon count; or possibly, use the sight gauge on your truck or tank. Open the right valves, start the pump, and be sure not to run the tank over--as we have on occasion. When driving to your destination, be sure to open the hatch before unloading. If you have an air-tight tank, you could collapse it. Once at your destination, start the pump, and unload the storage tanks or lawn trucks; or move the liquid with a semitanker. A 45,000-gallon tanker will unload in less than 30 minutes with one man: the driver. It takes 5 minutes to hook up and open the valves, 13 minutes to pump off the load, and 10 minutes to close the valves and unhook. Weightwise, this would be about the equivalent of 900 50 lb.-bags with probably 3 or 4 employees, possibly a fork lift, and 20 or more pallets. We can't guess the time involved with bagged fertilizer nor the cost.

A liquid lawn spray truck need not be expensive or complicated to handle 100 percent liquid fertilizer mixes. Mechanical agitation is not required, nor is a power take-off pump. With the high cost of fuel and interest rates on equipment, conversions to gas engines are becoming quite common.

The tanks used in the operation at Niles are a little unusual since they each hold 18,000 gallons. We pump and meter our concentrate of 16-2-6 and 20-5-10 through 3-inch lines, and sometimes process mistakes into the first tank.

We pick up 45,000 gallons of water from the river about two blocks away. We meter the water into the concentrate, and recirculate it anywhere from 5 to 10 hours. Then we run an analysis for N-P-K, and always run specific gravity tests that give us our weight per gallon and determine our nitrogen per gallon. The average weight per gallon of the finished product is about 8.6 lb. to 9.0 lb. per gallon. If our analysis is off slightly, we can immediately fortify it by adding more concentrate. If the mixture is too strong, we add more water. The lawn trucks are loaded by gravity flow with a 2-inch hose. Pesticides with the finished spray mixture are put into the truck while it's loading. The total time spent is about 10 minutes for a 750-gallon tank truck.

Particularly in the summer time, there is a notable difference between liquid controlled-release nitrogen fertilizer and 16-8-8 bagged farm fertilizer. On one occasion, we agreed to take care of the middle of a lawn, while the regular maintenance landscaper took care of the remainder. Due to high water and sewage rates, no irrigation was used at all on this facility. We saw visible differences between the middle, where liquid fertilizer had been used, and the sides, where dry fertilizer had been applied. For maximum effectiveness, however, moisture is necessary for liquid fertilizers. Even so, these fertilizers are still the most convenient, and they make it possible for us to fertilize with ease up to 5 acres of lawn per day.

IRON FERTILIZATION OF KENTUCKY BLUEGRASS

A. Yust and D. Wehner

INTRODUCTION

Kentucky bluegrass is the major turfgrass species used in Illinois. The quality of a Kentucky bluegrass turf can be judged by its color, density, uniformity, texture, and smoothness. Its most noticeable and desirable characteristic is its dark green color. Nitrogen fertilizers can be used to produce a dark green color, but high rates of nitrogen can also cause certain problems. More frequent mowing, increased disease incidence, and reduced stress tolerance are associated with high nitrogen levels (Beard, 1973). Foliar application of iron fertilizers can also be used to enhance color (Beard, 1973), although nitrogen fertilization will still be necessary. However, if reduced rates of nitrogen could be utilized, there would be fewer problems with excessive growth, disease, and other stresses.

Most Illinois soils contain sufficient quantities of available iron for turfgrass growth, but there are certain instances where soil iron is limited and can cause iron-related chlorosis. Soil factors which cause iron to be unavailable include hih pH, high levels of phosphorus or HCO_3^-, an imbalance of metallic ions, or a combination of high pH, high lime, high moisture, and cool temperature.

Iron is important in the plant for a number of functions. Iron is directly involved in photosynthesis, respiration, and nitrogen metabolism. It is also necessary for chlorophyll synthesis, although it is not an integral part of the chlorophyll molecule. Chlorophyll content and green color have been related in numerous studies, since chlorophyll is the green pigment found in plants.

Iron sulfate and iron chelate are the two main iron fertilizers used to correct plant chlorosis due to iron deficiencies. Iron fertilizers are most commonly applied in solutions directly to the foliage of the plant. Soil applications of iron fertilizers are generally less effective than foliar applications. Iron sulfate is cheaper, but iron chelates are able to maintain iron in a plant-available form longer, and can usually be applied at lower rates of actual iron than iron sulfate to correct iron chlorosis symptoms (Tilsdale and Nelson, 1975).

MATERIAL AND METHODS

Iron sulfate and iron chelate at rates of 0, 1, 2, and 4 pounds of actual iron per acre were combined with nitrogen at rates of 0, 0.5, and 1.0 pounds per 1000 sq. ft., and applied to a mature Touchdown-Columbia Kentucky bluegrass stand at the Ornamental Horticulture Research Center. Foliar applications of the fertilizer treatments were made to the individual 30 sq. ft. plots with a CO_2 sprayer on July 26, 1980, and October 1, 1980. Visual color ratings and chlorophyll determinations were made weekly until color differences no longer existed. Fresh weights and dry weights of clippings taken from the plots were also recorded.

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RESULTS AND DISCUSSION

Color ratings from the October 1 application (Table 1) indicate that iron chelate treated plots tend to produce darker green color than iron sulfate treated plants at the same rate of actual iron. As mentioned earlier, lower rates of iron chelate in proportion to iron sulfate can usually be used to correct iron chlorosis symptoms. Therefore, one can assume that darker green colors might also be produced by iron chelate at the same rate of actual iron as iron sulfate.

Table 1. Color Ratings of Plots Treated with Nitrogen and Iron Sulfate ($FeSO_4$) or Iron Chelate (FE Chelate)

Treatment	Days from application			
	7	14	35	63
0.5 lb. N/M (0 lb. Fe)	6.5[a]	6.7	6.8	6.2
0.5 lb. N/M + 2.0 lb. Fe - $FeSO_4$	7.7	7.3	7.7	6.7
0.5 lb. N/M + 2.0 lb. Fe - Fe chelate/A	8.3	8.0	8.3	6.3

Application date: Oct. 1, 1980.
[a]9.0 = dark green (on a scale of 1 to 9).

Table 2 lists both color ratings and chlorophyll content from the July application, and shows that only slight differences in chlorophyll may be responsible for green color differences.

Table 2. Comparison of Chlorophyll Content to Visual Color Rating

$FeSO_4$ + 0.5 lb. N/M[a]	Color rating	Chlorophyll
(lb./A)		(mg/g dry wt.)
0	7.5[b]	6.62
1	8.3	6.77
2	8.3	6.72
4	9.0	6.82

[a]$FeSo_4$ = iron sulfate
[b]9.0 = dark green (on a scale of 1 to 9).

