18TH ILLINOIS TURFGRASS CONFERENCE

DECEMBER 13-15, 1977

Arranged and conducted by

COOPERATIVE EXTENSION SERVICE
COLLEGE OF AGRICULTURE
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

In cooperation with

ILLINOIS TURFGRASS FOUNDATION

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HERBICIDE DAMAGE AND RELATED PROBLEMS ON WOODY ORNAMENTALS

R. E. Partyka

Although this conference is primarily about turf, we shall consider another important group of plants associated with turf--the trees and shrubs that are so necessary to compliment good turf. Turf areas utilized by the general public are always accompanied by trees and shrubs; therefore, trees and other woody plants are also a part of your maintenance responsibilities.

One of the major concerns about woody plant material is its decline or death. This is disconcerting because of the time involved in growing a specimen plant strategically located for symmetry or aesthetic value.

The first suspected reason for plant decline now appears to be the plant growth regulator materials used in lawn maintenance programs. These materials can damage woody plants if they are used improperly. However, these materials should not become scapegoats for one's lack of knowledge of other problems that are being covered up. It is often too convenient to blame growth regulator compounds when plants die shortly after being exposed to the materials. But for better management, one should have a reasonable understanding of how these plant regulator materials work and be able to recognize some of the symptom patterns that might be expected on foliage of plants where these compounds have been misused.

PREEMERGENCE

The first group of materials considered is used to control the development of seeds. This group, known as preemergence materials, includes compounds such as DCPA, bensulide, siduron, benefin, bandane, and pronamide. When used at recommended rates, these compounds do not damage established plant material and, therefore, are not considered harmful to such plants. However, these compounds must not be applied in gardens or other areas where seeded material is to be established later. Also, in lawn areas, one should be aware that reseeding will be delayed because these preemergence materials will prevent grass seeds as well as weed seeds from germinating.

GROWTH-REGULATING

Once seeds have germinated and broadleaf plants are established, another group of materials are used, generally referred to as hormone-type compounds. These include 2,4-D, 2,4,5-T, MCPP, silvex, and dicamba and are very effective in controlling broadleaf plants. One of the characteristic symptoms when plants come in contact with these compounds is foliage distortion: severe petiole curl, leaf cupping, twisting, and reduced growth. However, since these are growth-regulator-type materials, symptoms appear in actively growing tissue. New growth shows very distinct symptoms of parallel venation. This venation occurs when the leaf does not fully expand and the veins remain close together. If the new growth continues to show leaf distortion all season, one must question whether there is continued retreatment in the area or whether an excessive amount was applied to the soil such that

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the material is continually being taken up by the roots. This can happen if woody plants are accidentally fertilized with weed and feed materials.

Another consideration is the placement of these materials in the vicinity of the root ball of a recent transplant. Watering may carry the material to the root zone and put the plant in further stress in addition to its transplant shock. However, other factors may enter the picture with recent transplants, such as whether proper procedures were followed in transplanting. In general, normal, healthy plants will grow out of the damage caused by these materials, provided there is no further exposure to the plant and the rates in the soil are not above allowable levels.

Older, mature tissue is generally not damaged when contact is made by accident or through wind drift. One may see some petiole distortion or a leaf roll or twist, but little parallel venation. Diagnosis of damage from growth-regulator materials on old, mature tissue may be difficult to tell by just looking.

POSTEMERGENCE

Postemergence compounds are used to control certain grasses after they have become established. The arsenates are often used in these cases. However, pronamide is being used in some areas for specific weeds. When used properly, action is selective and slow with good results. These materials will also injure woody plants if used close by or in contact with them. The injury caused by these materials is very similar to that of the next group to be discussed.

NONSELECTIVE

Nonselective materials are often used around fences, driveways, and trees to eliminate all vegetation. Some materials used for this purpose include dalapon, amitrole, paraquat, and glyphosate. One consideration when using materials of this nature is their water solubility and residual time in the soil. Too often materials other than the four listed are used, and some may move to other locations and damage plants. Also, the size and distribution of root systems of large trees increase the possibility of root uptake of the compound placed at a seemingly safe distance. These materials may be slow to show symptoms on some plants, but when they do, there is no recourse left but to start with new plant material and, possibly, new soil.

Symptoms from these materials may vary. Some materials will cause outright death of tissue, which becomes evident in 2 to 3 days. Materials taken up by the roots may result in veinal or interveinal chlorosis, depending on the active ingredient. Overall yellowing followed by marginal browning and death of the plant may be evident. A contact material may damage only existing foliage, and regrowth from the woody tissue will occur in a few weeks.

OTHER CAUSES OF DAMAGE

There are many other factors to consider when looking at woody plant damage. One important point is the weather, not only in recent weeks but even 2 to 3 years before the symptoms became apparent. This is especially important on larger, established plants where weather records may help clarify the problem. The age of the plant and the transplant procedures that were used need careful consideration on recently planted material. Soil type and cultural practices need to be scrutinized as they also play a role in creating problems that may be confused with herbicide damage.

One cannot neglect diseases and insects as possible causes of similar problems, although most organisms associated with woody ornamental problems do not kill a plant rapidly. In most cases, symptoms or signs are visible on the plant in time to implement remedial procedures before the plant is killed. There are exceptions, such as cankers, root diseases, or wilt-inducing organisms, which often prove fatal by the time they become evident. Insect problems may cause severe defoliation or mimic other types of problems.

Some of the most common causes of plant decline are not associated with the use of herbicides or the presence of insects and diseases; rather, they are related to poor cultural practices that may become evident in a short time or may take several years to become evident.

In a few cases, fluctuating weather conditions may produce mimicking symptoms that can be confused with other factors. A good example is late spring frost that damages developing buds. Leaves will develop but often appear to have been eaten by insects. In other cases, low temperatures after buds have expanded may produce foliar tissue that appears to have been damaged by herbicides. Situations like this require careful examination of the problem and good weather records of the area.

The most disheartening problem is brown or dying leaves on a plant. Barring situations where the plant was sprayed with a toxic material, sprayed at improper rates, or subject to unusual weather conditions such as high winds damaging the leaves, the symptom pattern suggests a water shortage in the plant. The questions are why? and where is the damage evident?

Some plants will react to extreme heat and dry soil conditions, so genetic capability of the plant must be considered. This is often true of buckeye, yellow poplar, and sycamore in late summer. However, the symptoms on these plants often result in considerable leaf drop. Plants that fail to drop leaves but show severe browning are in most cases suffering from a true water shortage that often leads to severe injury or death of the plant.

A common cause of scorch or leaf browning on small, recently transplanted material is a limited root system or a poor top-to-root ratio, where water loss through the leaves is greater than root absorption. Planting too deep or too shallow and placing roots in oxygen or water tension levels different from normal will stress the plant. Container-grown plants that are rootbound may fail to become established in the soil; they may desiccate because of moisture shortage at the soil interfaces of the container soil and planting site. Lack of water or overwatering may damage certain root systems.

Older plants, 3 to 5 years old, should be checked for girdling plastic twine around the trunk or plastic around the root ball. Deep planting may not become evident until this time, especially if weather conditions were wet in recent years. Examine the trunk for mechanical damage or evidence of insect borers. Graft incompatibilities often become evident at this age.

Older established plants may show decline from girdling roots, construction damage in the vicinity of the roots, or placement of excess soil over established root systems. Fill dirt can change oxygen levels in the soil and kill fine feeder roots. Mechanical damage or blacktop driveways over tree roots will eventually cause some problems if proper maintenance procedures were not followed at the time of construction.

Last, but not least, one has to keep in mind the physiological maturity of the plant and the previous weather conditions that may have put the plant into a stress situation.

Remember that plants in an urban-suburban environment are growing outside of their natural habitats. They cannot be compared to the stately trees growing in a forest preserve where soils and water tables are undisturbed. The normal urban soil is in most cases a completly disturbed mixture of various horizons, compacted by heavy equipment and subjected to the whims of a public often unknowledgeable in the basics of plant growth. Until we develop plants that can tolerate these extreme conditions, problems will continue to appear, to the chagrin of maintenance people and the public.

SOIL FUMIGATION FOR TURFGRASS SOILS

L. E. Hammond and F. C. O'Melia

The amount of time and money spent on turf each year is impressive. In the Midwest alone probably several billion dollars are invested in turfgrasses plus billions of dollars spent annually for maintenance. To get the best return on this investment, it is of utmost importance to properly establish turfgrass in newly established areas or in areas to be renovated.

Whether it be for the new establishment of lawns, parks, golf greens or tees, athletic fields, commercial turf, or other ornamental or recreational turf areas, consideration must be given to the proper control of the pests affecting quality turf:

1. Seeds of broadleaf and grassy weeds and their roots, stolons, and bulbs, particularly bothersome *Poa annua* (annual bluegrass); and perennial grasses such as quackgrass, bermudagrass, johnsongrass, and nutgrass.
2. Plant-damaging nematodes, such as the stunt, stubby-root, lesion, root-knot, and cyst nematodes, among others.
3. Certain soil-borne fungi, such as *Pythium*, *Rhizoctonia*, and *Fusarium*.
4. Insects in the soil at the time of treatment, including wireworms, green June beetle larvae, and other grubs.

Satisfactory turf reestablishment requires complete kill of all plant growth in the area where new turf is desired and adequate nematode and disease control. Methyl bromide applied under proper conditions is recognized as one of the best chemicals available for this purpose, as it satisfactorily kills most weed seeds, rhizomes, stolons, tubers, and other vegetative plant organs capable of producing new plant growth; it also controls the plant-parasitic nematodes and certain turf diseases.

Two methods are available for applying methyl bromide to land areas to be planted to turf: application by ground soil fumigation rigs with automatic tarp-laying equipment, and manual applications to plant beds for smaller areas. The first is usually done by professional applicators such as Hendrix and Dail, Louisville Seed Company, or Southern Soil Fumigation Service. The second method is very nice where custom fumigation is not available or appropriate. Manually applied soil fumigation would fit small areas on golf courses, tree-site application, home lawn reestablishment, or transplants and potting soil at nurseries.

SOIL PREPARATION

The soil of areas to be treated should be worked into a fine, loose condition just before treatment. Soil should be free of clods and unpulverized pieces of sod, except in sandy soils. The fumigant will effectively penetrate only as deep as the soil is properly worked, except in loose soils. Soil should be moist but not wet. A good guideline is to have the soil in seeding condition.

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After the soil has been prepared, make at least a 6-inch furrow or trench around the margins. This will provide an easy and effective way of sealing the gasproof cover by burying its edges in the furrow before releasing the fumigant. If green manure is present, a decomposition period of two weeks should be allowed before fumigation treatment.

FUMIGATING USING THE DOWFUME® GAS BAG SYSTEM

Several methods have been used to release the methyl bromide gas under the polyethylene tarp:

1. Cans are placed in evaporating containers for the volatilization of the fumigant under the tarp.
2. The gas is released from cans outside the tarp by using a star model opener and running polyethylene tubing from the can under the tarp and into the evaporating tray.

Dow has improved upon these two systems by designing the DOWFUME gas bag system. This system is quicker to operate and does away with the more elaborate and expensive application equipment.

The system begins with the unique Dow 6-Pak: six 1.5-pound DOWFUME MC-2 cans, each containing 98 percent methyl bromide with 2 percent chloropicrin as a warning agent. The 6-Pak is enough to treat 900 square feet.

The steel Lance openers combine convenience with low cost, and they can last season after season. They can pierce the cans with about 20 pounds of hand pressure. The polyethylene Dow gas bags have been designed to replace expensive evaporation trays. Two 1.5-pound cans, enough to treat 300 square feet, are used in each bag.

After the ground is prepared, a block-like support (approximately 1 foot square, wood or metal) is placed on the ground at every 30 feet of running tarp. The 1.5-pound cans of fumigant are fitted with the Lance opener and placed into the gas bag and onto the support blocks. The entire plant bed is covered with a polyethylene tarp and the edges are sealed with soil. The cans are "popped" (opened) by using only the palms of the hands, pressing down firmly on each can until the barb, or point, of the Lance opener has punctured the can. Do not disturb the cans or bags, or attempt to remove them, until after the recommended 24- to 48-hour exposure period.

Note: To promote more rapid and even diffusion of the gas over the entire area of the treated area, prop up the cover with bundles of hay or straw, cardboard boxes, or crumpled fertilizer bags--anything that will not puncture or tear the cover.

EXPOSURE PERIOD

The minimum exposure period is 24 hours if the soil temperature is 60° F. or above. If the soil temperature is below 60° F., a 48-hour exposure period is necessary. If fumigation is done in the fall, it is suggested that the cover be left in place until the following spring, or until ready for planting when the soil is prepared for planting. This will help to keep the treated soil from becoming contaminated.

AERATION PERIOD

The treated soil must be aerated before planting. Some seeds such as turfgrass can be planted 48 hours after the tarp is removed. A longer aeration period may be required before planting certain flower seeds. If living plants are to be used, set them out 7 to 10 days after the cover is removed.

USE PRECAUTIONS

1. Do not treat very cold (below 50° F.), very wet, or very dry soils.

2. Be sure treated plots are free from gas before planting seed or setting out mats. If there is a doubt as to complete aeration, working the soil after treatment will help, particularly when soil is cool or wet or both.

3. Avoid contaminating fumigated areas. If you must walk from unfumigated to fumigated soil, clean your shoes thoroughly. If the treated area is in a location where flooding or washing is possible after rains, plow a furrow or make a trench around the treated area for proper drainage.

4. Because DOWFUME MC-2 and other products containing methyl bromide are toxic to plants, do not apply to areas containing roots of desirable vegetation. The edge of the cover should be at least 1 foot away from the roots of living plants. Watering the soil near the edges of the tarp will help confine the vapors to the tarped area.

5. When fumigating sloping ground, place the cover with the contour because the gas tends to concentrate in the lower areas.

HANDLING PRECAUTIONS

Products containing methyl bromide such as DOWFUME MC-2 Soil Fumigant are highly volatile, poisonous gases, but they can be handled satisfactorily if the following precautions are observed:

1. Be sure to read directions on the label before applying, and follow them carefully. Store the containers in secured outbuildings away from dwellings, in a cool place.

2. Do not breathe the vapor.

3. Do not spill. If liquid gets on the shoes or clothing, *REMOVE THEM AT ONCE*, and do not wear them again until thoroughly aired outdoors for several days. Do not use gloves when applying this material.

4. Keep animals and children away from the plots while treatment is being given and for at least 30 minutes after the cover is removed. DOWFUME MC-2 contains a warning agent that causes pain and watering of the eyes if the gas concentration becomes too high. This will warn against leakage or spillage of fumigant during storage and handling; however, the warning agent disappears a few hours after discharge and will not keep children and animals from crawling under the cover.

If you want a relatively maintenance-free seedbed, or would like to establish a clean turf in nearly one-half the time, or see transplanted trees grow faster--consider using methyl bromide soil fumigant. Control of diseases, weeds, insects, and plant-damaging nematodes can be achieved in one application. A small investment of time, manpower, and chemical will pay high dividends in pride of management.

COOL-WEATHER PYTHIUM BLIGHT

John L. Saladini

Although Pythium (cottony) blight is usually associated with temperatures above 68° F., two *Pythium* species can cause "typical" cottony blight at 50° to 65° F. Root rot and decline of turfgrass probably occur during summer without any "typical" Pythium blight foliar symptoms. Cool-weather Pythium blight has been confirmed only twice; however, this serious turfgrass disease can be controlled like the hot weather cottony blight.

In the fall of 1972 a serious disease occurred on several greens on a golf course located in the Cincinnati, Ohio, area. Symptoms and signs of the disease resembled Pythium blight (rapid disease development, water-soaked leaves, and cobweb-like mold growth on foliage), but air temperatures were unfavorable for "typical" Pythium blight development. Temperatures ranged from 50° to 60° F., but the relative humidity was high and the area was exceedingly wet. Several *Pythium* species were isolated from the affected bentgrass. Applications of chloroneb and ethazol prevented further disease development.

This disease occurrence represents the first positive confirmation of specific *Pythium* species causing foliar blighting of cultivated turfgrass at low temperatures. This Pythium disease was confirmed recently (October, 1977) as the cause of foliar blighting of a lawn grass in Long Island, N.Y. References to cool-weather *Pythium* turf problems have been made from other states, and undoubtedly this disease is a problem.

To more fully understand the Pythium disease complex, a research program at The Ohio State University (from 1974 to 1976) was designed to identify the *Pythium* species present on healthy and diseased turfgrasses and in soils from Ohio golf courses and to study the foliar and root disease potential of these species under low (55° to 65° F.) and high (86° to 92° F.) temperatures.

Of the 18 *Pythium* species isolated from 54 golf courses, only three were capable of causing foliar blighting of 'Pennlawn' red fescue. Occurrence and severity of blighting were temperature-dependent (Table 1). *P. aphanidermatum*, most frequently isolated from blighted turf, caused severe disease at 86° to 92° F. but not at 55° to 65° F. *P. graminicola*, also isolated from blighted turf, caused moderate foliage blight at both high and low temperatures. *P. vanterpoolii*, isolated from healthy plants and soil, caused severe foliar blighting only at low temperatures. No field incidence of cool-weather Pythium blight was noted during this survey.

Of the 10 *Pythium* species tested as potential root rotters of Pennlawn red fescue, only *P. aphanidermatum* and *P. graminicola* caused root damage and then only at 86°

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Table 1. Disease Potential[a] of Pythium Species to 'Pennlawn' Red Fescue at Two Temperature Ranges

	Foliage blight		Root rot	
	55°-65°F.	86°-92°F.	55°-65°F.	86°-92°F.
P. aphanidermatum	?	++++	-	++
P. graminicola	+++	+++	-	++++
P. vanterpoolii	++++	-	-	-

[a]Disease ratings: ++++ = highly severe; +++ = moderately severe; ++ = slightly severe; - = no disease development observed; and ? = not enough information.

to 92° F. (Table 1). *P. graminicola* caused extremely severe root rot and decline of turf. Symptoms were observed after only three days' incubation with total root deterioration after seven days. Little, if any, foliage growth occurred after five days' incubation. *P. aphanidermatum* was less severe: moderate root rot was observed after seven days' incubation; foliage growth did occur, but was less than on control plants.

In the Cincinnati example, there was an additional factor. The greens recently had been aerated (by coring) and cores were spread over the surface of the green prior to the disease outbreak. By spreading the soil over the surface of the green, the superintendent inadvertently distributed *Pythium* propagules onto the turf foliage. Cool, wet weather followed, providing ideal conditions for Pythium blight, especially since *P. graminicola* and *P. vanterpoolii* were present in the soils. It may be beneficial to apply a Pythium fungicide if soil cultivation or reseeding is followed by wet weather, even if cool.

Since *P. aphanidermatum* and *P. graminicola* were capable of causing root rot of 'Pennlawn' red fescue under warm soil temperatures, it is possible that this injury occurs to established turf during the summer growing season. Root rotting may precede foliar blighting when the prevailing atmosphere is not saturated with moisture. If this is the case, it would be of interest to study the effect of soil-drenching Pythium fungicides to turf areas prior to weather conditions that are conducive for foliar blighting. By drenching, it may be possible to inhibit the Pythium blight damage to roots and decrease the *Pythium* soil population, thereby reducing the severity of potential foliar blight. Field studies using this approach could prove worthwhile.