Earlier it was mentioned that one of the problems associated with higher nitrogen rates was increased mowing frequency. The overall ratings from the July treatment (Table 3) show darker green color associated with the 0.5 pound per 100 sq. ft. rate of nitrogen combined with the 2 pounds per acre rate of iron chelate, and fewer clippings than plots treated with 1 pound of nitrogen per 100 sq. ft.

Plots receiving iron showed a greening response 24 hours after both the July 26 and the October 1 treatments. Differences in green color between treatments were detectable for about 4 weeks after the July 26 treatment. Green color differences due to the October 1, 1980, treatments were noticeable throughout the fall and well into the winter until the first snow cover. These plots will be monitored for early spring greenup and for any overwinter stress that may have occurred as a result of the treatments.

Table 3. Comparison of Color Rating and Fresh Weight of Clippings

Treatment	Color rating	Total fresh wt.
		(g/plot)
Check	6.5[a]	337.5
2 lb. Fe - Fe chelate/A (0 lb. N)	7.2	442.8
0.5 lb. N/M (0 lb. Fe)	7.6	564.3
0.5 lb. N/M + 2 lb. Fe - Fe chelate/A	8.4	671.4
1 lb. N/M (0 lb. Fe)	8.1	756.9

Application date: July 26, 1980.
[a]9.0 = dark green (on a scale of 1 to 9).

Four more applications of the above treatments will be made at times approximating applications made by home lawn care companies. Also, a field study will be conducted to determine at what level of iron fertilization toxicity symptoms occur.

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ASSESSING THE LEASE-OR-BUY DECISION

Charles Linke and Kenton Zumwalt

[*This paper follows closely the chapter on leasing contributed by Charles Linke to the book by Robert H. Behrens and Thomas L. Frey, Lending to Agricultural Enterprises (Boston: Bankers Publishing Company, 1981).*]

Firms make profits through the use of assets, not through their ownership. Typically, debt and equity funds are used to buy equipment and buildings. Leasing provides an alternative way firms can acquire the use of assets without ownership. Accordingly, the lease decision is often viewed as a "lease-or-borrow decision" from the user's perspective, and a "lease-or-lend decision" from the perspective of the capital supplier.

A lease is a contract whereby the owner of an asset, the *lessor*, confers on the user of the asset, the *lessee*, the right to use the asset for a specified time period in exchange for a promise to pay a series of (rental) payments over the leasing period. By separating use from ownership, a lease allows a firm to acquire the service flow of an asset without the large initial cash outflows typically associated with purchase. The lease contract specifies the leasing period, the amount and timing of lease payments, the lessee's responsibilities regarding such items as taxes, insurance, maintenance expenses, etc., and the lessee's rights for purchase and/or re-lease of the asset at expiration of the leasing period.

Today, it is possible to lease virtually any asset--computers, combines, bulldozers, railroad cars, trucks, tractors, printing presses, nuclear fuel cores, airplanes, even horses and dairy herds. The demand for leasing is increasing rapidly in the inflationary economy of the 1980s. The major lessors are banks, independent leasing companies, leasing subsidiaries of manufacturers, insurance companies, finance companies, pension funds, foundations, and individual investors.

Following a brief review of some of the characteristics of financial leases, the logic of leasing from the lessee's perspective is analyzed in this paper.

FINANCIAL LEASES

The two most frequently encountered types of leases are the *operating* lease and the *financial* lease. This paper is directed toward financial or capital leasing.

Under an operating (or service) lease, the lessor (owner) provides not only financing but is also responsible for maintenance, insurance, and property taxes. Compensation for providing these services is embodied in the lease payment. Equipment such as computers, copying machines, automobiles, and trucks are the types of assets involved in operating or service leases. An important characteristic of operating leases is the right of the lessee to cancel the lease upon

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sufficient notice to the lessor. This means the lessee can return equipment to the lessor if it is rendered obsolete by technological development, or is no longer needed. Not surprisingly, lessors establish a lease charge that reflects the risk of entering into a cancelable short-to-intermediate term lease with rental payments that will not recover the full cost of the leased property. Operating leases are written for a period of time substantially less than the asset's expected economic life, and the lessor expects to recover all costs either in subsequent renewal payments or through disposal of the leased equipment.

Financial leases are noncancelable contracts requiring a set of payments that normally will fully recover the original cost of the leased asset plus a predetermined expected rate of return. Full amortization of cost and noncancelability are the key characteristics that distinguish financial leases from operating leases. Indeed, a financial lease is simply a financing device that creates an obligation not unlike that imposed by formal indebtedness. The lessee pays a fixed rental for a specified period covering the amortization of the asset cost and the margin to the lessor. From a cash flow vantage point, this arrangement is comparable to a firm buying the asset via a borrowing arrangement that requires the amortization of principal by a series of annual payments. Further, the lease payments are fixed and contractual, and default by the lessee can result in bankruptcy, just as with debt financing.

Being a financial device, financial leases place the responsibility for maintenance, insurance, and taxes upon the lessee (user). This is why financial leases are often referred to as "net leases." The length of the lease is related to the economic life of the asset. Provision may be made for the lessee to continue the use of the asset after expiration of the lease term via renewal or purchase, but care must be taken, as such provisions can cause the IRS to view the lease as a disguised contract for conditional sales.

IRS Lease Criteria

Lease payments are a deductible expense for income tax purposes, providing the Internal Revenue Service agrees that a lease contract is not simply an installment loan disguised as a lease. Without tax deductible lease payments, leasing would not be an economically viable alternative to borrowing. This means a lease contract must be written in a form consistent with IRS criteria for a lease. Below are listed three major lease provisions that determine whether a particular contract is likely to be treated as a lease transaction or a conditional sale by the IRS. For a contract to be considered a lease, it is important to keep in mind the following facts:

1. There should be no option for the lessee to renew the lease or purchase the asset at the end of the lease term at a bargain price.

2. The maturity of the lease should be less than 75 per cent of the estimated economic life of the asset.

3. The present value of the minimum lease payments must provide a reasonable rate of return to the lessor on the fair value of the leased property.

The IRS is concerned about the terms of leases, special buyout bargan prices, and lessor's returns because without any restrictions, companies would use leases to depreciate equipment over a much shorter period than its useful life and/or the IRS depreciation guidelines. For example, without restrictions a business would acquire the use of a $200,000 computer with an eight-year depreciable life on a three-year lease with a purchase option for $1 (or a $1 annual lease renewal). Such a lease would provide the business with a cash flow configuration equal to the cash flow pattern associated with borrowing, purchasing the computer, and depreciating it over a three-year period.