METHODS FOR IMPROVING WATER EFFICIENCY ON TURFGRASS SITES

J. R. Watson

An efficient and properly executed watering program for turfgrass areas requires the balance and adjustment of many complex factors. The basic requirements are the same for all areas--large or small, home lawn, park, industrial site, or golf course. On all it is necessary to consider the soil conditions, the amount and kind of use, the demand of climate, and the physiological requirements of the plants--grass, trees, shrubs, and flowers.

There are complicating factors associated with the proper and effective watering of small areas like clubhouse grounds, home lawns, and industrial sites that are not necessarily found on larger areas like golf courses or large parks. Examples would include the complexity of landscape patterns and designs, space limitations, concentrations of plants with widely differing water requirements, and, sometimes, a limited water supply, poor quality of water, inadequate pressure, and a poor or restrictive distribution system.

Yet, the need to develop techniques of improving water efficiency on small areas may be more critical than on larger sites. The small areas--home lawns, industrial lawns, school playgrounds, small community parks, athletic fields, and, in some cases, intensively used sections of larger areas--constitute a very large part of the green and landscaped areas of our cities and towns. They are valuable and necessary, functional and aesthetic. They constitute places to play and to relax; they filter the atmosphere of our communities and utilize pollutants; they enhance the beauty and value of property. When properly landscaped, maintained, and groomed, they attract visitors and invite industry; thus, they are economically important. For these reasons, among others, watering systems and the techniques used in applying water on turfgrass areas merit careful study, evaluation, selection, and execution.

Proper system selection is the initial step toward improving water efficiency. Systems must be chosen on the basis of performance--efficient performance that results in production of the *highest quality* turf, shrubs, trees, and flowers with a *minimum* use of water. The conservation of water is already a vital issue in many areas and will inevitably become so in most areas. Thus one of the basic requirements for improved irrigation efficiency must be the application of water in a manner that results in maximum conservation. This can occur only when the watering program has flexibility to (1) apply water in a manner suitable to a wide range of plant and soil conditions, (2) provide for maintenance of good soil-air-water relationships, and (3) permit application of water in "off-peak" use periods.

In addition, to water turf effectively and efficiently requires an understanding of several basic concepts that affect water and its proper use. There can be no set, predetermined formula or prescription for effective watering of turfgrass areas in general. Rather, the superintendent or turfgrass manager must balance

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the variables that affect the watering practices on his turf facility and arrive at the solution that best suits each park, each lawn, each green, tee, and fairway, as well as the rough and the clubhouse grounds.

To water efficiently requires an understanding of the fundamental role water plays in plant growth and of the effects of climate and weather on growth rates, water-use rates, and choice of grass. Effective and efficient watering demands a knowledge of the basic physical and chemical soil properties and of how these properties affect water absorption, storage, and drainage, as well as the frequency, rate, and manner in which water must be applied. All such basic information must be correlated with the requirements for play and adjusted to fit the existing or planned irrigation facilities. Let's review briefly several key factors involved in using and improving water efficiency.

WATER

Water is essential to plant growth and is involved either directly or indirectly in all phases of the care and management of turfgrass. Water is necessary for germination, cellular development, tissue growth, food manufacture (photosynthesis), temperature control, and resistance to pressure. It acts as a solvent and a carrier of plant food materials. Nutrients dissolved in the soil are taken in through the roots and then carried to all parts of the grass plant in water. The food manufactured in the leaves is also distributed through the plant body in water.

Water transpired through the leaves and evaporated from the surface serves as a temperature regulator for the plant. The practice of syringing greens during periods of excessive evapotranspiration is based on this phenomenon.

The amount of water within the cells of the grass leaves plays a role in counteracting the effects of traffic. When the plant cells are filled with water, they are said to be turgid, a condition that helps leaves resist pressure from traffic (foot and vehicular), avoiding the damage, sometimes death, that may occur. Wilt, on the other hand, is a condition that exists when cells do not contain enough water and are said to be flaccid. A 10-percent loss of water from the plant body frequently will cause permanent wilting and death.

SOIL

The soil from any turfgrass area must provide support for the grass, serve as a storehouse for nutrients, supply oxygen, and act as a reservoir for moisture. The texture (size of soil particle), structure (arrangement of soil particles), and porosity (percentage of soil volume not occupied by solid particles) of a soil are the basic physical factors that control the movement of water into the soil (infiltration), through the soil (percolation), and out of the soil (drainage). Texture, structure, porosity, and organic matter content determine the water-holding capacity and control the air-water relationships of the soil.

These characteristics directly affect satisfactory watering practices. The intake of water is through the roots; specifically, the root hairs are the organs through which water is taken in. Hence, the depth of rooting and the extent to which a given root system occupies the soil determine the depth to which the soil should be wet. The volume of soil occupied by roots represents the soil reservoir capacity for that plant. When the need for water by the plant is great (during high temperatures, high wind movement, low humidity), this reservoir may have to be continually replenished, especially if the root system is shallow.

If the need for moisture is 0.3-inch daily, as the case may be during July and August, the soil must supply to the plant 0.3 inch of water between irrigations. Soils on certain turfgrass sites, for example, putting greens, may hold only 0.5 to 0.75 inch of water per cubic foot. This would be an adequate amount of water for one to two days if all of this moisture were available to the plant. However, for such to be the case, the roots must extend through (permeate) the entire volume of soil, the soil must have the capability to supply the water, and the soil must have the characteristics necessary to move the needed amount of water at a rate rapid enough to permit uptake by the roots. Unfortunately, root systems on many turfgrass facilities--especially putting greens--frequently do not extend to a 1-foot depth (particularly in the summer). When they grow only to a depth of 3 or 4 inches, the volume of potentially available water is reduced by one-third to one-fourth. An insufficient reservoir of moisture must be replenshed by irrigation. Thus, the advice to water deeply and infrequently may not be valid for many putting greens or, for that matter, for many turfgrass areas. To improve efficiency of water application on these areas, the irrigation system must have the capability and flexibility to apply small amounts of water frequently.

Poor aeration, whether from poor drainage, compaction, or an inherent soil condition, further complicates efficient watering of turfgrass on shallow soils and on soils with low water-holding capacity.

AMOUNT OF WATER

The actual amount of supplemental water required to keep the turfgrass green and healthy throughout the growing season is dependent principally upon temperature, sunlight, wind movement, and rainfall. In Illinois, to sustain growth and to keep turfgrass green during the growing season, supplemental water will have to be applied in varying amounts for five months (May through September), a substantial portion of the growing season. This calculation is based on average weather data for nine climatic regions of Illinois over a 30-year period:

	Maximum deficit, July (inches of rainfall)
Rockford (NW)	3.31
Chicago (NE)	3.60
Quincy (West)	3.86
Peoria (Central)	3.93
Danville (East)	3.56
Springfield (WSW)	4.32
Mattoon (ESE)	4.09
Belleville (SW)	4.38
Mt. Vernon (SE)	4.28

AUTOMATIC SYSTEMS

If reliable, well-trained manpower were available, the job of applying water to turf areas could be accomplished with any type of sprinkler device or other techniques. However, since such operators rapidly are becoming unavailable, there seems little doubt that the most effective, most efficient, most convenient, and most economical way to water golf courses and other landscaped turf and recreational facilities is by automatic underground sprinklers. Clock-controlled systems are flexible and constant--always on duty and available on demand. They are a practical means of preventing waste (conservation of water) and assuring good watering techniques. They are perhaps the most important method of improving water efficiency on turfgrass sites.

Within the past several years there has been marked progress in the development of equipment to permit automatic watering of turfgrass and other landscaped areas. Equipment presently available permits the controlled application of precise amounts of water. Further, such systems are capable of delivering the water in accordance with the needs of plants--grass, trees, shrubs, and flowers--and in conformance with the ability of a given soil to absorb the water and store it. Most important, today's systems are economical and perform their functions in such a manner as to assure conservation of water and minimal operating cost.

Advances in controllers, valves, and sprinklers within the past few years have been substantial. It is well to keep in mind, however, that any system, old or new, irrespective of how well it has been installed, used, and maintained, can be no better than its basic design.

The system

The design, installation, and maintenance of a system are the factors that control its operational efficiency. Hence, effective performance has to start with the specifications laid down by the owner or his representative, preferably someone with knowledge of turfgrass requirements. He must specify what he wants the system to do. In this respect, your local irrigation or turf supply distributor may be of invaluable help, especially if he has trained personnel and handles nationally recognized lines of equipment.

Basically, any system design is a compromise between cost and performance. Thus, the owner (or operator, or turf manager, or golf course superintendent) must make certain basic decisions, all of which revolve around obtaining the best performance for the costs involved.

Design

Design of an efficient system begins with the owner, operator, or turfgrass manager determining such factors as what area is to be covered, how many hours are available for watering, what amount of water is to be applied, what type of system is wanted, what minimum (and maximum) precipitation rate can be tolerated, what wind velocities and directions prevail during anticipated watering hours, and what is the service life of the equipment. These decisions, once incorporated into the system design, are fixed--they are nonvariable! And, if at a later date it becomes necessary to alter one of these *fixed* factors, then the system *will not perform* as originally designed and *it will not operate efficiently*.

The area to be covered or watered must be determined, preferably by use of an accurate plot plan. There will be no embarrassing questions later if this is scaled and laid out in advance.

On areas like a golf course, when the time available or allowable to apply a specified amount of water is limited or restricted, cost may be substantially affected. This may also be a factor on small areas and is one reason why a competent irrigation specialist should be consulted on system design for small as well as large areas.

An irrigation system is purchased to water grass to keep it green during the growing season and to protect the facility investment in plants during periods of stress (often the driest time of the year). Failure to specify a system large enough to provide adequate water will produce trouble for all concerned. An inadequate system will operate inefficiently and will be costly to operate.

Another design factor that contributes to efficiency and conservation of water is proper spacing of heads. When heads are overspaced, it is difficult and inefficient to maintain an adequate level of soil moisture--the water does not reach or the heads will apply water unevenly. This can result only in overwatering the sections that are covered or underwatering the difficult-to-reach areas. Wind and low operating pressure further contribute to these problems. A properly designed system can be programmed to apply the exact amount of water needed. Single head control and heads equipped with two-speed features add greatly to the ability to apply water efficiently.

Servicing

An irrigation system is a management tool and must be handled like any other tool or piece of equipment. It must be checked, and it must be serviced. Like any piece of equipment, the system has moving parts (controllers, valves, heads) and a framework (pipe).

Other items and factors that contribute to improved water efficiency through efficient use of an irrigation system on turfgrass areas are as follows:

1. There should be no more than two people with keys to the controllers. This prevents vandalism and keeps unauthorized individuals from tinkering with the system.

2. Turf facility managers should train crew members to keep their eyes open and look for malfunctions. The manager or superintendent should check the irrigation system during his daily rounds of the facility.

3. Once a week each control should be checked to make sure the unit is working automatically. Also, each head should be checked each week to see if it is working properly. Check the heads manually--operate the controls, turn each one--make sure that all are operating.

4. During the first year after installation, the turf facility manager should make sure the proper amount of water is being delivered for maximum performance, efficiency of operation, and production of highest quality turf. In other words, verify the accuracy of the watering program and adjust controllers, nozzles, and stations to accommodate modifications needed to improve efficiency.

5. Regardless of how much rain falls, run through the system periodically (weekly or monthly) to make sure that it is functioning and that inactivity does not cause moving parts to bind.

6. In areas where dirty water is used, check filters periodically to make sure they are free of debris.

7. Water at night whenever possible. There is less evaporation and pressure is better during off-peak use periods.

SUMMARY

Techniques of watering that permit the efficient and effective use of water require an understanding of the fundamental role that water plays in plant growth and of the effects that climate and weather have on growth rates, water-use rates, and choice of grass or plant materials. Good techniques of watering demand a knowledge of basic physical and chemical soil properties; how they affect water absorption, storage, and drainage; and the frequency, rate, and manner in which water must be applied.

Irrigation systems must perform efficiently and effectively. They must permit maximum conservation of water and they should be economical to operate. They should be designed by a specialist, installed properly, and programed to meet the requirements of the grass and other plants, and they should satisfy the demands for play or other use placed upon the facility. Above all, they must be serviced routinely.

Automatic underground sprinkler systems provide the best answer to the problems associated with techniques of watering. Their flexibility permits efficient and effective watering despite the varied conditions that exist on landscaped areas. Moreover, they are economical to operate and they conserve water.

CONTEMPORARY USE OF PERENNIAL RYEGRASSES

Howard E. Kaerwer

The fine-textured perennial ryegrasses have come into their own during the last few years. Since the introduction of 'NK100' perennial ryegrasses along the east coast in 1962, turf-type ryegrasses have spread across the United States, with 26 cultivars now on the market. This discussion deals with generic characteristics of the species and with the practical utilization of turf-type ryegrasses.

The narrow-bladed ryegrasses differ from the older types of ryegrasses. Annual ryegrass is short-lived with a few plants living into the second or third years to produce a weed problem. Overly aggressive, broad-bladed, and light green, annual ryegrass plants are not considered attractive. 'Oregon' or 'Linn' perennial ryegrass tends to persist more than annual ryegrass and has more broad-bladed, poor-mowing plants to disfigure a lawn into the second and third years; it is not permanent enough to be considered as more than a weed. The turf-type cultivars are narrower bladed, have slower and more prostrate growth, and are longer lived. In addition, they are attractive, looking to the casual observer like a fine bluegrass lawn.

The fine-textured perennial ryegrasses can save turf management operators money and work. They establish easily, resist wear and tear, and are compatible in texture, color, and competitiveness with Kentucky bluegrass and fine fescues. Moreover, they root into moderately compacted soils, maintain color when bluegrasses go dormant, and do not contribute to thatch.

GROWTH CHARACTERISTICS

Grown as a turf, fine-leaved ryegrasses have leaves about the width of Kentucky bluegrass leaves and are in about the same color range. However, the backs of their leaves, shinier than those of bluegrass, give a sparkling, attractive appearance to the turf. Tillers and leaves tend to be semiprostrate in growth habit, thus allowing short mowing. While not rhizomatous, these plants can spread by tillers which originate at the base of the crown. In some instances, prostrate tillers can root down at the nodes in a semicreeping fashion. Some plants in a few varieties produce subsurface tillers that emerge from the soil several inches from the parent plant. Mowing characteristics are not quite equal to the better Kentucky bluegrass cultivars, but mowing quality seldom seriously disfigures a lawn.

Speed of germination and seedling vigor are exceptional, about equal to those for annual ryegrass. Top growth, however, is considerably slower, reducing the competitive effect on other grasses planted in a mixture. More importantly, fine-leaved ryegrasses continue germination under adverse moisture conditions, within thatch, and in moderately compacted soils that normally spell failure for other turf species. The fibrous root system further aids establishment as it quickly penetrates to depths where moisture is assured.

It is not unusual to have a lawn that includes turf ryegrasses ready to mow within three to four weeks. In some instances golf course fairways can be played a season

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sooner. The University of Minnesota football field, seeded May 31 last year to 50 percent 'NK200' perennial ryegrass, was ready for play before the first game on September 10. Besides allowing quicker utilization of new turf areas, the speed with which fine-leaved ryegrasses establish means less chance for seeding failures. These characteristics are also valuable in renewing or renovating an older turf, making success much more likely and usually at less cost for establishment maintenance.

There are approximately 270,000 to 300,000 seeds in a pound of fine-leaved ryegrass, compared with about 1.8 to 2.1 million seeds in a pound of Kentucky bluegrass, giving a ratio of about 1 to 7. However, establishment of fine-textured ryegrass is likely to be 70 percent when under the same conditions bluegrass establishment is around 30 percent. Because of its better establishment characteristics, the quantity of ryegrass used in a mixture should be limited. Experience has shown that not more than 20 percent by weight of fine-textured ryegrass should be used in a mixture to be seeded on freshly prepared ground. A higher percentage, up to 40 percent, is useful when renovating old turf. The added ryegrass plants compete with the older established plants to the benefit of the new seeding.

MANAGEMENT

Establishment management for fine-leaved ryegrass is similar to that recommended for Kentucky bluegrass. However, if turf ryegrass is seeded in formulas with slower-establishing species, it will be necessary to provide light, frequent irrigations until the other grasses are well established.

Although management after establishment is also similar to that used on Kentucky bluegrass, there are a few differences. While it is possible to maintain a stand of Kentucky bluegrass without regular applications of nitrogen, fine-leaved ryegrasses will soon thin if thus neglected. A reasonable amount of nitrogen is required, such as 1 to 2 pounds nitrogen per 1,000 square feet per year. Today's cultivars all appear to be especially susceptible to leaf rust in the first year, but this, too, can usually be controlled by late summer applications of nitrogen.

Other problems include summer or winter thinning, but this varies among varieties. 'Pennfine' is an example of the more summer-persistant cultivars, and 'Nk200' is one of the more winter-hardy types.

DISEASE AND DROUGHT TOLERANCE

Like other species, ryegrass is subject to diseases and insects. However, the growth cycles of the fine-textured ryegrasses tend to differ from those of Kentucky bluegrass and fine fescues, and often these differences help reduce the turf decline of a mixture at any particular time. Snow mold (especially pink snow mold) can be very damaging to the fine-textured ryegrasses. Including Kentucky bluegrass in a stand of ryegrass seems to reduce the severity of damage. Where there is fall wear, snow mold chemical control is advised. There appears to be a degree of tolerance within the fine-textured ryegrasses to Fusarium blight and to sod webworms.

While ryegrasses have been considered adapted primarily to maritime or moist climates, it has been shown that the newer fine-textured ryegrasses do have certain amounts of drought tolerance. They are found green and growing in a turf long after Kentucky bluegrass or fine-leaved fescues have gone dormant. Conversely, fine-leaved ryegrasses are tolerant of wet soils. They do well on heavy soils and, if adequately fertilized, are satisfactory on sandy soils.

DURABILITY

The major advantage of the fine-textured ryegrasses over other species is their ability to withstand wear and tear. When properly maintained, they provide a wear-resistant surface on athletic fields, golf course tees, cart paths, picnic areas, and other turf areas subject to traffic. For best performance on athletic fields, 50 to 60 percent fine-textured ryegrass by weight gives the best results. In addition, the establishment characteristics of these ryegrasses allow quick repair to damaged athletic fields. Another big advantage is resistance to divoting, once well established. The base or crown tissue is tough; instead of readily tearing off, the leaves shred or wear down to allow recovery from the crowns when traffic is reduced.

The advantages of these useful grasses can be negated, however, by inadequate management or poor soil structure. While turf ryegrasses will withstand more soil compaction than Kentucky bluegrass, they do respond to a friable soil structure. Heavily utilized athletic areas, such as football fields, should be programed and funded each year to provide for aeration, overseeding, sufficient fertilization and irrigation, and regular mowing. For heavily trafficked turf, both subsoil and surface drainage is essential, and a mowing height of 2-1/2 to 3 inches is desirable. However, where use requirements demand a shorter turf, fine-leaved ryegrasses can be maintained at 3/4-inch mowing height. Under heavy traffic conditions, a high sand base will produce the best results and should be seriously considered when constructing a new facility.