CRUCIAL VARIABLES IN THE LEASE-OR-BORROW DECISION

A representative sequence of events leading to a financial lease arrangement is as follows:

1. The firm decides to acquire the use of a particular piece of equipment based upon the price and delivery terms it has negotiated with the supplier. This decision emerges from the firm's ongoing capital expenditure and decision-making (or capital budgeting) process.
2. Once the equipment acquisition decision has been made, the next question for the firm is how to finance the acquisition. Funds to pay for the equipment could be raised by selling equity, by borrowing, or by leasing the asset.
3. The equipment seller may quote leasing terms, or the purchasing firm may apply for lease financing at a bank or some other leasing service. The leasing terms quoted--payment per $1,000 of cost, lease maturity, the lessee's responsibilities for maintenance, insurance and taxes, renewal/purchase options, and so forth—are subject to negotiation, of course. But to the extent there is substantial competition between lessors and lenders, significant differences in financial lease terms should not frequently appear on standard equipment assets.
4. If the purchasing firm decides to lease instead of borrow, the lessor will buy the equipment from the distributor and simultaneously execute the lease contract with the user firm. Whether or not a firm should lease equipment can be determined only by comparing the consequences of leasing with those of the nearest comparable alternative--purchasing the asset with borrowed funds.

Why Lease?

Leasing advocates cite a variety of advantages that singly or in combination may cause the financial lease to be preferred to borrowing and owning:

OFF-THE-BALANCE-SHEET FINANCING. A lease, like a debt, obligates the firm to a set series of future payments. To the extent lease data appear only as footnotes in the financial statements, lease financing does not explicitly raise the debt/equity ratio and reduce the borrowing capacity of the firm. This advantage is possibly overstated, as only a naive analyst would ignore the impact of leases on the financial position of the firm. Also, new accounting rules now require firms to show both the asset and liability implications of lease obligations.

100 PERCENT FINANCING. Firms often find that conventional lenders, such as commercial banks, will not lend the entire cost of the asset being acquired. By leasing, these companies may be able to obtain more financing.

FLEXIBILITY. Lease agreements generally do not concede to the lessor the right to restrict financing by the lessee, whereas covenants in bond indentures and term loan agreements sometimes impose restrictions on future financing (including leasing), dividend, and compensation decisions. The lessor's financial position is presumed to be safeguarded by the leased asset itself.

In internal operations the lease may also be more flexible than borrowing and owning. For example, since leases are often treated as operating rather than capital expenditure, managers in many firms can authorize leasing up to their discretionary budget authority without going through the lengthy capital expenditure authorization route. Finally, tax laws make it easier to write off improvements on leased property in a more flexible manner than on property owned by the firm.

AVAILABILITY OF FINANCING. Many small and intermediate sized firms are unable to obtain longer debt financing consistent with the economic life of the asset being acquired. Leasing may represent the only form of term credit generally available to a number of firms today. Also, the term of a lease revolves around the economic life of the asset, whereas the maturity of a term loan is often affected by a term lender's maturity preference and loan policy.

LOWER EFFECTIVE FINANCING COST. The cost of leasing relative to the cost of borrowing and owning depends upon the nominal cost of money built into the lease, the lease term, the impact of taxes, and the residual asset value. Leasing can be less expensive than borrowing and owning for some firms.

All the same, leasing is no panacea for firms attempting to obtain the use of assets. For example, if a firm owns the property, it can sell or abandon the asset that is no longer needed. If the asset is leased, the firm has lost some flexibility. Unanticipated inflation shifts value from the lessee to the lessor in the form of a larger anticipated residual equipment value at the end of the lease. Clearly, the rapid growth of lease financing is dependent upon tax legislation, accounting conventions, and the economic climate.

Key Variables in the Lease-or-Borrow Decision

As indicated earlier in this paper, a financial lease is comparable to a loan in the sense that the firm is obligated to make a series of future payments. Not making these payments threatens financial failure, just as failure to meet debt service payments would. Thus, an appropriate way to evaluate leasing is to compare the cost of lease financing with the cost of debt (owning) financing.

Lease analysis is an exercise in present value or discounted cash flow valuation. The relative costs of leasing and borrowing-owning are affected by the differential impact of the two financing methods upon a firm's after-tax cash flow. More specifically, in lease analysis the investment decision (or the decision to use the asset) is taken as given, and the analysis is undertaken to compare the present value of the after-tax costs of leasing to the after-tax costs of owning.

Since leasing may provide up to 100 percent financing, it is compared with 100 percent debt financing. The analysis follows the incremental cash flow rule of capital budgeting to identify the cash flows associated with leasing and with owning. Table 1 identifies the more important differences between leasing and borrowing that affect the after-tax cash flows of the asset user. By leasing, the firm or user of the asset avoids the cash outlay required to purchase the asset, incurs an obligation to make lease payments, can relinquish the investment tax credit (ITC), foregoes the depreciation tax deduction, and forfeits the residual or salvage value of the asset at the expiration of the lease. By borrowing, the firm incurs the initial cash outlay to purchase the asset, but obtains the ITC and depreciation tax shield, retains the residual value of the asset, and gets a tax shield from the interest on the borrowed funds. Costs of operation, maintenance, insurance, property taxes, and so on, often are the same under leasing or buying, but if different, the differences represent an incremental cash flow that must be considered on an after-tax basis.

Table 1. Some Differences Between Leasing and Borrowing that Affect an Asset User's Incremental After-Tax Cash Flow

Method for acquiring use of asset	User of asset	Financier
Leasing	Lessee: . entitled to lease . payment deduction . avoids cash pur- . chase outlay	Lessor entitled to: . depreciation de- duction . residual value . investment tax . credit (ITC)
Borrowing	Borrower gets: . depreciation . deduction . interest deduction . investment tax credit . (ITC) . residual value	Lender: . entitled to no . deductions

THE LEASE-OR-BORROW DECISION

The potential lessee, having decided to acquire the use of an asset, must choose between leasing or borrowing and owning. The choice will normally be the financing alternative that has the lower cost based on a present value analysis of incremental after-tax cash flows. Much debate centers on the theoretically correct method to evaluate lease versus borrow-and-buy decisions. A number of sophisticated models have been offered to aid in the analysis. A straightforward analysis method that is accurate enough for most lease-borrow decisions is used here to demonstrate how a potential lessee could evaluate the costs of leasing and borrowing.

Suppose a lawn service firm, Grass, Inc., has decided to acquire a truck fleet costing $100,000 and having an expected economic life of eight years. Other conditions assumed are as follows:

1. An investment tax credit (ITC) of 10 percent of the $100,000 cost, or $10,000, is available to the purchaser of the trucks. It is assumed at this time that Grass Inc. is able to use the tax credit in its entirety to offset taxes it would otherwise pay. The relative desirability of leasing or owning is affected importantly by this assumption. Thus, the net financing required of Grass Inc. is $90,000 if the purchase option is selected.

2. The trucks have a depreciable life of eight years but will be used for seven years, at which time Grass Inc. estimates the trucks will have a $12,500 sale or residual value. Assuming straight line depreciation and no salvage value at the end of year eight, this estimated residual value is equal to one year's depreciation or the undepreciated cost of the trucks at the end of year seven.

3. Operating costs such as maintenance, insurance, and taxes are the responsibility of Grass Inc., whether the trucks are leased or bought.

4. Grass Inc. has an effective tax rate of 50 percent. The use of this rate in the analysis that the firm's future taxable income will be sufficient so as to fully utilize the tax shield associated with tax deductible (lease-depreciation-interest) expenses.

5. Grass Inc. can lease the trucks from Leasing Inc. under a seven-year contract with payments that will completely amortize the lessor's $100,000 purchase cost after deducting one-half of the $10,000 ITC benefit or $95,000, and yield a 12 percent return. A major reason for purchasing an asset via debt financing instead of leasing is the realization of the ITC at the outset. The ITC effectively reduces the purchase price and the amount of financing needed. If the asset is leased, the lessor is entitled to the ITC. However, the tax laws permit the lessor to share the ITC benefit either by direct assignment of ITC to the lessee, or, as in this example, via lower lease payments than would otherwise be the case.

As is customary, lease payments are to be made in advance--that is, one payment at the lease-signing and one payment at the end of each of the next six years. The amount of the annual lease payment may be calculated by solving the following equation with references to the time value of money:

$$\$95{,}000 = \text{Payment at signing} + \text{Present value of payments at end of years 1-6} \qquad (1)$$

$$\$95{,}000 = P + P \sum_{t=1}^{6} \frac{1}{(1 + 0.12)^t}$$

$$\$95{,}000 = P + 4.111407\ P$$

$$P = \frac{\$95{,}000}{5.111407} = \$18{,}585$$

The schedule of after-tax cash outflows to be associated with leasing follows.

End of year	Lease payment	Tax savings	Cash outflow after taxes
0	$18,586	$9,293	$9,293
1-6	$18,586	$9,293	$9,293

Grass Inc. can accept the potential lessor's offer, negotiate, or reject it and buy the trucks, or solicit offers from other lessors. It is noteworthy that the lease payment schedule above provides a 9.8 percent return on the $100,000 truck fleet. Leasing Inc. will own the trucks at the end of the lease period. Presumably, Grass Inc. will negotiate the right to buy or release the trucks at fair market prices.

6. Grass Inc. can borrow funds from its commercial bank to acquire the trucks on a 15.0 percent term loan. With owning, the firm is assumed to finance the trucks entirely with a six-year term loan that has a payment schedule with the same configuration as the lease payment schedule. This makes the borrowing alternative more comparable to leasing in terms of the firm's borrowing capacity.

As noted earlier, Grass Inc. will need to borrow only $90,000 because of the $10,000 ITC. A loan of $90,000 is assumed to be taken out at the time of the truck purchase. Just as with the lease, the first of the seven loan payments will be made at time 0 or closing. In credit transactions this is known as a down payment. The other six payments will be made at the end of each of the first six years. A $90,000 loan at 15 percent with this payment schedule would require annual payments of $18,811.

$$\$90{,}000 = \text{Payment at purchase} + \text{Present value of future payments at end of years 1-6} \qquad (2)$$

$$\$90{,}000 = P + P \sum_{t=1}^{6} \frac{1}{(1 + 0.15)^t}$$

$$\$90{,}000 = P + 3.78449\,P$$

$$P = \$18{,}811$$

The loan amortization schedule is shown below.

End of year	Payment	Interest	Principal amount owned end-of-year
0	$18,811	0	$71,189
1	18,811	$10,678	63,056
2	18,811	9,458	53,704
3	18,811	8,056	42,949
4	18,811	6,443	30,581
5	18,811	4,587	16,357
6	18,811	2,453	0
7	0	0	0

The loan amortization schedule and the lease payment schedule are quite close in years 1-6, and thus comparable in their use of Grass Inc.'s borrowing capacity (at least on a before-tax basis).

The lease versus borrow-and-purchase analysis is illustrated in Table 2. Columns (2) through (7) develop the after-tax cash flows to be associated with borrowing and owning. Tax deductible expenses--interest and depreciation--are summed up in Column (5), while Column (6) shows the tax savings because Grass Inc. borrows and owns. Column (7) gives the after-tax cash flow of owning by subtracting the tax savings from the loan payments. The residual value of the trucks in year seven is shown in Column (7) as an after-tax cash benefit of owning, because no tax liability would be incurred as long as the trucks are sold at a price equal to the undepreciated book value. The after-tax cash flow of leasing discussed above is shown in Column (8).

To be able to compare the costs of leasing and borrowing, the after-tax cash flows of each alternative must be put on a common basis by discounting these flows to their present value. Disagreement exists over what is an appropriate discount rate. However, financial leasing is analogous to borrowing-owning. Therefore, an appropriate discount rate might be the after-tax cost of borrowing or 7.5 percent for Grass Inc. (a 15 percent pre-tax borrowing rate is a 7.5 percent after-tax borrowing rate assuming a 50 percent tax bracket). The after-tax borrowing rate has appeal because most of the flows involved (interest expense, depreciation tax savings, lease payments) are not risky estimates such as those found in capital expenditure decision-making, but rather are relatively certain. Of course, use of the after-tax borrowing rate assumes Grass Inc.'s future taxable income will be sufficient to fully utilize the envisioned tax shields, and that the effective 50 percent tax rate will not change.

Given these assumptions, the present value analysis reveals Grass Inc. would incur a cost of only \$51,361 if it borrowed and owned the trucks, and a \$52,914 cost if it leased the trucks. The cheaper cost associated with owning arises despite the fact that lease payments imply an interest rate of only 9.8 percent on the \$100,000 purchase cost as shown earlier, while the explicit interest cost of borrowing is 15 percent. However, this 9.8 percent and 15 percent comparison exaggerates the difference between leasing and borrowing as the present value analysis of the alternative shows.