CONCLUSION

When used with Kentucky bluegrass and the fine-leaved fescues, the fine-textured ryegrasses help maintain year-round density, color, and growth. They perform best under sunny conditions, but have been used with some success under moderate shade. They have difficulty developing new tillers under shade, however, and gradually thin unless repeatedly reseeded. Except in special instances where other grasses will not grow, it is best to develop a mixed stand with Kentucky bluegrass or a bluegrass plus other species. Even the best ryegrasses are quite heat-sensitive, and growth slows substantially in hot weather. On the other hand, the most winter-hardy cultivars can be injured by desiccation or by overstimulation with excessive nitrogen. Ryegrasses, of course, have their own distinct disease and insect problems. The fine-textured perennial ryegrasses do not develop a surface mat useful in cushioning player falls as does Kentucky bluegrass.

Although the turf-type perennial ryegrasses are extremely versatile, it would be a mistake to indicate that they can be used universally. They are not foolproof, but they do add new dimensions to turfgrass culture not obtainable with other species. Used in mixtures with other adapted grasses and given adequate management, they can help the turf manager maintain quality turf under a wide range of conditions.

A CONTEMPORARY VIEW OF TURFGRASS THATCH

K. A. Hurto and A. J. Turgeon

A small amount of thatch in a turf has been considered advantageous because it provides some resiliency, increases wear tolerance, and insulates the underlying soil against temperature extremes. However, an excessive thatch accumulation has been associated with increased disease incidence, localized dry spots, poor response to fertilization, greater susceptibility to injury from temperature extremes, and proneness to scalping (*1*).[1] Where these conditions prevail, the thatch layer should be removed or reduced. On parks and fairways or other large acreages, this often is not feasible, however.

An excessive thatch layer has the net effect of elevating the turfgrass crowns above the soil surface. Consequently, the root and rhizome growth from these crowns is within the thatch and has little rooting into the underlying soil. As a result, the thatch becomes the primary growing medium for the turfgrass community, while the soil may be of only secondary importance (*6*).

Recently completed studies by Hurto and Turgeon (*3*) have shown that thatch is not a highly favorable growing medium for turfgrasses. However, by recognizing its physical and chemical characteristics, cultural practices can be modified to partially compensate for the differences in physical and chemical properties of thatch and soil.

Thatch is a fibrous and porous medium. Because of its poor moisture retention, it requires frequent irrigation. On the other hand, because of its high aeration porosity and resiliency, it resists compaction under traffic. Chemically, the nutrient retention of thatch is poor. Thus, more frequent fertilizer applications are required to sustain a desired level of turfgrass growth, especially where water-soluble nitrogen carriers are used in conjunction with frequent irrigation.

An alternative approach to fertilization may be to use slowly soluble carriers to take advantage of their gradual release of nitrogen. Unpublished studies by Falkenstrom, Turgeon, and Street in 1977 have shown nitrogen to be more mobile in thatch than in soil from a thatch-free turf; however they noted that the loss of nitrogen by leaching through thatch was reduced by using a slowly soluble nitrogen source.

Additional factors must also be considered in developing cultural programs for thatchy sites. Disease and insect problems may be more prevalent. Pesticide application methods may also require some alteration to insure proper efficacy and safety to the turf.

[1]Italicized numerals in parentheses refer to Literature Cited at the end of this paper.

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Where annual grasses such as crabgrass are a serious problem in turf, preemergence herbicides are used. Previous studies showed that applications of bandane and calcium arsenate induced thatch development (*5*); however, the effects of thatch on herbicide activity had not been reported. Thus, a series of studies was initiated in 1977 by Hurto and Turgeon to determine the effects of thatch on herbicide activity.

Field applications in spring of benefin, oxadiazon, and prosulfalin to thatchy Kentucky bluegrass turf caused injury that was apparent during midsummer stress; DCPA and bensulide caused little or no injury. The same treatments on thatch-free sites revealed that only prosulfalin was injurious.

Further studies in the laboratory revealed that the adsorption of benefin, bensulide, and DCPA from solution was greater by thatch than by soil; however, the mobility of these herbicides in undisturbed surface thatch profiles was greater than measured in undisturbed surface soil from thatch-free sites. Preemergence herbicides function by maintaining a chemical barrier at the soil surface to prevent the development of weeds from seed germination. The low water solubility and immobility of preemergence herbicides in soil may account for their ability to effectively control annual grasses yet not come into direct contact with roots of actively growing Kentucky bluegrass turf.

Where roots and rhizomes are confined to the thatch layer, the greater mobility of preemergence herbicides in thatch allows the herbicide to come into direct contact with the plant roots, injuring the turf. Greenhouse studies by Solon and Turgeon (*4*) revealed that applications of oxadiazon, benefin, and bensulide to Kentucky bluegrass growing in sand cultures reduced shoot and root growth; DCPA did not inhibit their growth. Thus, turfgrass injury from preemergence herbicides on thatchy sites is due to at least two factors: the greater mobility of preemergence herbicides in thatch than in soil, and the inherent susceptibility of Kentucky bluegrass to injury from preemergence herbicides that come into direct contact with plant roots.

Ideally, a herbicide should provide an effective period of weed control without persisting or accumulating from one season to another. Previous studies on the persistence and metabolism of herbicides used in turf have been conducted in soil. In more recent studies, it has been found that under laboratory conditions, metabolism of benefin and DCPA is significantly higher in thatch than in soil (Hurto and Turgeon, 1977, unpublished report). This would suggest that the persistence of field-applied herbicides to thatchy sites is less than when applied to thatch-free sites, but additional studies are needed in this area.

Different approaches to controlling thatch have been developed. With the exception of topdressing, these methods often result in partial destruction of the turf because of the removal of vegetative propagules growing in close association with the thatch. Moreover, these methods are not always completely effective.

Topdressing, although effective, requires so much expense and labor that it is generally restricted to putting greens and other intensively cultured turfs. An alternative approach that may be feasible is the introduction of soil by core cultivation. Besides alleviating soil compaction, this practice modifies the physical and chemical properties of the thatch layer when the soil cores are pulverized and reincorporated into the turf. The beneficial effects of this treatment were clearly demonstrated in an earlier study, where residual activity of paraquat in thatch was reduced (*2*).

The differences in physical and chemical characteristics of thatch and soil suggest that cultural practices must be adjusted according to the situation to provide favorable conditions for turfgrass growth. Further studies are necessary to determine what effect cultural practices such as core cultivation and reincorporation of soil into thatch have on nutrient mobility and pesticide activity.

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DEW IS NOT DEW

Tom Mascaro

Dew, in the popular sense, is water of condensation. Dew forms on a cold surface when the air is warm and water is present as humidity.

Much of the "dew" on turfgrass areas is not water of condensation. Rather, this water is the plant sap pumped out or "exudated" from the hydathodes. The hydathodes are relief mechanisms that transport excess water out of the plant system.

Relatively speaking, very little research has been done on this important aspect of turfgrass culture. In 1887, Dr. Marloth in Egypt studied the Tamarix (salt cedar) and found that it exuded salts, which he identified.

Dr. J.K. Wilson, Cornell University, in 1923 found that the difference in dew on turfgrass areas was not due to soil moisture but to the species that grew there. He classified the different grasses in the following manner:

1. Bentgrasses, bermudagrasses, and *Poa annua* are prolific pumpers of exudate.
2. The bluegrass family (except *Poa annua*) are medium pumpers of exudate.
3. Zoysiagrasses, fescue, and ryegrasses are low pumpers and produce the least amount of exudated water.

The difference in the rate of exudation explains why we can observe patches of heavy "dew" on turfgrass areas that are not pure stands.

Dr. Endo, University of California, in 1969 found that spores of dollar spot fungus grew sparingly in ordinary water; but when germinated in exudated water, they grew sparingly to well and caused a variable amount of infection. In other words, exudated water increased infection and disease. It induced an acceleration and increase in spore germination.

Dr. G.N. Hoffer, Purdue University, in 1949 demonstrated that quickly available nitrogen was rapidly transported through the leaf tissue and into exudated water. The high salt content of the exudate caused leaf, stem, and root burn.

With this background information we can begin to understand better why the United States Golf Association Green Section advocated syringing of greens many years ago. Their findings indicated that the superintendent who syringed his greens in the early morning had less disease than the man who didn't. This practice simply dilutes the concentration of the exudated water and renders it harmless.

Exudated water contains glutamine, a form of sugar that is ideal for bacterial and fungal growth. If you touch your hand to exudated water, you will feel the stickiness of this material, which is similar to that of the plant sap.

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The salt index of exudated water will rise sharply when quickly available plant foods (especially nitrogen) are applied. If these salts are allowed to accumulate in the thatch or compacted soil, surface root, stem, or lower leaf burn may occur. The potency of the exudate can be demonstrated by gathering a cupful from a well-fertilized green and pouring it in one spot. A chemical burn will result.

These combinations of factors can and do have a profound effect upon the survival of turfgrasses under certain conditions. Until more research is conducted to supply more information, the wise turf manager will do the following:

1. Practice early morning syringing to dilute exudated water.

2. Use sufficient water to wash the exudate into the soil. Aerify to insure water intake.

3. Use slowly available plant foods to minimize the salt concentration in the exudate. If quickly available plant foods are used, split the feeding into light amounts on a frequent basis.

4. Control thatch to minimize the accumulation of exudate. Frequent verticutting, light topdressing, dragging, and brushing all help to keep excess thatch under control.

5. Maintain favorable soil pH, which is a factor that can be related to exudated water. The lower the pH, the more susceptible turfgrasses are to disease attack. Dusting (during periods of stress) with 5 to 10 pounds of hydrated lime per 1,000 square feet when grass is dry, or applying dolomitic limestone, 10 to 20 pounds per 1,000 square feet, will raise the pH in the thatch layer to a more desirable level if it is acid.

I hope that this discussion has given you a better understanding of this rather unrecognized subject.

Some will continue to call it Dew. Others will call it Exudated Water. Another common name is Guttated Water, or Guttation Water. Whatever we call this liquid that is exuded from the hydathodes of the grass leaf, we must always remember that it is the result of a normal function of the plant. The turfgrass manager who recognizes this basic principle and adapts his management practices to it wisely is the one who will produce superior putting surfaces for better golf.

MANAGING BENTGRASS GREENS DURING A SUMMER CRISIS

A. M. Radco

The putting green is the most intensively maintained turf area in the world. The surface should be billiard table smooth, but the grade, slope, and contours of the green should challenge a player each time he or she steps up to stroke the putt.

Bentgrasses, properly managed, make the finest putting surfaces. Summer management, however, especially in July and August, can be difficult where bentgrasses are used. Year-round excellence in management is necessary to prepare for adverse summer conditions.

Every manager seeks perfection and goes about it in his individual way, covering major needs and adding special touches on his own as a result of experience or training. In my view, of all the management factors required, the following are the most important:

1. *True height of cut.* Bentgrasses must be close cut if they are to perform well on the putting surface. To obtain a close cut, the mower must cut a true 3/16 to 1/4 inch. Since the mower setting is not an accurate indicator of the actual mowing height, measure the height after cutting.
2. *Frequency of cut.* Greens must be mowed six to seven times weekly and double-cut on occasion. Mowing direction must be changed with each cut.
3. *Nutrition.* A balance of nutrients must be applied, but nitrogen rate is most important. For those who prefer fast greens, the nitrogen level must be minimal.
4. *Irrigation.* Prepare the turf for summer stress by withholding water until it is absolutely essential to keep the grass alive. Forcing growth with early irrigation sends grasses (especially *Poa annua*) into the summer in a weak condition. Firm greens are best for golf, and irrigation practices play an important part in firmness, *Poa annua* encroachment, and rapidity of growth.
5. *Turfgrass cover.* Management depends greatly upon whether your greens are predominantly bentgrass or *Poa annua*. Select a bentgrass adapted to your area.
6. *Soil improvement.* If putting green soils drain poorly, then drainage must be improved. If the soil is tile drained but still holds water excessively, then it is necessary to rebuild or attempt to improve the soil through topdressing.

Summer stress comes in several ways: high temperatures and low humidity cause wilt; high temperatures and high humidity encourage disease problems; heavy rainfall saturates the soil and makes the thatch spongy and puffy, subjecting grasses to wet wilt and scalping. The best remedy for thatchy, puffy grasses is a well-rounded program, as emphasized above. If thatch is minimal, then scalping is less likely, and diseases that normally harbor in thatch are not as severe.

To combat wilt, syringing is necessary merely to cool the turf, to help keep it alive on a day-to-day basis until the wilt crisis subsides. The rule of thumb is

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to shower the green with enough water to wet the blades without wetting the soil. This type of showering or syringing is usually done once or twice daily until the turf returns to normal.

Weekly spiking has been used to advantage during the summer months. There are advantages and disadvantages to spiking greens, but in my experience the advantages for spiking during summer stress outweigh the disadvantages. During this critical time, spiking helps keep the upper surface dynamic.

Aeration, on the other hand, should generally be done in spring or fall. On compact greens it is preferable to aerate troublesome greens in late spring to help them through the summer stress period. Care must always be exercised not to increase crabgrass or *Poa annua* population when introducing an aeration program on troublesome soils.

Pesticide programs must be carefully monitored during times of stress. Diseases and insects take no vacation "when the heat is on"; in fact, they add to the difficulties. Preventative programs should emphasize protection against *Pythium* under conditions of high moisture and high humidity.

CHARACTERIZATION OF A NEW GOLF COURSE PEST

Roscoe Randell

An insect pest not commonly found on bentgrass was observed causing severe feeding damage to golf greens in Illinois in 1977.

This insect, the bluegrass webworm *(Crambus teterrellus)*, is widely distributed throughout the eastern part of the United States. It has been a common webworm feeding on bluegrass in Kentucky and Tennessee. Because of its small size and lack of economic damage, the bluegrass webworm has not previously been considered a serious pest in managed turfgrass in Illinois.

During the third week in August 1977 serious damage was observed on golf course greens in the western part of Illinois and in and around St. Louis. Large areas of the greens and sometimes an entire green were killed. The bentgrass roots were fed upon and the turfgrass was cut loose from the soil surface. Adult webworm moths were commonly observed on the green surface.

Also, there were small, vertical holes in the thatch. Close examination revealed both pupae and pupal cases in these holes. The holes were often as numerous as one per square inch. The holes were constructed by the webworms before changing to the pupal stage. The pupae stand vertically in the upper soil layer, and the adult moths emerge through the holes in the thatch at the upper end of each pupal case. The adult moths crawl about and then fly over the turfgrass surface. Full-grown larvae and adult webworms are about 1/2-inch long.

There are two generations per year. The second generation of webworm larvae appears in late July and early August in central Illinois. Distribution maps of the bluegrass webworm show its northern-most limit is about Interstate 80 through Indiana, Illinois, and Iowa.

Insecticides suggested for lawn or sod webworm control also give good control of the bluegrass webworm. These insecticides include diazinon, Dursban, and Dylox or Proxol. The important part of webworm control is detection and identification of the insect problem.

Whether the bluegrass webworm will be a problem in bentgrass turf in 1978 is not known. There were many webworm larvae in the fall, and they overwintered in bentgrass areas at Urbana-Champaign as well as areas to the west and south.

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SOIL LAYERING AND ITS POSSIBLE EFFECT ON TURFGRASS GROWTH

L. Art Spomer

Turfgrass plants grow by accumulating raw materials from their environment. Light energy and carbon dioxide are absorbed by the leaves from the air, and water and minerals are absorbed by the roots from the soil. Turfgrass plants contain and use more water than any of the other raw materials; in fact, probably every aspect of growth is influenced either directly or indirectly by water. Since all of this large amount of water required for turfgrass growth is absorbed from the soil, anything that reduces the *availability* of soil water for turfgrass use will reduce turfgrass plant growth.

For soil water to be available for turfgrass use, it has to be present in the soil in sufficient quantities and the plant must be able to absorb it. For the plant to absorb the water, the plant's root system must thoroughly permeate the soil mass and the roots must be permeable to water. Both of these factors depend to a large degree on the soil environment. Roots must have an adequate soil environment to ensure sufficient absorption and root growth.

The soil layering situations common to golf course turfgrass sites can strongly affect the soil physical environment by affecting soil water retention. This paper briefly discusses the effect of two general soil layering situations on soil water retention: (1) a fine-textured material overlying a coarse-textured material and (2) a coarse-textured material overlying a fine-textured material.

FINE-TEXTURED OVER COARSE-TEXTURED SOILS (SMALLER OVER LARGER PORES)

Whenever a finer textured soil or other growth medium (smaller soil pore sizes) overlies a coarser textured soil or medium (larger soil pore size), a perched water table forms at the interface, and the finer textured soil will be saturated at that level (Fig. 1). Two commonly occurring instances of this situation on golf courses are the drained green and the sodded green.

Figure 2 illustrates the pattern of water retention in a typical drained green site filled with three different soils: a very coarse-textured sand (a), a silty clay loam (c), and a mixture of the two (b). All three soils are saturated at the drainage level (fine over coarse interface), and water content increases with height above the drainage level.

The loam remains essentially saturated throughout, whereas the sand is saturated at the bottom and dry at the top. Any plant growing in the loam will likely suffer from poor aeration, whereas any plant growing in the sand (especially small plants with shallow root systems) will likely suffer from a water deficit. The main difference between these two soils is that the loam contains predominantly small *water retention* pores, which remain saturated under the influence of the water table, whereas the sand contains predominately large *aeration* pores, which drain despite the water table. An ideal soil for such a soil layering site would be a compromise between

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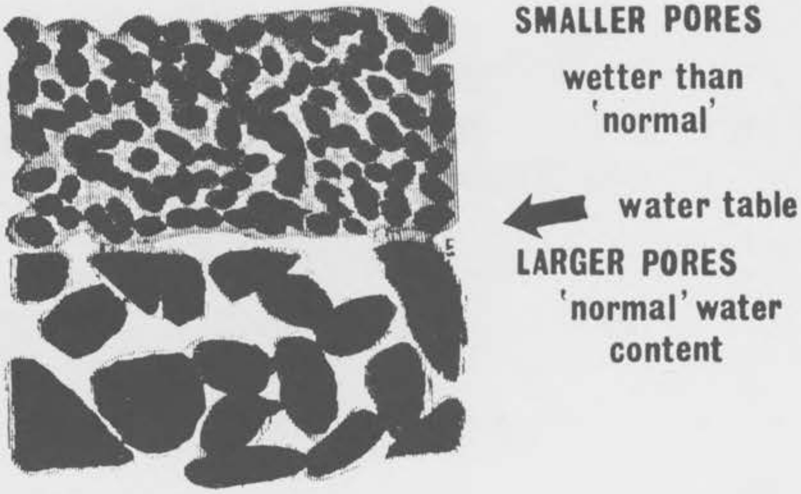

FIGURE 1. A fine-textured soil overlying a coarse-textured soil will be wetter than normal following irrigation and drainage because a perched water table forms at the bottom of the finer soil (at their interface).

these two, which is obtained by mixing fine- and coarse-textured materials together in proper porportions to obtain a balance between water retention and aeration.

Figure 3 illustrates the pattern of water retention in a typical golf course green site (or other site) that has been sodded with sod produced on a finer textured soil than the transplant site. As with the previous example, a perched water table forms at the fine over coarse interface, which in this case is only 1 or 2 inches below the surface, and the sod soil remains saturated. Although the significance of this occurrence on turfgrass is not fully known, it is supposed that this effect will retard establishment and growth. This potentially adverse situation can be avoided through the use of "soilless" sod or sod produced on a soil similar in texture to that of the transplant site.

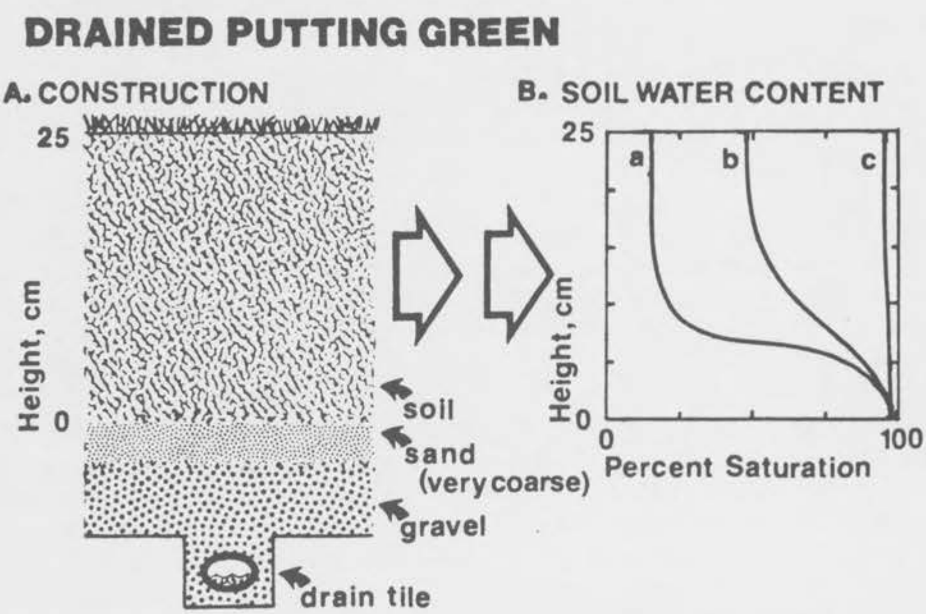

FIGURE 2. The most common example of a fine soil overlying a coarse soil is the drained putting green. Note that all three soils (a, b, and c) are saturated at the bottom (perched water table) and water content decreases with height above the bottom.

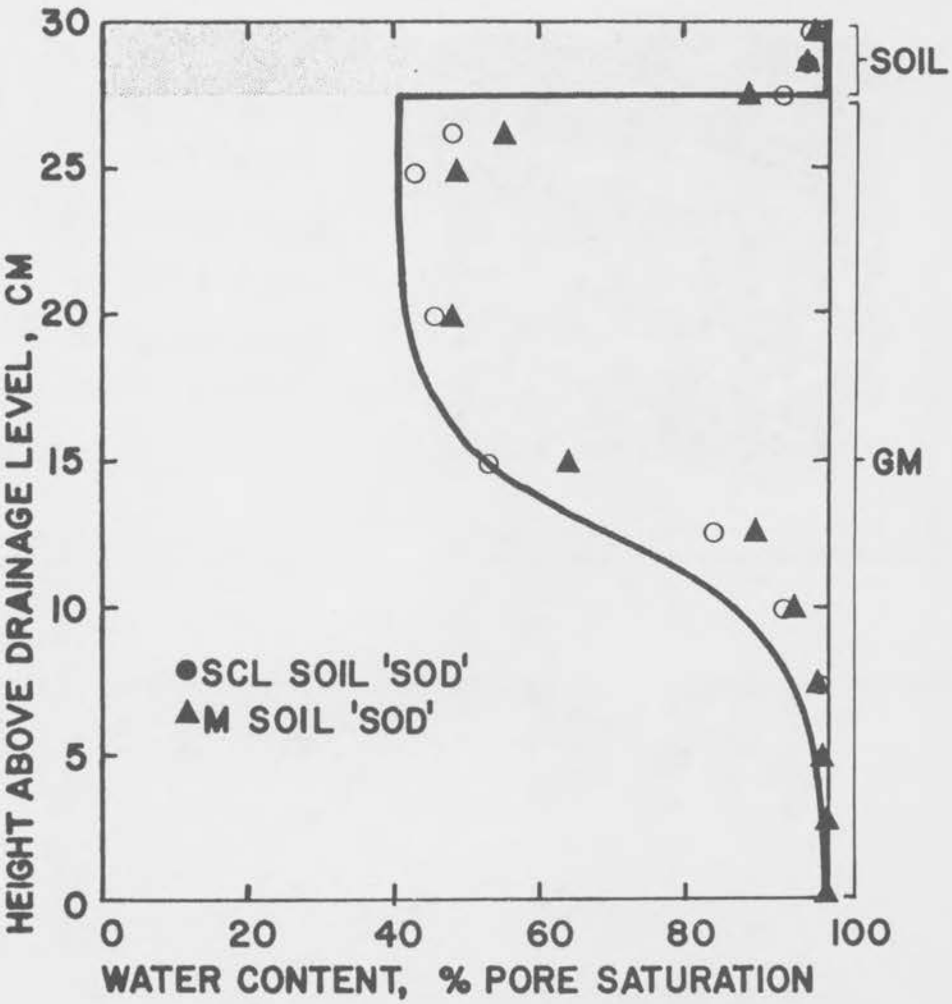

FIGURE 3. Another common example of a fine soil overlying a coarse soil is a sodded, drained golf green in which the sod soil overlies a coarser green soil mixture (GM) which, in turn, overlies a drainage system. In this case, two perched water tables form, one at the bottom of the sod and the other at the bottom of the GM. Note that the sod soil remains saturated following irrigation and drainage even though the GM is adequately drained. SCL is silty clay loam and M is muck.

COARSE-TEXTURED OVER FINE-TEXTURED SOILS (LARGER OVER SMALLER PORES)

Whenever a coarser textured soil or other growth media overlie a finer textured soil or media, no water table occurs. The water content of the coarse-textured soil when drainage ceases will be what would be normally expected for a similar nonlayered soil having a similar drainage depth (Fig. 4). Probably the most common occurrence of this layering situation is when a thatch layer forms on the soil surface.

Although no water table occurs in this situation, drainage through the coarse soil is so much faster than through the fine soil that water may "back up" at the interface and the coarse layer may remain saturated for a time. However, water will eventually drain out of the coarse material. Again, the significance of this situation is not fully known, but in the case of thatch the coarse layer may not retain enough water to support good plant growth without more frequent irrigation.

Another instance occurs where coarse material such as sand is incorporated into the upper layer of soil during landscape construction (Fig. 5). Usually, insufficient material is used to affect soil-water relations; incorporation also does little good as far as the plant is concerned, and it is doubtful that this is a useful practice.

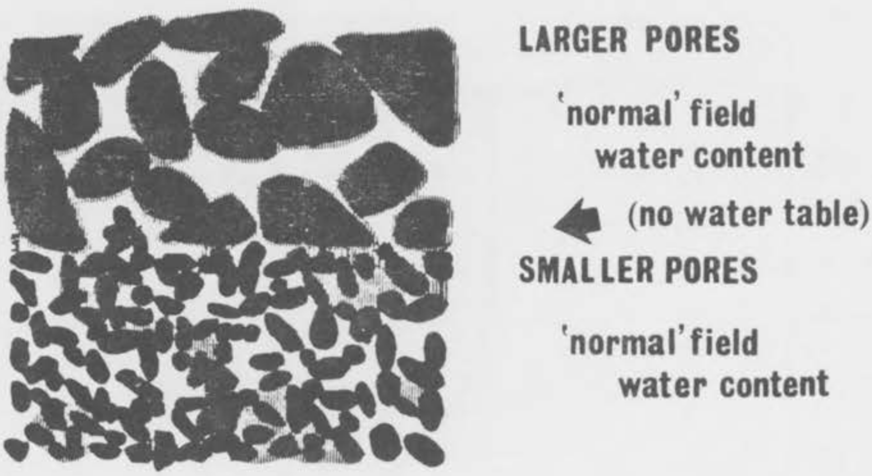

FIGURE 4. When a coarse-textured soil overlies a fine-textured soil, no perched water table forms, and the water content of both will be "normal" following drainage. Drainage may be temporarily impeded at their interface by the slower infiltration rate of the finer soil.

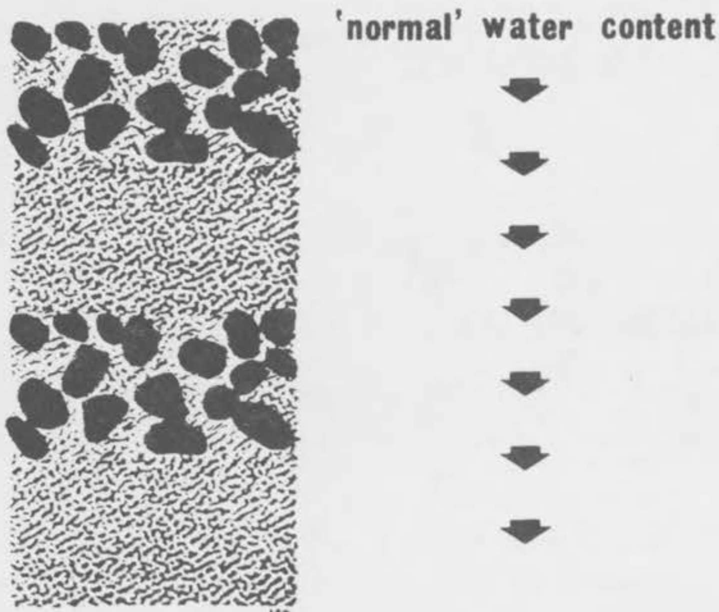

FIGURE 5. Where soils are amended to improve their tilth, no effect on water retention patterns will occur (unless sufficient coarse-textured amendment is added to form large aeration pores). No water table forms in this case, regardless of the order of layering.

CONCLUSION

Soil layering affects turfgrass growth primarily through its effect on soil water retention. Such a problem might occur where a fine-textured soil overlies a coarse-textured soil.

TOPDRESSING YOUR WAY TO BETTER GREENS

Roy L. Goss

Topdressing may be defined as a surface application of any growth medium intended to perform some of the following functions: correct putting surfaces; develop firmer, drier surfaces; increase infiltration rates of water; help relieve hard, compacted surfaces; increase air porosity (noncapillary pore space); aid thatch decomposition; prevent surface puddling; provide cover for overseeding; supply nutrients; modify topsoils; and, no doubt, many other uses.

Topdressing, which has been practiced for over a century, was probably conceived of as a means supplying plant food nutrients and smoothing putting surfaces more than anything else; it has developed, however, into a practice designed to perform all the functions listed above. Its effectiveness with some of these is still open for debate, and topdressing will, no doubt, be practiced by turfgrass managers to suit their own beliefs and immediate needs. Let us briefly examine some reasons for topdressing.

REASONS FOR TOPDRESSING

Smoothing Putting Surfaces

Smoothing the putting green surface is a cosmetic effect related to the play of the game and also the operation of equipment. Smooth surfaces not only will allow the ball to roll with more accuracy but also will result in more uniform and smoother mowing practices. In this respect, nearly any material can be used for topdressing; however, this may not necessarily result in what is best for the grass. Materials used for cosmetic topdressing have ranged all the way from soils containing high amounts of silt and clay to pure sand.

Producing Firm, Dry Putting Surfaces

Many putting greens, probably most of the putting greens around today, have been improperly built from the standpoint of using soil types for easy-to-maintain putting greens. Many were built from existing materials, which resulted in wet, compacted, hard-to-manage greens. As surfaces become hard and compacted, naturally they become wetter. Topdressing with materials that are not easily compactable will tend to produce drier putting surfaces. Sand topdressing is the most useful tool for correcting this condition.

Of course, problem greens cannot be corrected overnight, and topdressing alone will not relieve all the problems of compaction, wetness, and poor rooting. Vigorous aerification must be practiced when restructuring or rebuilding putting green surfaces.

Improving Water Infiltration Rates

Normal agricultural soils classified as sandy loam or heavier texture will tend to puddle and compact under intensive use. Because of the nature of golf, such

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soils are subjected to a great deal of abuse. Playing them when they are too wet leads to structural deterioration, which reduces air porosity and increases bulk density. The more tightly the soil particles are squeezed together, the slower the movement of water into the surface of the soil (a reduced infiltration rate of water). Initially, a putting green may drain quite rapidly, but with time it can become wetter and more unmanageable. Topdressing with sand or a material very high in sand content is one means of increasing the infiltration rate of water.

Relieving Compaction

Compaction can occur only if the soil particles are squeezed more closely together. Soils containing high amounts of silt and clay with sand can be physically squeezed or compacted. The finest particles can be forced between the coarser particles, eliminating much of the air space (noncapilliary pore space) and increasing the bulk density of the soil.

There are several means of relieving compaction but most are only temporary. Hollow-tined aerification, spiking, slitting, vertical grooving, hand-forking, and other means will partly accomplish the task, but topdressing with appropriate materials and supplying an excellent turf cover are the ultimate means to a permanent solution.

Increasing Air Porosity

It is very important to retain adequate air pore space in the soil to maintain normal root growth and water movement. Since grass roots are in a continuous state of respiration, oxygen is continuously required. If oxygen is deficient, root growth will be restricted or completely prevented. If oxygen is excluded from a soil for any significant period of time, the soil will develop an offensive anaerobic odor. Under these conditions roots will not develop.

Putting greens built from sands or from soils with very high sand contents will maintain a much higher air porosity than those built from soils of heavier textures.

Reducing Thatch

Next to hardness and wet surfaces, thatch is probably the most dominant reason for topdressing putting greens today. We have been using vigorous creeping bentgrasses such as 'Penncross,' 'Seaside,' and, more recently, 'Emerald' for many years. Because of the vigorous vegetative nature of these grasses, thatch will inevitably develop unless extensive mechanical treatments such as verticutting, aerification, brushing, etc. are practiced. Despite such measures, thatch will still develop in many cases. Topdressing has been demonstrated to be one of the best practices for managing thatch.

Topdressing does not prevent the development of stems and roots that normally cause most of the thatch; rather, it simply keeps the thatch separated to prevent dense, compacted mats from forming. This may be related to the carbon:nitrogen ratio in the thatch layer or perhaps to many other factors. By intermingling sand or other suitable topdressing materials with this organic material as it develops, formation of thatch layers will be prevented. The intermingling of suitable soil material also creates a better atmosphere for organisms that normally decompose thatch.

Reducing Surface Puddling

Puddled surfaces refer only to structural decomposition and the accumulation of organic debris. Upon decomposition of plant materials, principally stems, leaves, and roots, thin films of organic material can virtually seal the surfaces of putting greens and can result in extremely wet, unstable conditions. When this condition becomes serious, even aerification and other mechanical treatments will not produce desired results. Topdressing, then, becomes one of the few means of correcting this condition in conjunction with mechanical processes. Since sand is a single-grained material, it has no structure; therefore, it cannot become puddled except through adding high amounts of decomposed organic material.

Modifying Topsoil

Topdressing has been used widely for the modification of topsoil. Putting greens that were originally built with poor quality materials have been modified through the addition of sand. Excellent results can be achieved through combining aerification and frequent sand topdressing to alter the surface 2 to 3 inches of putting greens. With continued sand topdressing, deeper surface profiles with high infiltration rates and high air porosity can be developed; this creates a more favorable environment for root growth and will produce firmer, drier surfaces. There is a limit, however, to how deep soils can be modified without having to use specialized equipment and extensive labor.

Supplying Nutrients

Many golf superintendents or other turfgrass managers prepare their own topdressing materials; others buy them commercially. Some of these materials have very high amounts of organic matter of a composted nature. Upon decomposition of plant materials, large amounts of nutrients are released for plant use. Many turfgrass managers boast that they apply very low amounts of nitrogen to their putting greens while topdressing four or more times a year with highly composted materials. They may be producing some very fine putting greens, but they are not taking into account the large amount of nutrients, especially nitrogen, derived from the composted organic material they are applying. The point is, good composted topdressing materials can be an important source of plant nutrients.

Providing Cover for Overseeding

We all know that when we throw seed onto the soil surface without any protection our chances for successful germination and establishment are highly reduced. After surface overseeding, topdressing should be applied to provide some cover for moisture retention around the grass seed to aid germination and establishment.

SOME PRACTICAL APPLICATIONS AND RESULTS OF TOPDRESSING

The northwest coast of the Pacific Northwest is characterized by rather mild, wet winters. Golf can be played any month during the winter season and, in fact, on most days. Except for brief periods of frost and some short-lasting snows, the ground remains unfrozen and turfgrasses continue growing to a limited extent. This sets the stage for development of serious soil and grass problems on putting greens. Because of the slow growth conditions, turfgrasses may become thin and weak, thereby providing less protection to soil surfaces. This can result in puddling, compaction, sealing, loss of air porosity, and many of the problem factors previously discussed.

Putting green construction with sand is not a new principle in the Pacific Northwest, although the adoption of this practice has been rather slow. Putting greens were built with 85 percent sand and 15 percent peat moss as early as 1956. Since that time sand construction has gained increasing popularity. In fact, under our conditions, it is a method of survival.

Dr. Fred Grau a number of years ago pretty well summed up the picture on sand: "Sand has been discovered to be the critical factor in determining whether a putting green is easy to keep or hard to keep. The higher the sand content, the easier the green is to keep. Cup cutter cores were collected from golf courses all over the United States on the basis of (a) easy to keep and (b) hard to keep. Tests run at Beltsville on physical analyses showed the trend to be conclusively toward higher sand for easier to keep greens."

We don't have to be very good agronomists to know that it is much more difficult to develop fertility programs for sand than for soils of better quality; however, we run the risk of many problems if we use soils of heavier texture. It also is easily understood that putting greens built from sands are more droughty than those built with heavier soils simply because of the difference in water-holding capacity. With modern irrigation equipment this should not be a factor since we can water the greens any time we wish during stress periods.

Normal topdressing procedures in the Pacific Northwest followed about the same trend as the rest of the country. Most putting greens were topdressed between one and three times per year with very heavy doses. The production of large amounts of organic material (stems and roots) during the major growing season would produce a layer of organic matter over the previous topdressing. With the next application of topdressing material, there would be a thin layer of entrapped organic material without any mixing with soil. These so-called growth rings are apparent in most of the greens in the Northwest, and for that matter in most parts of the United States. Each of these thin layers of dissimilar material can represent perched water tables, thereby impeding the movement of water through the soil. These layers, depending upon the type of material used in topdressing, can also restrict root growth. Therefore, it appears more reasonable to try to create a more uniform soil profile through modified topdressing procedures.

THE MADISON PROCEDURE

Dr. John Madison, University of California at Davis, has described a method of topdressing putting greens through applying a prescription-type sand in light, multiple applications throughout the growing year. Since most of you may be familiar with this procedure, the details will be treated rather lightly. Essentially, medium fine sand is applied at approximately 3 cubic feet per 1,000 square feet of putting green area per application. The number of applications can vary from 14 to 20 per year, depending upon the growing season. Dr. Madison has described many variations to his program by including fungicides, insecticides, fertilizers, or other materials to minimize labor.