Leasing will not provide a pecuniary advantage over borrowing and owning if both the lessee and the lessor are in the same tax bracket; if they have sufficient income to be able to utilize full the yearly tax shields provided by the asset and the ITC at purchase; and if they hold similar expectations regarding the asset's residual value, and have roughly equivalent access to the capital markets. When the lessee and the lessor are not comparable with respect to one or more of these characteristics, then leasing may be preferred to borrowing. For example, the advantage of purchasing via borrowing revolves around the ITC at the time of purchase, the deductibility of interest and depreciation for tax purposes, and the residual asset value. If a firm could not use the ITC, it would be better off to attempt to lease equipment from a lessor that would pass part (as in the Grass Inc. truck fleet example) or all of the ITC benefit along in the form of lower lease (and interest) payments. The same would hold for a firm needing equipment but unable to use the depreciation and interest tax shields at all, or at the tax rates to which lessors are exposed. If a thousand dollars of depreciation that will save a firm only three hundred dollars in taxes can be shifted to a lessor and save five hundred dollars in taxes, two hundred dollars of tax savings is created by the lease transaction that can be distributed between the parties according to their respective negotiating abilities. Residual value is another variable that creates the opportunity for mutually beneficial trading between lessors and lessees, especially so in an inflationary period.

An alternative to computing the present value of the after-tax cash flows of the two financing alternatives is to compute an after-tax percentage cost of leasing (i_L) that can be compared with the after-tax cost of borrowing. This lease cost rate, i_L, is the time value of money or rate of discount that equates the after-tax cost of owning with the after-tax cost of leasing. In other words, i_L is the discount rate that will cause the costs of leasing (after-tax lease payments) and the nonfinancing costs of borrowing-owning (cost of asset, ITC, depreciation tax shield, and residual value) to be equal. Interest costs are not introduced explicitly as in the present value analysis because this alternative approach determines an after-tax rate that is to be compared with the after-tax cost of borrowing.

Table 2. Grass Inc. Lease-or-Borrow/Own Analysis

	Cost of borrowing & owning						Leasing cost	Comparative costs		
Year	Loan payment	Interest cost	Deprecia- tion charge	Tax de- ductible expenses (3)+(4)	Tax savings 0.5(5)	After- tax cash flow (2)-(6)	After-tax cash flow	Present value (PV) factors 7.5%	PV cost of owning (9)x(7)	PV cost of leasing (9)x(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
0	$18,811						$9,293	1.0000	$18,811	$9,293
1	18,811	$10,678	$12,500	$23,178	$11,589	$ 7,222	9,293	0.9302	6,718	8,644
2	18,811	9,458	12,500	21,958	10,979	7,832	9,293	0.8653	6,777	8,041
3	18,811	8,056	12,500	20,556	10,278	8,533	9,293	0.8050	6,869	7,481
4	18,811	6,443	12,500	18,943	9,472	9,339	9,293	0.7488	8,993	6,969
5	18,811	4,587	12,500	17,087	8,544	10,267	9,293	0.6966	7,152	6,474
6	18,811	2,453	12,500	14,953	7,477	11,334	9,293	0.6480	7,344	6,022
7			12,500	12,500	6,250	(6,250)		0.6028	(3,768)	
						(12,500)*			(7,535)	
			$87,500						$51,361	$52,914

*The $12,500 represents the estimated after-tax residual value of the trucks at the end of year seven that would accrue to Grass Inc. if the trucks were financed by borrowing instead of leasing. The residual value can be shown as a benefit of owning as it is here, or as a cost of leasing in year seven as in column (8).

Table 3. Grass Inc. Lease Analysis: Schedules of Cash Flows Needed for Calculating i_L

Year (1)	Cost of asset (2)	After-tax lease payment $(L_T - TL_t)$ (3)	Tax saving from depreciation shield TD_t (4)	Investment tax credit (5)	Residual value (after-tax) (6)	Cash flow after-tax (2)-(3)-(4)-(5)-(6)
0	$100,000	$9,293		$10,000		$80,707
1	--	9,293	$6,250			15,543
2	--	9,293	6,250			15,543
3	--	9,293	6,250			15,543
4	--	9,293	6,250			15,543
5	--	9,293	6,250			15,543
6	--	9,293	6,250			15,543
7			6,250		$12,500	18,750

Using equation (4): $$\$100,000 = \sum_{t=0}^{6} \frac{\$9,293}{(1 + i_L)^t} + \sum_{t=1}^{7} \frac{\$6,250}{(1 + i_L)^t} + \$100,000 + \frac{\$12,500}{(1 + i_L)^7}$$

$$i_L = 8.74\%$$

Following the logic of present value analysis expressed in Table 3, this bond yield or internal rate of return construct can be derived by setting the present value of the cost of leasing equal to the present value of the cost of borrowing when both costs at i_L are discounted.

The internal rate of return can be derived as follows:

$$\begin{array}{ccc} \text{Present value of} & & \text{Present value of} \\ \text{after-tax cost} & = & \text{after-tax cost} \\ \text{of owning} & & \text{of leasing} \end{array}$$

$$C_o - ITC_o - \sum_{t=1}^{n} \frac{TD_t}{(1 = i_L)^t} - \frac{RV_n}{(1 + i_L)^n} = \sum_{t=0}^{n-1} \frac{L_t - TL_t}{(1 + i_L)^t} \quad (3)$$

where C_o = cost of asset to be leased in time period 0;

n = number of years of lease;

L_t= lease payment at end of period t;

T= tax rate;

D_T= depreciation charge in time period t if asset owned;

ITC_o = investment tax credit in time 0 if asset owned;

RV_n = residual value of asset in time n if asset owned.

i_L is an internal rate of return construct and can be estimated easily by rearranging equation (3):

$$C_o = \sum_{t=0}^{n-1} \frac{L_t - TL_t}{(1 + i_L)^t} + \sum_{t=1}^{n} \frac{TD_t}{(1 + i_L)^t} + ITC_o + \frac{RV_n}{(1 + i_L)^n} \quad (4)$$

Equation (4) in Table 3 makes clear the logic of the after-tax cost of leasing rate, i_L. A firm can pay the cost of an asset (C_o), and own the asset; or, the firm can lease the asset and incur the explicit after-tax cost of the lease payments and the implicit costs of foregoing the depreciation tax shield, ITC, and residual value associated with buying. The cash flows schedule needed to calculate i_L is shown in Table 3 for Grass Inc. The after-tax cost of leasing is 8.74 percent which is greater than the 7.5 percent after-tax cost of debt. This method of analysis also suggests that borrowing is preferred to leasing--as is to be expected since it is built on the same logic as the present value analysis. The value of this method relative to the present value analysis is twofold. First, businessmen generally are more comfortable comparing percentage rates of return than comparing net present values. Second, this method obviates the need to select an after-tax borrowing rate. The calculated i_L can be compared easily with a range of possible borrowing rates.