Because of the logistics of adding fertilizers and pesticides to the sand, most superintendents in our area do not practice mixing other materials but apply only the sand topdressing, after which other materials are applied as needed for specific purposes. After testing Madison's procedure for two years on bentgrass putting greens at the Research Station, we adopted and recommended this procedure for golf course use in our area. Further, when three golf courses in the Seattle area developed serious problems on nearly all 18 of their putting greens, the superintendents at these courses initiated the light, frequent sanding method with significant results. Within approximately one year all three of these courses had completely reversed their wet, unstable surface conditions and had significantly improved turfgrass density and putting greens. No other serious problems have resulted from continued use of this sand topdressing procedure.

In my observations, putting greens that have been continually sand topdressed have fewer ball marks that have to be repaired, and most golf shots played properly will hold on them. In general, these greens are slightly firmer and have excellent surfaces. Of course, conditions are not the same everywhere and we should not expect all good or bad things that are observed in one geographic area to occur in all of the others. This is why we do research and continue our observations.

In an experimental putting green at the Research Station at Puyallup where topdressing has been continually practiced for four years, we have not observed a significant increase in bentgrass establishment through competition with *Poa annua*. There has been some gain, but the turf is still approximately 50 percent annual bluegrass. The surface of this test green has definitely improved and, since the developing organic material is uniformly mixed with frequent applications of sand, there are not definable thatch layers.

OTHER PRACTICAL USES OF SAND OTHER THAN PUTTING GREENS

All of you, I am sure, have had problems with the development of unstable, wet, soggy turf, particularly in areas on the putting green approaches and in areas that receive heavy wear from play and maintenance equipment. If these areas were once dry and stable, they can be repaired with applications of sand. We have done this for a number of years with outstanding results, and it continues to be a normal practice on many of our golf courses. On areas other than putting greens, heavier applications of sand may be applied, reducing the time required to restabilize these areas.

THE ORGANIC MATTER QUESTION

We are frequently asked whether organic materials should be included with the sand for topdressing. My opinion is that we should approach this very cautiously. Large amounts of organic matter are produced by the developing turfgrass plants. Any subsequent additions of organic matter may substantially add to this buildup. As a compromise, no more than 10 to 15 percent by volume of either composted or uncomposted organic material should be added to topdressing materials.

If you are one of the fortunate ones whose greens were constructed properly with the right type of sand, aerifier plugs may be processed and matted back into the surface with good results for the first few years. As time progresses, the organic material in putting green surfaces will increase until you may be applying 50 percent or more of organic material back to the surface. When this happens, I recommend you remove the plugs and apply pure sand as a topdressing.

SAND QUALITY

It is extremely important in both topdressing and new construction to carefully select the proper quality sand. A tremendous amount of information has been developed on this subject by John Madison and Bill Davis at the University of California at Davis. It may be that what has been found to be best for one area may not necessarily be the very best for another, but their information certainly serves as an excellent guide.

From our viewpoint in the Pacific Northwest, particularly in the heavier winter rainfall area, we are somewhat concerned about accepting a very large percentage of fine sand particles. Our recommended program for sands for both topdressing and construction is approximately as follows: 100 percent passing a No. 18 screen (Tyler Standard Screen--U.S. Series equivalent) and 0 to 5 percent passing a No. 100 screen. The sand particle sizes should fall between a No. 30 and 100 screen. Obviously, it is not always possible to find this ideal sand; therefore, a small percentage of particles coarser than a No. 18 screen and finer than the No. 100 screen must be tolerated, but this must be kept to a minimum.

DEVELOPING A CHEMICAL LAWN CARE PROGRAM

Roger Funk

Lawn care is big business. A number of lawn care services had gross sales last year of over $10 million. Lawn maintenance businesses are expected to grow by 25 percent in 1978, making lawn care a $2 billion industry.

Most of the services provide a dry or granular program, which has long been considered the industry standard. However, recent innovations have allowed the liquid application services to provide the same quality as dry programs. When developing a chemical lawn care program, one of the first major decisions is whether to apply the materials in a liquid spray or as dry granules.

FERTILIZERS

Granular fertilizers have a distinct quality advantage: they provide more uniform turf response and less potential for fertilizer "burn" than soluble fertilizers. On the other hand, plant nutrients are absorbed through the root system primarily from soil solution, and therefore fertilizers must be solubilized before they are available for absorption. Nutrients from liquid fertilizers are already in solution when sprayed on the lawn and are immediately available, whereas nutrients from granular fertilizers are available more slowly as the granule dissolves in soil solution.

But besides being more available, soluble nutrients are more readily leached from the root zone. Soluble fertilizers tend to move with groundwater much the same as dissolved sugar moves with coffee when poured from a cup. Thus, liquid, soluble fertilizers produce a rapid, succulent flush of growth of turf that yellows from a nutrient deficiency as the soluble fertilizers are leached below the root level. Granular fertilizers produce more uniform growth because the nutrients are more uniformly available.

Fertilizer "burn" is a visible symptom of excess soluble fertilizer salts in soil solution. When the concentration of these salts reaches a critical level, the absorption of water by plant roots is suppressed, resulting in physiological drought or burn. The higher the solubility of a fertilizer, the higher the burn potential.

To summarize fertilizer response, soluble fertilizers are immediately available but will cause turf burn at lower concentrations than will granular fertilizers and are leached from the root zone more quickly.

To counter these weaknesses, liquid spraying systems can incorporate powdered urea-formaldehyde, which does not go into solution but provides the same slow-release, nonburning qualities attributed to dry fertilization. Therefore, with the proper use of materials there is little, if any, difference between the response of turfgrass to fertilizer applied as granules and fertilizer applied in a water carrier.

Roger Funk is Research Director, Davey Tree Expert Company, and Director, Davey Lawnscape Institute, Kent, Ohio.

HERBICIDES

Liquid herbicides are more effective than granular applications in the control of broadleaf weeds. Even companies marketing a granular materials program usually apply liquid herbicides.

In the past, many liquid services have had a problem with herbicidal drift because of a waist-high delivery system. The higher the delivery height, the greater the effect of wind on spray distribution and drift. Fortunately, the development of nozzles designed to apply the spray close to the ground has allowed better control of the spray pattern.

EQUIPMENT

The initial costs for equipment may be an important factor in determining the application technique, particularly for a small company. The liquid system may cost more than twice as much to equip as a comparable dry system. Truck-mounted spray tanks with hose and reel usually cost more than $15,000, and some units may approach $25,000. A dry unit typically consists of a panel truck, a cyclone spreader, and a small truck-mounted or wheeled tank for weed control.

The major advantage of the liquid application technique is efficiency. The selection of compatible materials allows fertilizers and pesticides to be mixed in the spray tank and applied in a single application in about one-half the time required for a comparable dry program. The economic potential of a liquid program is obvious since, although labor is necessary for application, no actual benefit is derived from labor but rather from the materials applied.

OTHER MAINTENANCE CONSIDERATIONS

The development of the materials program is affected by soil and environmental conditions, by the turfgrass species, and by the weed, insect, and disease problems. The number of applications is determined by the length of the growing season and the timings for specific pest control.

Fertilization is the most important aspect of chemical lawn maintenance. More benefit is derived from fertilizer than from any other material applied to a lawn. Although the amount and types of fertilizer vary, most lawn care programs in the temperate zone apply between 3.5 and 4 pounds of nitrogen per 1,000 square feet.

Broadleaf weeds are a universal problem and are best controlled when the weeds are actively growing. A combination of 2,4-D, MCPP, and dicamba will control practically every weed in a home lawn and, if properly applied, will not constitute a hazard to trees and ornamentals.

Crabgrass is a problem in most areas and is usually controlled with preemergence herbicides. Postemergence herbicides for annual grass control cause turf to yellow and require repeated applications. Satisfactory crabgrass control generally takes at least two years, particularly if the turf is thin.

Insect infestations and their severity vary from one area to another and from one year to the next. Although surface insects can be controlled on a programed basis, soil insects are more effectively controlled when insecticides are applied as a service when the problem occurs.

Fungicides are not included in most areas because of the high cost of materials and because of the infrequent and unpredictable appearance of serious diseases on home lawns. An exception is brown patch in southern lawns. One or two fungicide applications are usually programed for the control of this disease. In the Midwest and Northeast, disease control is commonly offered as a special service and the customer is counseled regarding the seriousness of the infection and the alternatives to chemical control.

Personnel training is essential in developing a quality lawn care service. The proper application of the materials program and the ability to diagnose problems and advise the client are important parts of the service offered by a professional lawn care company.

ARE YOU SURE THAT'S THE PROBLEM?

R. E. Partyka

Probably one of the most difficult areas in which to diagnose a problem is the home lawn. Not only are the lawn sites variable, but also homeowners have different objectives for their lawns. The degree of the homeowner's interest will often determine the type of lawn to be found throughout the season.

In most cases, interest in turf is high in the spring after a long winter; the turf is responding after a period of dormancy and, barring a few winter problems, it will look good in the spring. In many cases, the homeowner feels that he is at least partly responsible for a good-looking turf. As the season progresses, however, his interest in his lawn may wane because of other activities; now the more basic underlying problems become more apparent. This is the time that lawn service companies will hear from their customers: "What did you do to my lawn?"

Diagnosing lawn problems in mid- to late summer, in fact almost any time, can be trying where little is known about the turf or area. Invariably, many questions must be raised and, with luck, the homeowner will be able to answer them. Unfortunately, man has a short memory and commonly fails to keep adequate records. The diagnostician may then find himself in a quandary when investigating a lawn site. Certain questions and clues may lead to the proper answer, but in other situations laboratory work is needed to reach a more accurate conclusion.

GENERAL MAINTENANCE

Numerous factors must be kept in mind when troubleshooting a home lawn turf problem. One area includes general maintenance practices such as mowing height for the turf species and mowing intervals. Proper removal of top growth to maintain a good top-to-root ratio is important for grass plant vigor. In many cases just a glance at the lawn will tell you how it is maintained.

SOILS

Poor soil probably creates more problems than anything else. It is now standard construction practice to remove all the topsoil, grade the lawn area with basement clay, and pack it with heavy equipment. A thin layer of "topsoil" is placed on top of this and a lawn is established by seeding or sodding. The turf responds and looks good for a while. Later, however, stress conditions may develop where mineral deficiencies occur, soil moisture becomes inadequate, roots fail to penetrate to adequate depths, or oxygen tension becomes too low for good root growth. In such circumstances, the turf easily becomes susceptible to diseases, insects, or environmental conditions. Some remedial practices can be used to restore the turf, but they are costly, must be done routinely, and in general will maintain only a mediocre turf because of the poor growing medium.

WATER

The failure to recognize the amount of water needed to maintain turf often results in undue stress to a lawn. Insufficient water, improperly designed irrigation

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systems, graded and packed lawn areas that encourage runoff rather than penetration, and a thatch buildup that results in a shallow root system contribute to lawn stress. Improper watering programs may create so much stress that the turf will fail to recover, especially if fertility levels have been adjusted for a high level of maintenance.

OVERALL VIEW

When looking at a problem, an overall view is important. Similar situations may exist on other lawns in the area and be a key in diagnosis. Homeowners see only their immediate area and are not concerned with other lawns unless they are better than theirs. Therefore, be aware of what is going on in the neighborhood.

Once an overview has been made, concentrate on a small or local area to determine whether the pattern fits that of a specific type of problem; for example, the symptom patterns of many pests are definitive. The next step should be to look at individual plants. Leaves, stems, crowns, and roots can often present clues that are helpful in determining the problem.

In cases where several factors may be involved, more work will have to be done by soil testing or other time-consuming laboratory procedures to help pinpoint the problem. Even though homeowners are often impatient and expect a solution on site, this may not be possible with a far-advanced problem. However, some recommendations can be made to start remedial procedures until a more adequate answer is found. Being familiar with the area will help determine what should be done. Especially where disease is concerned, knowing what types of problems can occur and at what time of the year is very important in making diagnoses.

In cases of temperature and moisture stresses, just watering may be sufficient. Of course, the old answer of, "I water plenty--look at my bill," comes up. Just convincing the homeowner to soak one spot for 24 hours will often show a remarkable recovery of the turf and help to prove a point.

SEASONAL PROBLEMS AND DISEASES

Early spring problems are often associated with snow mold damage to turf if snow accumulation has been excessive in certain areas. The dark sclerotia of *Typhula* sp. imbedded in the tissue or the pink mycelial growth of *Fusarium nivale* is evidence of this problem. Be aware of other factors that may confuse the issue, however, such as desiccation injury on high spots or around corners of buildings, ice smothering along drives and walkways or where children's snow forts were constructed, salt damage, or low areas damaged by freezing and thawing conditions in late winter.

As the season progresses, melting-out symptoms may appear, which are similar to sod webworm or billbug injury. Careful examination for insects or their damage will help differentiate these problems. Dollar spot and red thread on home lawns look similar to dog urine damage or mower burn from a distance. Close examination will reveal typical leaf symptoms of dollar spot, and coral pink strands on the ends of the blades will identify red thread. Stripe smut can be readily identified by the sooty spores in the infected blades and general unthrifty appearance of the diseased turf. Slime molds and powdery mildews are often present in turf, but powdery mildew is serious only in shady areas.

Fusarium blight has become a serious disease in many new or improved turfgrass varieties. A common symptom pattern, the frogeye effect, has become associated with this disease. Unfortunately, other diseases, including brown patch and Pythium blight, may also form a frogeye symptom, which confuses diagnoses and has resulted in poor control because of the use of improper materials. In general, Fusarium blight kills the crown of the plant; the roots and leaves are injured by the brown patch fungus, but the crown will remain viable for a longer period of time and, if weather conditions change, the plant will recover. Pythium blight, a hot-weather disease, is more common on ryegrass; it is generally identified by fungal growth during humid conditions and by the matted, collapsed appearance of diseased turf.

Rust and fairy rings can be readily identified, but yellowing of turf in definite areas requires much closer scrutiny to determine whether damage is from mineral deficiencies, nematodes, yellow tuft, aphids, or inadequate root systems on the plant. Soil testing is often needed to help resolve such problems.

OTHER PROBLEMS

Some problems are not as easily determined as diseases or insects but may be interrelated with them. At the beginning, drought stress may look like a disease problem. Root competition with trees weakens the turf and may resemble a disease or insect problem. Brown spots may be caused by spilled fertilizer, oil, or gasoline; heat reflection from a muffler; or footprints on frozen turf. Erratic patterns in narrow lines are often caused by mice but could be the result of vandalism. Observing how the turf recovers or taking a close look at the crowns can determine the cause.

Diagnosing home lawn problems is a definite challenge. Although frustrating when you have an irate customer, it can be rewarding when you find the answer.

TURFGRASS RENOVATION

John R. Street

Turfgrass renovation is a method of turfgrass improvement or rejuvenation beyond the routine cultural practices; its main feature is reseeding or replanting into the existing living or dead vegetation.

In renovation various cultivation techniques are used that bypass traditional reestablishment procedures such as complete turf removal and tillage with a plow or rotovator. Thus, renovation usually requires less effort, time, and labor than the traditional reestablishment approach. Reseeded areas will generally support traffic much sooner (4 to 8 weeks) since the soil is not loosened extensively. This is especially important on certain sport and recreational turfs where a minimal amount of time is available for reestablishment programs. In addition, the erosion hazard is significantly reduced, weed pressure is usually lower in seedling stands, and mulching in most cases is not required. This more moderate approach to restoration may also be more acceptable to homeowners when evaluated against total reestablishment.

The most important consideration prior to renovation is correction of the original cause or causes of turfgrass deterioration. Otherwise, the new turf may not establish itself properly or, once established, may deteriorate under conditions of stress. Poor turf may have developed for any number of reasons: (1) the use of unadapted species or cultivars; (2) undesirable soil conditions; (3) excessive thatch accumulation; (4) improper soil fertility and unfavorable soil reaction; (5) damage from insects, diseases, nematodes, or drought; (6) direct injury from fertilizer burn; (7) phytotoxicity from pesticides; (8) poorly designed or improperly used irrigation systems; (9) infestation of undesirable weedy species; and (10) improper cultural practices.

Undesirable conditions affecting turf can best be identified by a comprehensive analysis of the site. This means making a surface examination of the turf and adjacent landscape and characterizing the underlying soil by probing or other means. Many individuals conducting an on-site analysis fail to examine a key portion of the turfgrass environment, the growing medium. Thatch, soil compaction, buried debris, a shallow rootzone, or soil layering, among other factors, may be the key cause of poor turf performance. For example, surface examination may reveal Fusarium blight as the cause of turfgrass deterioration, but the disease incidence may have been favored by surface compaction or excessive thatch accumulation. In certain situations, several factors may be interacting to produce an unfavorable environment for turfgrass growth.

In many cases, specific weed species are frequently indicative of certain conditions unfavorable for turf. For example, excessive shade may result in the invasion of Kentucky bluegrass by ground ivy, chickweed, or annual bluegrass. Knotweed, goosegrass, and prostrate spurge typically occur on poorly drained or severely

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compacted sites. Severe infestation of creeping bentgrass may develop on poorly drained sites in a Kentucky bluegrass turf; for such sites the prerequisites to successful renovation would be improvements in soil drainage and soil aeration, or improvements in the irrigation program. Thus, a basic knowledge of environmental conditions favoring one weed or grass species over another can be a valuable asset in diagnosing field problems.

Many turf problems result from seeding grasses under environmental or cultural situations to which they are not adapted. Turfgrass species or cultivars should be selected carefully for the desired characteristics for a particular soil, environment, cultural intensity, and use. Species suitable for the northern climates include bentgrasses, bluegrasses, fescues, and ryegrasses. Kentucky bluegrasses are best adapted for use in open, sunny locations, while fine-leafed fescues are more suited to dry, shaded environments. In Illinois, fine-leafed fescues have not performed well on sunny sites where fine-textured soils predominate. The more improved turf-type perennial ryegrass cultivars (for example, 'Manhattan,' 'Pennfine,' 'Citation,' and 'Derby') may be included in mixtures where rapid establishment is desired. Bentgrass, because of its high maintenance requirement, is primarily confined to finely manicured sport turfs.

Within a particular species, turfgrass cultivars vary widely in their adaptation, pest resistance, and cultural requirements. In Illinois research trials, 'Touchdown,' 'Brunswick,' and 'A-34' Kentucky bluegrasses have proven more tolerant of close mowing (0.75-inch mowing height) than 'Kenblue,' 'Majestic,' 'Bonnieblue,' and several other cultivars. Consequently, cultivars in the latter group are more prone to invasion by annual bluegrass, creeping bentgrass, and other weeds. 'Nugget,' 'Merion,' 'Fylking,' and 'Pennstar' Kentucky bluegrasses are susceptible to Fusarium blight and should never be planted as a monostand. Blending several (two to four) adapted cultivars is highly recommended.

The decision to reestablish or renovate a turfgrass site is dependent upon the particular problem or problems involved and the degree of severity. Soil modification, extensive improvements in surface or subsurface drainage, severe compaction, and reshaping to improve the landscape design will usually dictate reestablishment over renovation. On the other hand, programs involving moderate improvements such as dethatching, core cultivation to reduce surface compaction, and the introduction of new species or cultivars could certainly be adequately accomplished by renovation.

HERBICIDE CONTROL OF COMPETING VEGETATION

The first step in any renovation program involves the control of undesirable vegetation. This usually requires the application of one or more herbicides. The choice of herbicides for renovation will be dependent upon the degree of renovation necessary and the grass species and weeds involved. Annual grasses such as crabgrass, foxtail, goosegrass, and barnyardgrass can be selectively removed from desirable turfgrasses with repeated applications of an organic arsenical herbicide such as DSMA or MSMA at 7- to 10-day intervals. Broadleaf weeds can be selectively removed with 2,4-D, mecoprop, silvex, or dicamba either alone or in combination. For broad spectrum control of broadleaf weeds, 2,4-D is usually used in combination with one or more of the latter herbicides. Herbicide combinations containing dicamba are very effective on difficult-to-control weeds but require cautious use around trees and shrubs, where uptake may cause damage. The residual activity of the broadleaf weed herbicides necessitates a waiting period of several weeks before overseeding. In general, a turfgrass area should contain 50 percent or more desirable turfgrass species to justify rejuvenation with organic arsenical or broadleaf herbicides.

An alternative treatment is to spot-treat or kill all existing vegetation with a nonselective contact or systemic herbicide. This procedure is sometimes referred to as the "scorched earth" technique. This method is usually required when high populations of annual grasses, broadleaf weeds, or undesirable perennial grasses exist on a site. Paraquat, a nonselective contact herbicide, is useful in renovating turfs infested with extensive populations of annual weeds. Because paraquat has low soil-residual activity, treated areas may be reseeded soon after chemical application. The most effective control of undesirable perennial grasses (such as bentgrass, tall fescue, bermudagrass, and quackgrass) is obtained with nonselective, systemic herbicides, which translocate into regenerative organs (stolons, rhizomes, etc.). Dalapon and amitrole have been traditionally used for this purpose. Their application should be followed by a waiting period of four to six weeks before reseeding because of their residual activity.

In our research trials the herbicide glyphosate (Roundup by Monsanto) has been quite effective for killing existing vegetation. Glyphosate is a broad-spectrum, nonselective, systemic herbicide that is rapidly inactivated once it contacts the soil. Applications of glyphosate at rates up to 16 pounds of active ingredient per acre, applied either preplant or preemergent to a prepared seedbed of Kentucky bluegrass and perennial ryegrass, had no effect on subsequent stand density or clipping yields. Thus, overseeding operations can be conducted shortly after glyphosate treatment with a high margin of safety to seeded species. A waiting period of at least three days is currently recommended, however, before reseeding a glyphosate-treated site; this allows adequate translocation of the herbicide to regenerative organs (stolons, rhizomes, etc.) of the plant before any cultivation is performed. Grasses with extensive underground rhizome systems, like quackgrass, may require repeated applications for effective control. Glyphosate is now registered for turfgrass renovation.

SEEDBED PREPARATION

The next series of renovation steps involves various cultivation procedures to provide an adequate seedbed for successful overseeding. The planting methods currently used for overseeding are slit or disc seeding and broadcast seeding after vertical mowing (thatching) or core cultivation.

It is critical in site preparation to expose sufficient soil to provide a good seedbed for germination and maximum seedling survival, whichever method of seeding is used. A common mistake in renovation operations is seeding on or within the thatch layer. Thatch is a poor growing medium not only for established turf but also for young turfgrass seedlings; it has poor moisture-retention characteristics, compared with soil, and repels water readily once it becomes dry. Thus, the moisture characteristics of thatch are very undesirable for seedling survival. Seeds distributed on or within thatch may germinate, but they commonly die during the initial seedling stage because of inadequate moisture availability. Thus, a *cardinal principle in renovation is to reduce and penetrate the thatch layer* to expose the underlying soil for seed or vegetative materials.

Vertical mowing (thatching)--cutting into the turf and physically removing excess vegetation and organic debris--may require several passes over an area before sufficient dead vegetation and thatch are removed to ensure proper seed-soil contact. Thatching machines should be adjusted to cut through the thatch and loosen or penetrate the underlying soil to a depth of 1/4 to 1/2 inch or more. The best solution to serious thatch problems may be to remove the turf with a sod cutter and reestablish grass on the bare soil.

Vertical mowing is commonly preceded or followed by core cultivation. In core cultivation, spoons or tines are inserted into the soil, and soil cores 2 to 4 inches long are brought to the soil surface. The soil cores are broken up by a light dragging or vertical mowing of the area. The soil material is distributed across the soil surface and introduced into any remaining organic debris that might be present at the surface. The loose soil acts as a light topdressing, further enhancing seed-soil contact. Core cultivation alone will usually require at least 8 to 10 passes over an area to disturb the soil sufficiently before overseeding.

Seeders are now available that provide for vertical mowing and seeding in one operation. These devices have vertical slicing knives in front to remove excess vegetation and loosen the soil surface. Next, free-rotation coulters cut slits into the existing sod. Seed is then dropped into the slits through seed distribution tubes. This method, referred to commonly as slit or disc seeding, is an excellent method of assuring good seed-soil contact and is very efficient in terms of labor and seed requirements. An obvious advantage is that overseeding can be accomplished with minimal disturbance to the turfgrass area. The success of this method is reduced where too much thatch exists or where soil compaction is too severe.

The "scorched earth" method appears to have proved most successful in renovation programs since all existing vegetation is killed, thus eliminating any future competition. Competition between young seedlings and existing vegetation is an important factor influencing the degree of renovation success, especially when overseeding into an annual bluegrass infested turf. On established sites, seeding into existing live vegetation may take more than a year to introduce a sufficient percentage of new grasses. Competition from existing vegetation can sometimes be reduced by lowering the mowing height until the seeded turf has germinated and can compete for light, nutrients, and moisture. Growth regulators are presently being evaluated for use in reducing the growth and competitive ability of existing vegetation during overseeding.

SEEDING AND MAINTENANCE

Adequate fertility and pH levels are essential in renovating and maintaining a new turfgrass area. Nutrient deficiencies or improper soil reaction may have been responsible for the original turfgrass deterioration. Thus, several weeks before renovation, representative soil samples should be taken and submitted to a reputable soil testing laboratory for analysis. Corrective applications of fertilizer, lime, or acidifying materials should be applied during cultivation so that these materials can be mixed to some extent with loosened soil and can penetrate to deeper soil depths.

A nitrogen or complete fertilizer may be applied at seeding for starter purposes; however, overapplication of fertilizer may simply increase competition for existing grasses and new weed seedlings. One should also be careful not to apply excess quantities of corrective fertilizer and lime since high concentrations of salts may severely burn or damage young seedlings. In some cases, multiple applications of lime or fertilizer over a period of time may be necessary following renovation.

The best time for turfgrass renovation is during the late summer or early fall, at which time temperature, moisture, and evapotranspiration rates are highly favorable for germination and seedling survival. All renovation practices should be well planned in advance so that seeding can be accomplished at the optimum time. Early spring and late fall renovations are discouraged on highly maintained turf areas since these are peak germination and growth periods for annual bluegrass. Sport or recreational turfs that are under intensive use during the fall should be renovated as early in the spring as possible. It may be advantageous to use siduron (Tupersan) in spring operations to reduce the potential pressure from anuual weeds.

The recommended seeding rate for broadcast seeding is 1 to 1-1/2 times the normal rate; for disc seeding, 1/2 the normal rate is suggested. Higher rates for disc seeding may increase competition among seedlings within slits, resulting in reduced development or survival of seedlings. For Kentucky bluegrass blends, suggested seeding rates for broadcast and disc seeding are, respectively, 2 to 3 pounds and 1/2 to 1 pound of seed per 1,000 square feet. Dragging or raking the area after seeding is recommended to cover the seeds and to try to carry seeds into the slits or holes produced by vertical mowing or coring. During the germination and establishment period the area should be thoroughly irrigated to a depth of 6 inches and the surface moisture maintained. A light application of nitrogen fertilizer can be applied three to five weeks after seeding to enhance the establishment rate. Activity on the renovated area should be limited for at least four to six weeks after overseeding.

Renovation is not a panacea. There have been reports of both successes and failures. Careful planning and a thorough understanding of the various techniques involved are necessary for success. Individuals unfamiliar with these procedures should practice these on small areas first. Finally, good cultural practices must be incorporated into the overall management program following renovation to sustain long-term turfgrass quality.

A PRACTICAL APPROACH TO LAWN DISEASE CONTROL

J. M. Vargas, Jr.

The easiest way to control Kentucky bluegrass diseases is through the use of cultivars that offer the best disease resistance to the three major diseases and through the use of sound cultural practices with these resistant cultivars. The major diseases are melting-out, caused by *Helminthosporium vagans;* Fusarium blight, caused by *Fusarium roseum;* and stripe smut, caused by *Ustilago striiformis*. The minor diseases are powdery mildew, caused by *Erysiphe graminis;* the rusts, caused by *Puccinia* spp.; dollar spot, caused by *Sclerotinia homeocarpa;* and fairy ring, caused by various fungi, mostly in the class Basidiomycetes.

MINOR DISEASES

Powdery mildew is a problem on some Kentucky bluegrass varieties (for example, 'Merion,' 'Baron,' 'Fylking') when they are grown in the shade. The solution is to avoid planting susceptible varieties in the shade and instead use Kentucky bluegrass cultivars like 'Warren's A-34' and 'Nugget' in the northern part of the state where they are adapted to shade. You may also wish to consider using other species of grass in the shade. The fine-leaf fescues will do well in dry shade, and *Poa trivialis* can be used under dense, moist shade.

The rusts are a problem on slow-growing turfs, usually because of the lack of nitrogen fertility. The rust problem can be eliminated by increasing the amount of nitrogen or the frequency of the nitrogen application so the turf is mowed at least once a week. If Kentucky bluegrass fails to respond because of cool weather, applications of a fungicide like Fore, Zineb, or Tersan LSR should correct the problem.

Dollar spot can usually be controlled in Kentucky bluegrass by increasing the nitrogen; however, in the more southern areas of the state, chemical control may be necessary. Planting 'Nugget' should be avoided in areas where dollar spot is a problem.

This leaves only fairy ring as an unsolved problem. Fairy ring is really not a disease problem in the sense that a pathogen attacks a grass host; it is simply a fungus growing in the thatch or organic matter. The fungus body (mycelium), which is hydrophobic, forms a water-impervious layer. Consequently, where the main body of the fungus is located, the turf dies from lack of water. The only controls are to remove the fairy ring and the contamined soil and replace it with clean soil, or fumigate the area. Fairy rings are most often found in turf areas where tree branches, roots, or trunks have not been removed or where they have been used as fill. Avoiding such practices will help prevent the development of fairy rings.

MAJOR DISEASES

Most of you probably do not consider melting-out to be a major problem in Kentucky bluegrass. It is not a major disease problem because of the many *Helminthosporium*-resistant cultivars that have been available for many years. The popularity and

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wide use of 'Merion' can be directly attributed to the fact that it was the first and only *Helminthosporium*-resistant cultivar available for many years. Today, Fusarium blight and stripe smut receive all the notoriety as the major diseases of Kentucky bluegrass; however, if it were not for the many *Helminthosporium*-resistant cultivars available, Fusarium blight and stripe smut would not be important because melting-out would have eliminated the desirable Kentucky bluegrasses long before Fusarium blight and stripe smut had a chance to be a problem!

What are the best *Helminthosporium*-resistant cultivars? Many cultivars have excellent melting-out resistance, but this disease cannot be looked at alone: Fusarium blight and stripe smut must also be taken into consideration. 'Merion' and 'Windsor' have excellent resistance to melting-out but are very susceptible to stripe smut and Fusarium blight. 'Fylking,' 'Nugget,' and 'Pennstar' likewise have excellent resistance to melting-out, but all are highly susceptible to Fusarium blight. Using any of these cultivars will result in an unsatisfactory turf.

Rather than trying to list all the Kentucky bluegrass cultivars that are susceptible to stripe smut and Fusarium blight, it is better to emphasize the positive and list what today appear to be the varieties with the best resistance to all three diseases:

'Cheri'	'Majestic'	'Edmundi'	'Baron'
'Adelphi'	'Touchdown'	'Parade'	'Warren A-20'

Since blends give added strength to a turf, especially against such diseases as stripe smut, a blend of three or four of these Kentucky bluegrass cultivars would be ideal.

This is not to say that these cultivars will always remain resistant or that some new disease won't come along and destroy them. However, on the basis of our present knowledge, these are the best varieties available. At least there is a chance to have a disease-free turf using these resistant cultivars. No such chance exists when you use the disease-susceptible cultivars like 'Merion,' 'Fylking,' 'Pennstar,' 'Nugget,' and 'Windsor.'

Proper cultural practices consist of watering in the daytime to allow the foliage to dry before dark; maintaining adequate levels of phosphorus (P_2O_5) and potassium (K_2O), based on periodic soil tests; and properly timing nitrogen applications. The table has a schedule for the Kentucky bluegrass turfs on fairways, park areas, industrial sites, or home lawns in the Illinois area. If we start with a cultivar of Kentucky bluegrass that is resistant to *Helminthosporium*, our two main concerns are going to be Fusarium blight and stripe smut. The nitrogen fertility schedule was developed with this in mind. By limiting the nitrogen fertility in the spring, the severity of Fusarium blight should be reduced; by limiting the nitrogen fertility in the summer, the amount of turf lost to stripe smut should also be reduced. Not fertilizing in the fall and avoiding lush growth going into the dormant season will reduce the severity of Typhula blight and Fusarium patch. A late fall application of nitrogen after the last mowing should give a slow, steady green-up the next spring and avoid the surge of lush growth that spring applications often produce. This lush growth in the spring is what encourages Fusarium blight problems later.

This nitrogen fertility schedule will be a tough one to implement, because of human nature. Most people are tired of their lawns by Labor Day and it is very difficult to get them to apply a late fall application of nitrogen. Likewise, it is just as difficult to get them not to apply large amounts of nitrogen in the spring when they have been "dormant" all winter, but if disease-free turf is desired, this is the best schedule to follow.

Nitrogen Fertility Schedule for Kentucky Bluegrass Turfs in the Cool-Season Grass Belt (pounds of nitrogen per 1,000 square feet)

	April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
Region	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
Southern:																		
High maintenance			1/2		1/2					1/2		1					1 (Dormant)	
Low maintenance					1/2												1 (Dormant)	
Diseases[a]	Melting out Fusarium blight				Stripe smut————							Fusarium patch						
Middle:																		
High maintenance					1/2					/1/2	1					1 (Dormant)		
Low maintenance					1/2						1					1 (Dormant)		
Diseases[a]	Melting out—— Fusarium blight					Stripe smut————					Fusarium patch———							
Northern:																		
High maintenance					1/2		1/2			1					1 (Dormant)			
Low maintenance					1/2					1					1 (Dormant)			
Diseases[a]	Melting out———— Fusarium blight						Stripe smut				Fusarium patch							

[a]Time of season when excess nitrogen fertility will increase the severity of the disease listed and *not* necesarily the time of year the disease occurs.

Dollar spot, red thread, and rust, which nitrogen fertility helps reduce, are not indicated, but this schedule will help reduce the severity of these diseases.

KENTUCKY BLUEGRASS TURFS WITH EXISTING DISEASE PROBLEMS

Melting-out

If you have a *Helminthosporium* melting-out problem in your turf now, you must be growing one of the "common types" of Kentucky bluegrass. To control melting-out, you should really begin your fungicide spray program in the fall when the cool, wet weather begins (temperature below 70° F.); use a fungicide like Daconil 2787, Dyrene, Actidione-thiram, Tersan LSR, or Fore on a 7- to 10-day basis. After making your last mowing, you should apply a fungicide treatment using one of the PCNB products. The PCNB products are the only fungicides that give protection for the entire winter period without having to be reapplied; on the other hand, they tend to be a little phytotoxic (will cause yellowing) when used in warm weather. With the arrival of spring, one of the fungicides applied in the fall will have to be applied again on a 7- to 10-day basis until summer weather arrives. Obviously, a fungicide program for the control of *Helminthosporium* can be very time consuming and costly, which all goes back to "do it right the first time"--specifically, plant a resistant cultivar.

Fusarium blight

Fusarium blight symptoms appear when the infected plants are under drought stress. Light, frequent waterings during dry periods will help suppress symptom development. Heavy, infrequent waterings are of little use because infected plants have short roots, usually no longer than an inch. Fusarium blight-infected turfs need no more than 20-minute waterings at any time, but they need it daily during warm weather and every two to three days during cool, dry weather. The ideal time to water would be at midday, the warmest time.

Chemical control can be obtained with any of the benzimidazole systemic fungicides (Tersan 1991, Fungo, Cleary's 3336), provided they are applied properly. This means irrigating the area the night before and drenching in the systemic fungicide before it has a chance to dry on the foliage. You are dealing with a crown and root rot problem, and that is where you need to get the fungicide. Fungicide will be translocated upward, but it is not translocated downward. This treatment is very expensive; because of the expense, many people have the idea that one treatment will cure their problem forever. It won't. You will need to treat every year if you don't want the problem to recur. It is no different from spraying your roses or apples every year for their disease problems.

Resistance to the benzimidazole systemic fungicides has been reported for some strains of *Fusarium* fungi. This should not be surprising since the development of resistance to the benzimidazoles has been reported for every other major pathogen on which they were used exclusively. This means that you will probably have success in controlling your Fusarium blight for two or three years; after that, you may not be able to obtain control.

In Michigan we have found nematodes also are involved in the development of Fusarium blight. The two most common nematodes associated with the disease are the stunt nematode (*Tylenchorhynchus dubius*) and the ring nematode (*Criconemoides* spp.). They appear to predispose the Kentucky bluegrass plants to infection by *Fusarium*. The nematodes continue to feed upon the plant's roots even after infection by *Fusarium* has occurred, causing additional stress on the infected plants. We have been able to control the disease with nematicides like Dasanit at 3 pounds per 1,000 square feet. These nematicides are extremely toxic and should be used only by professionals. Because of their toxicity, they should not be used on home lawn turfs, but rather on golf course or general turf areas. These areas should be closed to the public the day nematicides are applied. The nematicides should be drenched in for maximum benefit and for safety reasons. Besides the nematicides, systemic fungicides can reduce the nematode populations when they are drenched into the soil.

Stripe smut

A turfgrass plant infected with stripe smut is infected for life. All plants arising from the infected mother plant will be infected. It is a systemic disease that may remain dormant in the crown of the plant, or it can spread up the veins of the leaves, eventually rupturing the epidermis and releasing many black spores that may attack other plants. Whether you see the spores or not, the plant is always in a weakened condition and the first stress that comes along will kill it. The most common stress is drought. People who take good care of their lawns and water them religiously while they are at home go away on vacation and forget them, only to find them destroyed with stripe smut when they return. If you have a healthy lawn, the Kentucky bluegrass will simply go dormant when not watered and will revive again once water is applied. However, if your lawn is infected with stripe smut and you allow the same thing to happen, the lawn will die. It is important not to let a stripe-smut-infected lawn dry out.