SUMMARY

This paper has analyzed the lease-or-borrow decision for financial leases as distinguished from operating or service leases. The lease-or-borrow decision analysis is based upon a discounted cash flow evaluation of the after-tax cash flows associated with the two financing methods. Two analytical techniques were used to quantify the pecuniary advantage of leasing relative to borrowing and owning. The approach of present value analysis uses the after-tax cost of borrowing to evaluate the net cash flow associated with each alternative. The after-tax cost of leasing method derives a rate of return measure comparable to the after-tax cost of borrowing to determine whether leasing or borrowing is preferred.

The logic of leasing revolves around taxes. Leasing permits the tax shelters (ITC, tax deductible expenses) and residual values to be shifted from the user of an asset to a capital supplier. If asset users and capital suppliers are in different tax brackets, if they hold different expectations about the residual value of assets, or do not have equal access to financing, then lessors and potential lessees can gain through lease arrangements.

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WEED MANAGEMENT IN TURFGRASS STANDS

T. W. Fermanian

In any discussion of turfgrass weed control, it is first necessary to define precisely what a weed is in a turfgrass stand. The need for such a definition might seem trivial, yet it is essential to an understanding of the fine differences between a turfgrass and a weed. Generally speaking, a weed is a plant that is growing out of place. Such a description, although accurate, is not adequate. A better definition of a turf weed is that it is any plant in a turf stand differing from the rest in any component of turfgrass quality.

To really understand this definition, it is of value to examine what comprises turf quality. Turf quality is measured by three attributes: texture, color, density. The absolute characteristics of each attribute are not important, and they are selected according to the aesthetic requirements of the turf manager. What is of prime importance, however, is that the chosen texture, color, and density of the turf be uniform throughout the entire stand. Therefore, any plant or group of plants differing in texture, color, or density from the turf species selected is considered a weed. Common Kentucky bluegrass, therefore, is defined as a weed when it appears in "Baron" Kentucky bluegrass turf.

The goal of turfgrass weed management is based on this definition of weeds, and can be simply stated as the initiating of any management practice that will minimize the differences in either texture, color, or density in a turf stand. In the past, weed control was often accomplished by the application of a herbicide. This method is still the most rapid and effective one available, and will continue to be so in the near future. Its effectiveness, however, can be greatly enhanced by integrating other management practices (for example sanitation, cultivation, and fertilization).

Before a turf manager can intelligently formulate a weed management strategy, a basic understanding of turfgrass weed ecology is needed. In general, all turf weeds have either an annual or perennial life cycle. Annual weeds provide for the survival of their species by producing large quantities of seed. Since regrowth of all annual weeds occurs through seed, practices that eliminate their germination and growth are most effective. Perennial weeds, in addition to producing seeds, have developed specific organs such as stolons, rhizomes, bulbs, and tubers to ensure their survival.

Several mechanisms exist to delay the seed germination of weeds. Normally, seeds germinate each time the soil and climate regain the conditions necessary for germination. In some species, inhibitors of chemical germination are produced in the seed coat, which decomposes with age to allow normal germination.

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Legumes and other weeds have, on some seeds, a hard coat that provides a physical barrier to water absorption or to the expansion of tissue. Germination can then take place after the coat is cracked. The shedding of the seed with an immature embryo is another mechanism that delays germination. The embryo continues to develop for several months (even years) before germination occurs.

Storage organs of perennial weeds contain the meristematic tissue required for regrowth in addition to reserves of carbohydrates for energy. With this combination, the weed can survive short periods of environmental stress, such as heat or drought, provided that regrowth has been initiated. Control measures for perennial weeds, therefore, should be targeted at killing the meristematic tissue, or eliminating the carbohydrate reserves.

Climatic factors are probably the most dynamic components of the weed environment and also the hardest to control. All weeds have optimum temperature, light, and humidity levels that may or may not be the same as the turf species. Where large differences in climatic requirements between the turf species and a weed exist, management practices such as syringing and mowing can be used to promote conditions favoring the turf species.

Soil factors such as moisture, pH, nutrient levels, and structures also have a tremendous influence on weed growth. Some degree of control is possible by manipulating these factors so that weed growth is discouraged. Probably the highest degree of weed control is possible through cultural practices. With the proper use of irrigation, mowing, fertilization, and cultivation most weed problems can be prevented or eliminated.

Before attempting any corrective measures for a weed problem, the factors that first allowed the encroachment must be determined. Environmental extremes in temperature, moisture, and light weaken turf, giving weeds a competitive edge. Pests such as insects and disease thin a turfstand and reduce its general vigor, thus allowing weed encroachment. These stresses are often beyond the control of a turf manager; however, two other factors, cultural practices and traffic, *are* controllable and can give dramatic results. Proper cultural practices will ensure vigorous turf; and routing traffic on walks or paths will minimize wear and soil compaction. Areas under temporary stress from other factors should be closed to any traffic until their condition is improved.

With these factors in mind, several steps can be undertaken to prevent weeds from ever being a problem. Good sanitation practices are always important, so use only weed-free materials for seed, sod, topdressing, and mulch. Clean your cultivating and mowing equipment before moving to a weed-free area. Control weeds in areas adjacent to the turfstand to minimize the amount of seed dispersed into the stand. Prior to stand establishment, weed problems can be minimized through preplant weed control. Soil fumigation can reduce the population of all pests. Perennial grasses should be controlled with nonselective herbicides like glyphosate. The key to weed prevention, however, is the use of sound cultural practices. Healthy, dense turf results from proper soil pH, optimum levels of fertilizer and water, and cultivation when needed. A vigorous turfgrass provides the most effective preventive tool in weed control.

Prevention, however, will not answer all of your weed problems. For most turfs, some corrective measures are also necessary. Physical control methods include hand pulling, digging, mowing, and burning. These measures are usually only practical for small areas or isolated spots in large stands. The biological control of turf weeds still lies in the future, although some research in this area is currently under way. A possible biological control of bermudagrass is being investigated by the author and is reported on in a separate article in this proceedings.

Herbicides, however, are, to date, the most effective weed control tools. Turf weeds are placed in one of three groups according to growth characteristics. A herbicide strategy can then be formulated for each group. Annual grasses are best controlled with DCPA, bensulide, benefin, oxadiazon, and siduron, all of which are currently recommended for preemergence crabgrass control. With the exception of siduron, they will also control *Poa annua* with proper application. For all preemergence herbicides, however, the best control is obtained with two applications. The second application should be made 6 to 8 weeks after the initial application and at one-half the original rate. Benefin should not be applied to bentgrass putting greens, while DCPA is generally safe on all bentgrass except for the varieties "Cohansey" and "Toronto." One of the finest attributes of siduron is often overlooked: at one-half the normal rate, it may be applied at the time of seeding of Kentucky bluegrass, thus making spring establishment a possibility. Ronstar or oxadiazon, is new to the turf industry. It is used for preemergence crabgrass control on Kentucky bluegrass, ryegrass, or bermudagrass. Red fescue, bentgrass, and zoysiagrass cannot tolerate oxadiazon, and may be injured if it is applied. If oxidation is applied at the 4 lb. acre rate, it will control both *Poa annua* and crabgrass along with many annual broadleaf weeds. Oxadizon should not be applied to a wet turf, but it must be watered in well after application to move the herbicide into the soil.