Stripe smut can be "controlled" (more like arrested) with high rates (4 to 8 oz. per 1,000 sq. ft.) of the benzimidazole systemic fungicides. The best results are obtained when the systemic fungicides are applied as dormant drenches. However, applying the systemic fungicides as dormant drenches increases the amount of melting-out in the spring. Even *Helminthosporium*-resistant cultivars like 'Merion' become susceptible after such treatments. This means that the stripe smut treatment must be accompanied by a melting-out treatment, and the PCNB fungicides are the only ones that give this long-term *Helminthosporium* control over the entire dormant period.

Late spring and early fall applications of the benzimidazole systemic fungicides are also effective against stripe smut, if they are applied when the grass is actively growing. Avoid applying them when grass growth is beginning to slow down because of warm or cold temperatures. While this is not as effective as dormant applications, it does avoid melting-out problems.

But what is the bottom line? The bottom line is that these are merely stop-gap measures. The systemic fungicides, no matter when they are applied, do not eradicate the disease; it comes back every year. Resistance to the benzimidazole systemic fungicides has been reported for every major pathogen on which they have been used exclusively, and resistance to the systemic fungicides in the smuts will also occur. So, you may be able to get two or three years of stripe smut control.

SUMMARY

I think the answer to a Kentucky bluegrass turf infected with melting-out, Fusarium blight, or stripe smut is to renovate it and reseed it with a blend of resistant cultivars. This is not the time-consuming project it was when we had only herbicides like Dalapon and Amitrol. It used to require a six-week waiting period after application before reseeding could begin. With the newer herbicides like Roundup, reseeding can begin three to four days after treatment. It might seem like a big project, but it is a lot easier and less expensive in the long run than trying to control melting-out, Fusarium blight, and stripe smut every year with fungicides.

There is one exception to using the improved Kentucky bluegrass cultivars, specifically, in low-maintenance areas such as roadsides, parks, general use areas, and any area where less than 2 pounds of nitrogen per season or no supplemental irrigation is going to be applied. The common Kentucky bluegrass should be used in these areas, as they will survive better under low maintenance conditions. They should be maintained at a minimum 3-inch height of cut for best results. This will not have the appearance of first-class turf, but it will look better and survive better than the improved varieties under low maintenance conditions.

FERTILIZERS FOR THE LAWN CARE INDUSTRY — PRO AND CON

Roger A. Brown

We all know plants need the major nutrients nitrogen, phosphorus, and potassium. But what else do they need besides light, air, and water? They require the secondary nutrients--calcium, magnesium, and sulfur--and micronutrients--iron, manganese, copper, zinc, boron, and molybdenum.

ROLE OF FERTILIZER NUTRIENTS

Nitrogen is the nutrient that is so important in the growth of the visible portion of grass. It can promote or retard disease, winter hardiness, *Poa annua*, and the overall general health and stamina of the plant. Because it is so important and affects the top growth so dramatically, it is often overused, underused, or generally misused.

The amount of nitrogen used greatly determines the needs of all the other nutrients. Grass normally needs 1-1/2 to 2-1/2 times as much nitrogen as potash, and twice as much potash as phosphorus; this would be a ratio of 4 or 5 parts nitrogen to 1 part phosphorus to 2 or 3 parts potash.

Soil test surveys show us that much of the turf in the Midwest is not getting enough phosphorus or potash. Twenty percent of the soils tested were medium to low in phosphorus, and 58 percent were medium to low in potash. The type of grass, soil, and climate and the amount of traffic dictate how much fertilizer should be used.

You may have heard that our soils are too high in phosphorus and we don't need to add any more. Unless you have tests that conclusively show this, don't assume it. In the first place, when we refer to the middle number on the bag as phosphorus, we are technically not correct. The middle number is the percentage by weight of P_2O_5 (phosphoric oxide), 56 percent of which is oxygen. So only 44 percent of that middle number is phosphorus. Add to that the fact that phosphorus moves very little either laterally or vertically in the soil. In fact, it takes several years for surface-applied phosphorus to move 1 inch into the soil. Only 10 to 30 percent of the P_2O_5 applied this year will be available to the plant. If you apply 20 pounds per 1,000 square feet of a fertilizer containing 5 percent P_2O_5, over the growing season your grass will be getting 1 pound of P_2O_5 per 1,000 square feet, but only 1/5 to 2/3 pound of actual phosphorus per 1,000 square feet. Because of this, regular feeding of low phosphate grades is important. Phosphorus is needed for building strong, deep roots and promoting new growth.

Potassium (potash) is the second most important major turf nutrient. It makes the grass stem more rigid by making the cellular walls thicker. This makes the grass stand up faster after being stepped on. The thicker wall structure makes the grass less accessible to penetrating fungus spores and thereby more resistant to

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disease. Potash also helps phosphorus and nitrogen work better together. The third number on the fertilizer bag refers to potassium oxide, K_2O, not 100 percent potassium. Seventeen percent of K_2O is oxygen, and only 1/2 of the potash is available to the plant the year of application. Consequently, if you applied 2 pounds of K_2O per 1,000 square feet, over the growing season your grass would actually be getting only 5/6 pound of actual potassium per 1,000 square feet.

What about secondary and micro- or trace elements? Is it true that most soils have enough secondary trace elements to grow grass forever? The answer is yes and no. If you want grass to grow the way Mother Nature intended, several feet high in bumps and clumps, going to seed, dying and recycling, then, yes, most soils have enough elements to handle it. But suppose you start using a fancy variety and cut it from 2 inches to 3/16 inch high; push it with water and food; tramp on it, drive on it, scalp it, and divot it; and throw the clippings away--then it stands to reason you are going to have to replenish in some way what you are not allowing nature to replenish naturally. You have to put back the sulfur, calcium, magnesium, boron, iron, manganese, zinc, molybdenum, and copper. When you force a plant to grow under stressful conditions, soil nutrients are used up faster and leached down beyond availability to the roots; sometimes they become tied up because of pH conditions.

The most important secondary element for turf is sulfur. Sulfur deficiencies in soil have increased greatly in the last 10 to 20 years. In 1962, there were only 13 states deficient in sulfur; now there are over 30, including Illinois.

Without sulfur, grass will turn an intense yellow. Sulfur is needed to help the following processes:

1. Produce chlorophyll;
2. Activate important enzymes and vitamins;
3. Build protoplasm, which increases cold and drought resistance;
4. Improve water penetration in the soil;
5. Improve soil structure;
6. Increase availability of micronutrients;
7. Reduce diseases (adequate sulfur reduces Fusarium patch by 86 percent and helps prevent dollar spot and powdery mildew; it even helps prevent *Poa annua* from infesting bentgrass);
8. Stimulate soil organisms.

The important thing to remember is that sulfur does all this when applied in combination with N-P-K. The relationships among the major and secondary nutrients are important. The more nitrogen that is used, the more sulfur that is needed. Generally, plants contain as much sulfur as phosphorus. So you should apply about 1/3 to 1/4 as much sulfur as you do nitrogen.

What about the micronutrients? Iron is the most important; it prevents yellowing and helps produce chlorophyll.

All nutrients play an important part in filling the plant's needs. They are like links in a chain. Break one link and the chain loses its strength.

FERTILIZER COMPOSITION

Okay, we've talked about what the plants need and why. Now let's talk about some basic information on what turf fertilizer really is.

The three numbers on the fertilizer bag always designate nitrogen--phosphoric oxide (P_2O_5; P_2O_5 x .44 = phosphorus)--potassium oxide (K_2O; K_2O x .83 = potassium). It works the same in liquid fertilizer. If 1 gallon of liquid fertilizer weights 10 pounds, then a 5-gallon drum is equal to a 50-pound bag of dry fertilizer. A 55-gallon drum of liquid is equal to eleven 50-pound bags of dry fertilizer.

Grade numbers measure quantity, *not* quality. This is important to remember.

Seven important sources of nitrogen used for turf are urea, ammonium nitrate, ammonium sulfate, ureaformaldehyde, sludge, IBDU, and sulfur-coated urea.

Ammonium sulfate is 21 percent nitrogen and 23 percent sulfur--that's good, we need sulfur. The only problem is ammonium sulfate liberates almost all of its nitrogen in 3 to 4 weeks; as a source of water-soluble nitrogen, it is more expensive than others. Its salt content is high--its salt index is 3.5 per unit of nitrogen. Salt index or salt content in a fertilizer is what causes the problem. High salt concentration literally dehydrates the plant to death.

Sludge is safe and contains nitrogen and phosphorus. In most natural organics, 50 to 60 percent of the nitrogen is released in 3 to 4 weeks, but because of the low analysis, large amounts are needed to get the amount of nutrient needed. This means more labor and handling, more storage, and more freight costs.

Urea is 45 percent nitrogen; it converts to ammoniacal nitrogen within 1 to 3 days after application and is referred to as water-soluble organic. It is held by soil particles more so than nitrate-nitrogen is, so it is leached less than other water-soluble sources. One of the best of all chemical nitrogen sources for turf, urea lasts longer, is leached less, and has a low salt content per unit of nitrogen: 1.6 salt index.

Ammonium nitrate (33-0-0) is quick acting, perhaps a little too quick. It has a very high salt index, the third highest in the salt index chart for nitrogen sources; its salt index per unit of nitrogen is 3. This is the kind of N used in many farm fertilizers and 28-0-0 solution.

Liquid nitrogen (28-0-0) is designed for application to plowed ground, not growing grass; it has killed many a lawn through misapplication, so a cheap source of nitrogen becomes an expensive source.

LIQUID VS. DRY LAWN CARE SERVICE

Which is the best method for lawn care service, liquid or dry? Why are all the giants in lawn care liquid? The best method is liquid--and dry. Some things can be accomplished more efficiently and economically in liquid form and some in dry.

Let's look at the pros and cons of liquids and dry fertilizers in a lawn care service.

LIQUID APPLICATION LAWN SERVICE

PRO

1. Easier and faster to apply (One man can treat 180,000 to 200,000 square feet, or 5 acres, or 20 to 25 customers per day)
2. Several treatments possible in one spray application
3. Faster visual results
4. More professional looking
5. Better weed control

CON

1. Expensive initial investment--$15,000 to $25,000 for equipment
2. Easy to miss or skip
3. Can't spray on windy days or below freezing
4. Dursban and Balan more effective in dry granular form
5. Difficult to uniformly spray secondary nutrients and micronutrients
6. Form of slow-release nitrogen that can be sprayed in slurry is very expensive
7. Higher salt content

DRY GRANULAR LAWN SERVICE

PRO

1. No major investment in equipment
2. Fillups of water not necessary
3. Easier to go from point to point
4. No mixing on the job
5. Effects last longer and are leached less
6. Micro- and secondary nutrients and slow-release nitrogen easy and ecomical to include in your ready-to-spread product
7. Dursban and Balan work better with longer lasting benefits
8. Application is almost as fast as liquid
9. Less chance for error in application
10. Less hazardous to your health
11. Salt content easier to control

CON

1. Equipment not as impressive looking
2. Empty bags to dispose of
3. Labor in dumping product in spreader
4. Takes a little longer to see results and apply
5. One man can cover 160,000 to 185,000 square feet per day, or 4 to 4-1/2 acres, or 16 to 22 customers
6. Fall application more difficult because of leaves

Spraying liquids made from dry water-soluble fertilizer can save paying freight on water and expensive metal or plastic drums. Some equipment can handle regular granular fertilizer. Try to buy high-concentrate analysis fertilizer that does *not* have any inert carrier such as limestone, vermiculite, or corn cobs--just raw material.

In determining what type of fertilizer to buy, consider the following:

1. From whom are you buying it? Are they reputable? Do they stand behind what they sell?

2. Who is the manufacturer? Will they be here tomorrow? Are they capable of producing a consistent quality of fertilizer?

3. Does the product meet your nutritional requirements? Does it have the desired ratio of nitrogen, phosphorus, and potash? Does it include water-insoluble nitrogen? Does it contain the secondary and micro- or trace nutrients you need? Does it contain the type of nitrogen and potash you prefer?

4. Will it spread properly? Are particles uniform and large enough for broadcasting?

5. It it manufactured in such a way that it won't segregate and streak the turf? Is it uniform in particle size? Will the product flow easily through the spreader?

As you know, the lawn service is the fastest growing industry of its type. When will we hit the saturation point of too many lawn service companies in a given area? I think we have in some areas already. How is it possible for new lawn service accounts to move into saturated areas and pick up hundreds of new customers? Easy--in one small town, a brand new lawn service company solicited and got 1,000 new customers in two months' time. They were all customers who were dissatisfied with their previous lawn service company, which had burned up the grass.

Survival of the fittest is true of this industry, like any other. The cheapest may get some of the business for the short term, but the lawn service company operators who know what they are doing and why, and who do not cut corners in quality of product, service, or knowledge are the ones that will remain when the rest are long forgotten.

WARM-SEASON TURFGRASSES: SELECTION AND ESTABLISHMENT

H. L. Portz

Can warm-season turfgrasses such as bermudagrass and zoysiagrass be successfully used in the transition zone? The answer is debatable and varies from, "It's a damn weed," to "It's the best lawn carpet I've ever seen." The transition zone is located between the ideal climates for the cool- and warm-season grasses, roughly from Maryland and Virginia through the Midwest to Kansas. Bermudagrass is queen of the South, from lawn to golf green and everything in between. Zoysiagrass is less prominent and has greatest use in the "Upper South" and in the transition zone such as in St. Louis-area golf courses and Carbondale lawns.

The three Southern Illinois University turfgrass research locations are at Old Warson Country Club, St. Louis; Belleville Research Center, Belleville, Illinois; and Southern Illinois University at Carbondale; all are in the transition zone. Research at Old Warson is in cooperation with the University of Missouri and the University of Illinois.

The emphasis in this presentation will be (1) selection of species and cultivars for the transition zone and (2) their establishment.

SELECTION OF SPECIES AND CULTIVARS

Some of the advantages and disadvantages of cool- and warm-season turfgrasses can be summarized as follows:

Cool season--excellent in fall and spring, easy to establish from seed, often dormant in summer, susceptible to many disease and insect problems, usually needs irrigation for summer quality.

Warm season--excellent in the summer, tolerant to drouth and heat, winter dormancy with "dead" look, possible winterkill with bermudagrass, vegetative propagation necessary, often considered a weed.

Selection of species depends on matching species characteristics with the intended use and site:

BERMUDAGRASS (*Cynodon dactylon*)
--full sun required.
--wear-tolerance good, with especially rapid recovery; good for lawns, football fields, and golf tees.
--cold-tolerance variable, limited to southern Illinois; depends on cultivar selection, winter severity, and site exposure or protection.
--rapid and easy establishment.

ZOYSIAGRASS (*Zoysia japonica* and *Z. matrella*)
--more shade tolerant.
--good wear-tolerance but slow recovery; good for lawns and golf fairways.
--cold-tolerance good, adequate for Illinois.
--slow establishment, area needs to be fully prepared and weeds controlled.

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Table 1. Characteristics of Zoysiagrass Cultivars at Old Warson Country Club[a]

Cultivar	Texture[b]	Vigor (% stand) 13/5/76	Greenup 18/5/77	Fall color 11/11/77[c]	General appearance[d] 18/4/77	1/9/77
KSU 34-35A	MF	40	7	7	7	8
FZ-30	C	80	7	8	8	9
FZ-79	MC	80	8	6	7	8
FZ-93	MC	50	8	6	7	9
FZ-102	F	70	7	7	7	8
FZ-18	MF	60	8	6	8	8
FZ-26	C	80	7	8	7	9
KSU 34-35B	MF	60	7	5	7	8
KSU 56-18	M	20	7	6	6	7
Meyer	M	70	8	6	8	9

[a]Established 16 May 75; rated in 1976 and 1977.
[b]F=fine, MF=med. fine, M=med. (Meyer), MC=med. coarse, C=coarse.
[c]9=full color, 1=no green color.
[d]9=best, 1=poorest.

Twenty-two cultivars of bermudagrass and twenty of zoysiagrass are being tested at the three S.I.U. research locations. Sources are from Ray Keen, Kansas; John Dunn, Missouri (collection from G. Burton, A. Dudek, and others throughout the United States); and Jack Murray and Jerrold Powell, USDA, Maryland.

Characteristics and performance of zoysiagrass cultivars at Old Warson Country Club are noted in Table 1. Several cultivars ('FZ-30,' 'FZ-79,' and 'FZ-26') showed slightly better establishment vigor than 'Meyer' (80 percent cover in one year compared with 70 percent for Meyer). By September 1, 1977, no cultivar exceeded 'Meyer' in overall quality and general appearance although two coarse-textured cultivars, 'FZ-30' and 'FZ-26,' held fall color exceptionally well. A September 14 application of nitrogen probably helped most cultivars retain fall color.

In Table 2, the performance of bermudagrass cultivars at two locations is summarized. A number of new cultivars--'Midiron,' 'St. Joseph,' 'Q-17,' and 'Westwood'--exceed the old standard 'U-3' in greenup and general appearance ratings. 'Tufcote' bermudagrass establishes much more rapidly than 'U-3.' 'Midiron' and 'Westwood' are considered the most hardy cultivars, but there has not been a cold, open winter in the last two years to thoroughly test the cold tolerance of the cultivars.

ESTABLISHMENT

Common bermudagrass is normally established by seed, but plants produced from Arizona-grown common seed are not as winter hardy as local common seed. Also, common bermudagrass does not develop into a dense, desirable turf. The improved cultivars of bermudagrass are mostly sterile, however, so vegetative propagation of these cultivars is necessary. Zoysiagrass will produce some viable seeds, but the low yields, low germination, and very slow and variable germination time (2 to 8 weeks) also necessitate vegetative propagation.

Methods of propagation for bermudagrass usually are by sprigging, plugging, and sometimes stolonizing (broadcasting). For zoysiagrass the most common method is

Table 2. Performance of Bermudagrass Cultivars at Old Warson Country Club, St. Louis, Mo., and Southern Illinois University at Carbondale, Il.[a]

	Greenup[b]			General appearance[c]		
	St. Louis		Carbondale	St. Louis		Carbondale
Cultivars	7/4/76	18/4/77	30/3/77	3/6/76	28/4/77	18/4/77
Tufcote			2		6	
Tiflawn			1		3	
Tiffine			2		5	
KSU D-17	5	6	3	4	6	6
KSU E-7			3		6	
NK K8-18	3	1	1	4	1	1
KSU A-8	6	6	4	5	6	6
KSU P-1			3		7	
Midway	3	6	3	6	6	5
C-9	3	5		7		5
Midiron	5	5	4	7	7	5
KSU T-4	5	6	3	7	7	4
St. Joseph	5	6	3	7	7	5
KSU Q-17	3	4	3	8	7	3
C-53	5	6	3	6	7	5
Westwood	5	5	4	7	7	5
U-3	3	4	3	7	5	4

[a]Established May, 1975; rated in 1976 and 1977.
[b]9=Full green color, 1=no green color.
[c]9=best appearance, 1=poorest. Early dates of 18 and 28 April under general appearance indicate winter hardiness and spring vigor.

plugging with some sodding (full or strip) and occassionally sprigging or stolonizing large areas such as golf course fairways. Plugging into existing turf may take from 3 to 5 years to produce a monostand of zoysiagrass. J. Manka successfully established 'Meyer' zoysiagrass by hydrostolonizing at Old Warson Country Club in 1969; the procedure consisted of verticutting to obtain vegetative material, hydrostolonizing, rolling, and irrigating, followed by a herbicide application of atrazine at 6 weeks.