Proanamide or Kerb can provide excellent control of *Poa annua* when applied as either a postemergence or preemergence herbicide at 0.5-1.5 lb. a.i./acre. It is of limited use in Illinois, as it can only be used on bermudagrass.

Crabgrass can also be controlled after emergence with one of the organic arsonate compounds (such as DSMA, and MSMA). Unlike Na arsonate, these compounds are relatively nontoxic and safe to use.

With the suspension of silvex for broadleaf postemergence control, a search for a suitable substitute has begun. Currently, a 50-50 mixture of dichloroprop and 2,4-D ester applied at the rate of 2 lb./acre has equalled or surpassed the effectiveness of silvex. The triple formulation of 2,4-D, MCPP, and Dicamba are also very effective in controlling broadleaf weeds. Even tough-to-control weeds like clover, yellow wood sorrel, spurge, and ground ivy can be managed. Due to the synergistic effect of the mixture, Dicamba is only used at the rate of 1/8 lb./acre, thus greatly reducing the chances of injury to surrounding ornamentals.

Yellow nutsedge is an extremely hard weed to control. A few herbicides will adequately control the aerial portions of the plant, but regrowth usually follows from the nutlets. Basagran, applied at the rate of 1-2 qt./acre is very effective in the total control of yellow nutsedge. Repeat applications of Basagran may be necessary; however, a total application of 3 qt./acre each season should not be exceeded. One of the most critical factors in the application of Basagran is adequate spray coverage. This can be achieved by using a minimum water volume of 40 GPA and a minimum spray pressure of 40 psi. Make any subsequent applications on 10-14 day intervals and, as with most translocated pesticides, apply it during warm weather to actively growing weeds with good soil moisture. Rain within eight hours of application will reduce the effectiveness of Basagran.

Although there are no newly labeled herbicides for nonselective weed control in turf, a new formulation of glyphosate has been introduced. Kleen-up, manufactured by the Chevron Chemical Company, is a 5 percent liquid formulation of glyphosate. Packaged in quart containers, Kleen-up is marketed for homelawn use. Like Roundup, Kleen-up has no soil activity. It should be applied on sunny days only when the air temperature is above 60° F. Skipping a mowing prior to application will increase the leaf surface area available for absorption and thus increase the herbicide's uptake. Rainfall within 6 hours of application will reduce its effectiveness. Kleen-up treated lawns may be reseeded within 7 days. This delay in seeding allows glyphosate to translocate throughout the plant.

For annual weeds only, Paraquat may be used for nonselective turf renovation. One important consideration with the use of Paraquat, besides its high toxicity, is its effect on soil activity. Although Paraquat is normally tightly adsorbed by soil clay particles and thus rendered inactive, in sandy soil it may not be adsorbed and may, therefore, be available for root absorption by desired species.

This discussion of turfgrass weed management only begins to cover the vast range of weed management. It does, however, outline the basic principles required for formulating an effective weed management strategy. This strategy can then be modified in the future to meet changing needs.

TROUBLESHOOTING INSECT PROBLEMS

Ed Solon

The approach to troubleshooting turf insect problems is really no different than that used in diagnosing any turf problem. The most important step is a thorough hands-and-knees examination of the affected turf area. However, before actually diagnosing the problem and correcting it, one needs to understand the following:

LIFE CYCLE AND FEEDING HABITS OF INSECTS

This information is especially valuable today because our current insecticide materials are relatively shortlived; proper timing and placement, therefore, are essential for control. The life cycle provides information on the turf-damaging stage(s) and the controllable stage(s), while feeding habits tell us where to look (surface versus subsurface), and what to look for (chewing versus sucking) in the way of damage symptoms.

DAMAGE SYMPTOMS

Each turf insect produces characteristic damage symptoms. Surface feeding worm insects (sod webworm, armyworm, and cutworm) produce brown spots, leaving chewed blades and frass as glues. Green frass indicates recent feeding activity, and a thorough examination of that area should reveal the problem. Bird activity on the turf may also indicate the presence of insects; however, verification again requires a hands-and-knees inspection.

Color is another indicator of insects. Sucking insects impart a characteristic color to the turf when they are actively feeding. The aphid (green bug), for example, produces an orangish-colored turf, while the chinch bug leaves a straw-colored turf. Root damaging insects (white grub, billbug grub, and black *ataenius* grub) chew on the roots causing the turf to wilt and eventually turn brown. If grubs are present, a pull on the turf will result in either the turf peeling up (indicating white grub or *ataenius* grub), or individual plants breaking off at ground level (indicating billbug grub). An examination of the soil beneath the brown area will reveal the problem.

DAMAGING POPULATION LEVELS

Once insects have been found, population levels should be determined to see if an insecticide is warranted. The following numbers serve as a guideline for chemical control. Factors such as the relative value of the turf (i.e. golf course green, industrial area), and its general condition (i.e. moist or dry) may alter these guidelines.

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Table 1. Population Level for Control

Insect	Number per square foot
Sod webworm	4
Armyworm	4
Cutworm	5
Chinchbug	25
Aphid	when damage is visible (may indicate 4,000/sq. ft.)
White grub (annual)	12
Billbug grub	5
Ataenius grub	50

CONTROL

In situations where conditions are not right for natural controls and population levels are above the damaging threshold, an insecticide should be applied. When choosing an insecticide consider the following:

1. the location of the insect problem;
2. the toxicity, hazard potential, and precautionary measures for each material;
3. compatibility, phytotoxicity, available formulations, and residual of each insecticide.

In summary, troubleshooting turf insect problems requires a good knowledge of insect life cycles, feeding habits, damage symptoms, population levels, and control methods.

SOIL PROBLEMS

Stanley J. Zontek

The game of golf has changed considerably over the years, but in most golf courses, the soils, and especially the greens, have remained the same. Many older golf courses today have problems with compaction and inadequate internal soil drainage. It is interesting to reflect back to golf as it was a few years ago when these courses were built, and to compare their problems *then* to their problems *now*. A few years ago, play and the resulting compactive forces were less common than they are now. Indeed, the first practical putting green aerator was not even manufactured until the early 1950s, a fact indicating that there probably was no need for such equipment before that time. Light play on the topsoil based greens of that day seldom caused much of a compaction problem. The problems addressed by early construction techniques were mainly water-related. Supplying enough water to the grass was the main problem then, not compaction. Greens were built often with clay bases intentionally designed to increase the water-holding capacity of that putting green soil. Irrigation systems were primitive hose-and-sprinkler setups, in no way approaching what we have today. Indeed, the volume of many of the older systems was so low that it was practically impossible to overwater a green. The greens were built to solve the superintendents' problems of that day, namely, to maintain putting greens that held enough water to keep the grass alive during the summer drought and stress season. How things have changed!

Today we see high sand construction resulting from the pioneering efforts of the U.S. Golf Association Green Section. In 1960, our original specifications were published reflecting basic soils work begun in the mid 1950s. By the sixties, the emphasis had changed. No longer were irrigation systems inadequate. Now entire golf courses were watered. With the golf explosion of the late 1950s and 1960s, lush, green golf courses were the rule and standard. With increased play, compaction became the main problem. The old, small, topsoil based greens began to have difficulties handling the traffic. Poor drainage and shallow roots resulted in *Poa annua* infested greens that were quite unreliable. As a result, some golf courses rebuilt their greens; however, others did not.

This presentation will principally address issues related to the common soil problems we see today. These problems are as follows:

COMPACTION. Moist topsoil compacts, and increased irrigation to "soften the green up so it will hold a shot better" only makes compaction worse in the long run. It is recognized that hollow tine aeration is an effective management tool to increase the movement of air, water, roots, and nutrients into a heavily compacted soil. Although temporary, aeration does help in the short term.

In the long run, either reconstruction or a vigorous topdressing program may be necessary to build up a sandier, less compactible soil structure on top of the old, tight material. The reason more sand is necessary than ever before is simple.

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When you have the proper amount of sand in a soil mix, it simply will not compact. Also, a proper sand mix has enough large (or macro-) pores for good soil aeration and deeper roots, and, consequently, for a healthier turf.

LAYERING. Many putting greens over the years have been topdressed with all varieties and textures of topdressing materials. These changes in textures cause layers that can effectively impede the movement of water, air, and roots through the green's profile. Perhaps the best example of this is a "perched water table effect" which can exist between an old topsoil and a layer of sand sandwiched in between. To understand a perched water table, imagine soil water moving through the topsoil and reaching the sand layer. Instead of readily passing through this layer, as one would think, the water actually backs up or "perches" on top of this sand layer, eventually flushing through only when enough water pressure builds up. In a new construction, this perched water table is quite desirable. In old greens, perched water tables and slow water movement are serious problems.

The only effective way of solving the problem of layering is to aerate on an increased schedule, to punch as many holes as possible through the layer, and to follow it up with a topdressing designed to fill the holes and bury these layers. Also, some field data suggest that wetting agents, when properly used, can help negate the effect of soil layers.

The final solution, if management does not give the desired results, is to rebuild the old layered and compacted greens according to modern standards.

INADEQUATE SOIL DRAINAGE. Although directly related to compacted soil and layering, poor drainage deserves its own category because there are many management problems associated with it. Foremost among them is weak grass. It is an accepted fact that the deeper and more fibrous rooting system there is to support the grass plant, the stronger and more resistant the turf will be to all stresses, including disease. Slow internal water movement means a lack of large (or macro-) pores and and excess of small (or micro-) pores. Ideally, a soil should be 50 percent air space (25 percent micropores and 25 percent macropores), and 50 percent solid. With this amount of soil and air, there should be a deep, fibrous rooting system and good internal drainage. They go hand in hand for good golf turf.

Unfortunately, if a putting green's soil has inadequate soil drainage--particularly in an old green where a clay base exists under the profile--there is little you can really do other than to keep the soil aerated and topdressed. In essence, you are growing the grass in the upper portions of the soil because, with the clay base, you have essentially zero movement of water through the *entire* soil profile. There is movement on the surface, but when the water progresses down to the clay layer, it can go no farther. Management can help, but it may be necessary, particlarly in the transition zone, to consider rebuilding these clay based greens if they give you problems.

HARD GREENS. This is a problem of both coarse-textured, high sand greens, and the older, more compacted silt and clay soils discussed earlier in this presentation. Hard greens today can also be traced to putting greens that were rebuilt some years ago, using very coarse sand. Looking back to many original construction specifications, we see the emphasis on coarser or concrete sands. Although these sands grew good quality grass, they did tend to give a hard playing surface. To correct this, the sands were looked at and reevaluated through continued testing. The result is that finer sands are now recommended. These finer sands, with particle sizes ranging from 1.0 mm to 0.25 mm, have the dual benefits of having good aeration and drainage plus being firm (not hard) and resilient. If you have these hard greens with a high percentage of coarse sand and very coarse sand particles, you should follow the same recommendations for any poor soil. Keep it aerated and maintain a vigorous topdressing program to build a better soil structure on top of the existing material, using the finer sand.

PUTTING GREEN SIZE AND CONTOURS. Although not directly a soil problem, a putting green size with its surface contours and resulting surface drainage (or lack of it) can aggravate an already bad or marginal soil problem. Greens must be adequately sized to spread wear and tear. Generally, they should average between 5,500 to about 7,000 square feet. More contoured greens should be even larger. There should also be good surface drainage with a minimum of "pockets" to hold ice in the winter and surface water in the summer. Unfortunately, small greens can only be enlarged, and pocketed greens only drained, recontoured, or rebuilt.

In summary, there are no quick or easy solutions to the soil problems often encountered on golf courses, There is, however, a mechanism to keep the guesswork out of physical and chemical problem analysis, and soil mixture preparation. When assessing your greens chemically and physically, a good soils laboratory must be consulted. Such a laboratory is essential to analyze (a) the sand particle sizes for straight sand topdressing programs; (b) the sand, soil, and organic matter being used in new construction or topdressing preparation; and (c) the chemical and physical composition of existing putting green soils. Laboratories are available that take the guesswork out of material selection and mixing. There are several such laboratories, including one at the University of Illinois, equipped to do these tests. One such laboratory, supported by the U.S.G.A. Green Section, is located at the Texas A & M University (Soil Physics Section, Soil and Crop Sciences Department, Texas A & M University, College Station, Texas 77843. Telephone: 713-845-3041). We invite you to use this and any other laboratory equipped to properly analyze soils. These laboratories offer the useful services a progressive turfgrass manager needs to correctly analyze any soil problems he may have on his golf course before deciding on the best program to correct these problems.