Initial stolonizing experiments with use of pre- and postemergence herbicides were begun in 1976 at S.I.U.-Carbondale. Good weed control was obtained with simazine, diuron, and atrazine; however, excessive phytotoxicity from those three herbicides prevented good establishment. Good weed control and the best cover by fall was obtained with use of siduron.

Herbicides and activated charcoal

To reduce injury from the "hotter" herbicides, activated charcoal was tested as a stolon dip. Greenhouse results are shown in Table 3. Phytotoxicity on 'Tufcote' bermudagrass was reduced considerably with use of activated charcoal. An increase in stolon number and length was especially significant with use of stolons treated with activated charcoal and diuron, simazine, and methazole. However, a reduction in weed control was observed with use of activated charcoal. Results were similar with 'Meyer' zoysiagrass.

Table 3. Establishment of 'Tufcote' Bermudagrass Treated With Four Pre-Emergence Herbicides and Activated Charcoal, Greenhouse Experiment, 1977

Chemical treatment	Rate of active ingredient	Phytotoxicity and vigor[a] 8 May	Phytotoxicity and vigor[a] 17 May	Stolons (18 May) No.[b]	Stolons (18 May) Length[c]	Weed control (8 May)[d]
Check		8.0	6.7	11.7	27.4	2.0
Check + a.c.[e]		8.3	8.0	15.0	33.8	3.0
Diuron	.56 kg/ha	6.3	7.0	9.3	24.6	9.3
Diuron + a.c.	.56 kg/ha	7.7	8.0	14.3	41.2	6.7
Simazine	1.12 kg/ha	8.3	3.0	3.7	13.0	9.3
Simazine + a.c.	1.12 kg/ha	8.0	8.3	13.0	34.1	6.7
Bensulide	.5 g/pot	5.7	4.0	5.7	19.5	2.7
Bensulide + a.c.	.5 g/pot	7.3	5.0	7.3	24.0	4.3
Methazole	2.24 kg/ha	8.0	6.7	10.4	32.4	5.3
Methazole + a.c.	2.24 kg/ha	9.7	9.3	18.0	37.9	5.0

[a]0=complete kill, 10=none plus vigor.
[b]Total number of stolons more than 10 cm long.
[c]Average cm length of four longest stolons.
[d]0=no control, 10=complete control (primarily of grassy weeds--panicum, crabgrass, foxtail, and goosegrass).
[e]Activated charcoal=Gro-Safe slurry, 120 g/ℓ, stolons treated 5 minutes.

A field experiment begun at S.I.U.-Carbondale on June 1, 1977, used 'Tifgreen' bermudagrass, 'Meyer' zoysiagrass, and five preemergence herbicides with and without an activated charcoal treatment of stolons. After hand broadcasting, the stolons were lightly topdressed, rolled, and irrigated one or two times daily for two weeks. Two applications of 1 pound N per 1,000 square feet were made during the summer. Two followup treatments of MSMA + 2,4-D were applied in August over one-half of each plot. Results are shown in Tables 4, 5, and 6.

Phytotoxicity of the five herbicides on bermudagrass and zoysiagrass stolons at 2 and 6 weeks is shown in Table 4. Methazole, simazine, and bensulide were less toxic to stolons treated with activated charcoal than to untreated stolons. Simazine and bensulide were still very phytotoxic to bermudagrass after 6 weeks even with activated charcoal, whereas only bensulide remained quite phytotoxic to zoysiagrass.

A summary of charcoal means and significance (Table 5) indicates that in the third week there was a significant reduction in phytotoxicity on bermudagrass (from 5.1 to 3.9) related to use of activated charcoal. There was a highly significant difference in the herbicides at 3 and 6 weeks. A reduction in weed control is also noted. There was a highly significant difference from herbicides on ground cover at 6 and 9 weeks but little effect after 17 weeks. Although early phytotoxicity from several herbicides was severe, bermudagrass with its rapid growth rate had recovered in the 17-week period.

Results for 'Meyer' zoysiagrass were similar to bermudagrass in that there was a significant reduction in phytotoxicity with use of activated charcoal and less control of weeds. However, as shown in Table 6, there was a significant effect of activated charcoal and herbicide treatment on ground cover. Methazole, pronamide,

Table 4. Phytotoxicity of Five Herbicides on Bermudagrass and Zoysiagrass Stolons With No Charcoal and With Charcoal Treatments

Herbicide treatment	Rate, kg/ha active ingredient	Phytotoxicity rating[a]			
		Bermudagrass		Zoysiagrass	
		2 weeks	6 weeks	2 weeks	6 weeks
Methazole	2.24	5.3	4.3	4.3	2.3
Methazole + a.c.[b]	2.24	2.3	4.0	3.7	1.3
Simazine	1.12	6.7	7.7	5.7	2.7
Simazine + a.c.	1.12	3.0	6.7	4.3	1.0
Pronamide	1.12	1.7	2.7	4.7	1.7
Pronamide + a.c.	1.12	1.7	2.0	3.3	1.3
Diuron	.56	2.0	2.0	5.0	1.3
Diuron + a.c.	.56	3.0	2.7	2.7	1.3
Bensulide	11.20	5.7	8.7	6.7	8.3
Bensulide + a.c.	11.20	7.0	6.7	4.0	5.0

[a]1=no phytotoxicity, 9=severe.
[b]Activated charcoal=Gro-Safe slurry, 120 g/ℓ, stolons treated 5 minutes.

Table 5. Phytotoxicity, Percent Weed Control, and Percent Ground Cover of 'Tifgreen' Bermudagrass With Herbicide and Charcoal Treatments

Observations	Time, weeks	Charcoal means		Herbicide means
		No charcoal	Charcoal	
Phytotoxicity[a]	3	5.1	3.9**	4.5**
	6	5.1	4.4	4.7**
Weed control				
Broadleaf	6	80.3%	69.0%**	74.7%**
Grassy	6	63.0%	56.7%	59.8%**
Ground cover	6	38.9%	44.4%	41.6%**
	9	39.0%	47.8%	43.4%**
	17	90.8%	92.6%	91.7%

[a]1=no phytotoxicity, 9=severe.
**Highly significant at the P<0.01 level or probability.

Table 6. Percent Ground Cover of 'Meyer' Zoysiagrass With Five Herbicide Treatments With and Without Charcoal[a]

Treatment	Percent ground cover, September 29 (17 weeks after establishment)	
	No charcoal	Charcoal
Methazole	63.3 abc	73.3 ab
Simazine	58.3 bc	78.3 ab
Pronamide	71.7 ab	73.3 ab
Diuron	76.7 ab	80.0 a
Bensulide	16.7 d	48.0 c
Check	71.7 ab	80.0 a

[a]Means with different letters are significantly different (P<0.05) using Duncan's Multiple Range Test.

and diuron are not different from the checks in percentage ground cover in 17 weeks. Also, simazine with activated charcoal is not different from the check, but simazine treatment without activated charcoal and both bensulide treatments were significantly lower in percentage cover than the charcoal check. The slower growing zoysiagrass cannot recover as rapidly from early herbicide injury and cannot compete with weeds as well as bermudagrass.

Herbicides used experimentally for establishment of bermudagrass and zoysiagrass are summarized below.

PREEMERGENCE HERBICIDES

Bermudagrass

(without activated charcoal)

pronamide	(Kerb)*
diuron	(Karmex)**
DCPA	(Dacthal)

(with activated charcoal)

simazine	(Princep)
methazole	(Probe)
diuron	(Karmex)

Zoysiagrass

(without activated charcoal)

siduron	(Tupersan)
simazine	(Princep)**
pronamide	(Kerb)*
DCPA	(Dacthal)

(with activated charcoal)

simazine	(Princep)
atrazine	(AAtrex)
diuron	(Karmex)
methazole	(Probe)

POSTEMERGENCE HERBICIDES

Bermudagrass:

MSMA or DSMA + 2,4-D

pronamide	(Kerb)*

Zoysiagrass:

MSMA or DSMA + 2,4-D

pronamide	(Kerb)*
simazine	(Princep)**
atrazine	(AAtrex)**

COMBINATION (BOTH SPECIES)

One of above preemergence herbicides followed by MSMA + 2,4-D at least twice 7 to 10 days apart.

*Precaution--will kill cool-season grasses such as Kentucky bluegrass; moves with runoff water.

** Use lower rates to avoid excessive phytotoxicity.

SUMMARY

1. Bermudagrass and zoysiagrass can be successfully used for lawns, golf courses, and athletic fields in the transition zone, especially with present emphasis on lower maintenance costs.
2. Selection of improved cultivars of both species is underway and shows promise of adapted, winter-hardy cultivars with longer seasonal use.
3. Propagation by stolonizing accompanied by season-long weed control is a good method for establishment. Essentially 100 percent ground cover for bermudagrass and 70 to 80 percent for zoysiagrass can be obtained in 17 weeks.
4. Activated charcoal can reduce phytotoxicity of most herbicides although there is some loss in weed control.

5. Several preemergence herbicides have shown good possibilities for use in establishment; some would need to be used with activated charcoal to reduce phytotoxicity.

6. Postemergence herbicides are useful when applied several times during the season.

7. A combination of preemergence and one or more postemergence treatments is especially needed for zoysiagrass.

ANNUAL BLUEGRASS CONTROL

A. J. Turgeon

The primary objective in managing intensively cultured golf turf is to provide the golfer with a playable surface. On greens, this means "true" putting and some ball-holding capacity for incoming shots. On tees, the turf should provide firm footing and should be sufficiently vigorous to promote rapid recovery from wear. Fairways should have adequate density so that there is an unobstructed path to the ball atop the turf for clean shots. The shoot density and growth rate necessary for optimum playability are then the basis for close mowing, intensive irrigation, fertilization, and other practices employed in golf turf culture. It is these same cultural practices, however, that promote the natural invasion of turfgrass communities by annual bluegrass.

Conversion of perennial grass communities to predominantly aggressive annual grasses is not unique to turfgrass cultural systems. Analogous conversions occur in rangeland systems because of the traffic and grazing activities of livestock. The turfgrass wear and soil-compacting effects of traffic and play promote conversions to undesirable plant populations. Solving the annual bluegrass problem, then, requires a comprehensive analysis of all facets of a turfgrass cultural system: the adaptation of species and cultivars to the unique environmental regime characterizing a specific site; the specific mix of biotic, soil, and climatic conditions that make up the environmental regime; and the evolution of pest management programs designed to either prevent undesirable conversions within the plant community or promote shifts toward desirable turfgrass species.

TURFGRASS CULTIVARS

The adaptation of turfgrasses to conditions under which annual bluegrass is likely to thrive is limited primarily by the general performance of a specific turfgrass within a geographic region and by its adaptation to the cultural intensity employed at the site. For example, 'Nugget' Kentucky bluegrass typically declines during periods of midsummer stress in central Illinois and is quite susceptible to Fusarium blight and dollar spot diseases. Even at a moderate intensity of culture ("lawn" conditions), this is not a favored cultivar for this geographic region. In contrast, 'Majestic' Kentucky bluegrass generally performs well in this area as a lawn turf; under close mowing and high rates of nitrogen fertilization, however, it is quickly invaded by annual bluegrass. Some Kentucky bluegrass cultivars that appear to resist annual bluegrass invasion under intensive culture are 'A-34,' 'Brunswick,' and 'Touchdown.' These grasses generally are adapted both to central Illinois and to a cultural intensity that normally favors annual bluegrass invasion.

Among creeping bentgrasses sustained as putting green turfs, several experimental selections from Michigan State University have shown superior resistance to annual bluegrass invasion compared with 'Penncross' and most other commercially available cultivars. There is some evidence to indicate that perennial ryegrass cultivars also differ in their competitive ability with respect to annual bluegrass.

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Therefore, the turfgrass manager has at least two options in dealing with the annual bluegrass problem. He can adjust his cultural program to favor Kentucky bluegrass or another desirable turfgrass species, or he can select those turfgrass cultivars that are best adapted to the intensity of culture employed at his site. Since the former alternative is often not feasible because of the requirements of play (that is, golfers require a shoot density that cannot be sustained at mowing heights sufficient to sustain some Kentucky bluegrasses), selection and planting of culturally adapted cultivars are primary considerations for implementing an annual bluegrass control program.

ENVIRONMENTAL FACTORS

The turfgrass environment is composed of three distinct but interacting components: the edaphic, atmospheric, and biotic features of an ecosystem.

The *edaphic* environment includes the soil and associated biomass (thatch, mat, and plant organs) that make up the growth medium for the turfgrass community. The physical, chemical, and biological properties of this growth medium directly influence the suitability of the environment for sustaining a particular turfgrass community. Moisture, mineral nutrition, aeration, and buffering capacities are critical features of the medium that must be sustained at near-optimum levels if turfgrasses are to persist and compete against potential weed invaders, including annual bluegrass. Such problems as soil compaction, poor drainage, excessive thatch, inadequate moisture and nutrients, and toxic residues are conditions of the growth medium that adversely affect the turfgrass community and create infestation sites for annual bluegrass and other weeds.

Relationships between specific cultural practices and weed invasion are not always clear. For example, in one field study, increasing the rates of spring-applied nitrogen resulted in increasingly severe incidences of Fusarium blight disease during the summer. The necrotic areas were subsequently populated by annual bluegrass by midfall. The amount of annual bluegrass within treatment plots was directly proportional to the nitrogen fertilization rate applied several months earlier. Without side-by-side comparison of treatment effects, this relationship would not have been established.

Virtually any factor that accounts for the incidence of infestation sites in a turf or the reduced competitive ability of a turfgrass community can predispose a turf to annual bluegrass invasion. Even the voids resulting from the loss of crabgrass to frost in early fall can serve as infestation sites for annual bluegrass, given other conditions favorable for its germination and seedling growth. Diseases, insect-induced injury, differential compaction from mowing equipment and other traffic, and any other adversity associated with unfavorable conditions of the edaphic environment can pave the way for annual bluegrass invasion.

The *atmospheric* environment includes light, temperature, moisture, and air movement. These conditions may be characteristic of a specific geographic region or may be substantially modified by local features. Low sites with inadequate drainage and stagnant air, especially where trees and dense shrubbery obstruct prevailing winds, favor development of a microclimate that is characterized by higher than normal temperatures and relative humidity and is conducive to various diseases. Annual bluegrass frequently invades these sites before the desired turfgrass has recovered. Where trees shade the turf and reduce its vigor, annual bluegrass, which is quite shade tolerant, frequently invades. During periods of excessive rainfall, vegetative growth of annual bluegrass may be particularly vigorous, especially on poorly drained sites. The unique adaptation of annual bluegrass to cool, moist conditions of midspring and early fall makes it a severe competitor in turfs that have been thinned by conditions occurring before or during these periods in the growing season.

The *biotic* environment is largely created by man either through the cultural program or through the use of the turf for recreational or athletic purposes. Wear from traffic and direct scarring of the turf from play or cultural practices may predispose the turf to annual bluegrass invasion. Although many potentially damaging activities are unavoidable, some measures can be taken to reduce the severity of injury. Proper design of greens, tees, fairways, and the access routes connecting these features can result in maximum distribution of traffic over the turf and avoid concentrated wear on specific sites.

The intelligent implementation of mowing, irrigation, fertilization, and supplementary cultural practices in terms of timing, frequency, and intensity promotes the general health of a turf and its resistance to weed invasion. Most cultural practices are attempts to modify the natural environment in such a way that the persistance and quality of desired turfgrasses are favored. Irrigation simply compensates for insufficient or inadequately distributed rainfall. Fertilization ensures that essential plant nutrients are not limiting factors to turfgrass growth. Through cultivation practices, including coring, slicing, and vertical mowing, the turfgrass manager attempts to correct unfavorable conditions within the turfgrass growth medium. Even the practice of mowing essentially mimics the grazing of livestock, an activity believed to be responsible for the evolution of low-growing turfgrass species.

Contemporary turfgrass culture, therefore, is designed to extend the geographic range of adaptation of specific turfgrasses. It is ironic that these same practices, when misapplied, create an environmental regime that extends beyond that to which some desired turfgrasses are adapted.

PEST MANAGEMENT

Included within the biotic environment are cultural practices involving the application of pesticides. Because of their unique impact, pest management activities are frequently considered separately from other cultural practices. Pesticides are chemicals which, when applied at proper dosage rates, selectively control damaging organisms within a complex biological system. Although pesticides include more than just herbicides, all pesticides can influence the predisposition of a turf to weed invasion. Uncontrolled insect activity, for example, can result in turfgrass injury and subsequent weed invasion. Likewise, uncontrolled diseases allow weed infestation sites to develop in a turf. However, misuse of insecticides and fungicides can also result in the deterioration of a turf and, inevitably, an increase in weeds. This is certainly true of herbicides. Excessive application rates or improper timing of herbicide applications can seriously injure turfgrasses and eventually lead to weed invasion.

The use of herbicides for controlling annual bluegrass dates back to the late 1920's, when lead arsenate was found to discourage its growth. Until recently, both calcium arsenate and lead arsenate were widely used in annual bluegrass control programs. Results from these materials varied from dramatic success to devastating failure.

Although the arsenates are no longer commercially available, the research with them provided some sound principles of turfgrass weed control: First, a combination preemergence and postemergence herbicide could be effective in converting turf infested with annual bluegrass to one that was predominantly Kentucky bluegrass or creeping bentgrass; second, a strictly herbicide-oriented control procedure that did not include other corrective measures could simply trade one problem for another. For example, where a 'Merion' Kentucky bluegrass turf with approximately 40 percent annual bluegrass was treated with calcium arsenate, the plots eventually became creeping bentgrass. Since the environmental regime was so far removed from that considered optimum for Kentucky bluegrass, removal of annual bluegrass as a component of the turfgrass community resulted in the eventual dominance of a plant species that was both adapted to the prevailing environmental conditions and tolerant of calcium arsenate.

Other undesirable effects of calcium arsenate observed in research plots and on golf courses included complete loss of turf in poorly drained areas, excessive thatch development, severe disease incidence, high wilting tendency under midsummer stress, frost injury during midfall, and a general reduction in turfgrass vigor.

Contemporary approaches to annual bluegrass control with herbicides include use of (1) preemergence herbicides applied in early spring and late summer, (2) postemergence herbicides applied in midspring and late summer, and (3) growth retardants applied in early spring and early fall in conjunction with overseeding.

Preemergence Herbicides

These are herbicides that are applied prior to the emergence of a target weed species; they include DCPA, benefin, bensulide, and oxadiazon. Applications of preemergence herbicides should be timed to occur before annual bluegrass seed germinates in an open turf. In Illinois, this can be almost any time during the growing season but is most evident in late summer. Presumably, early spring and late summer applications of preemergence herbicides can reduce the amount of annual bluegrass development from germinating seed. Two concerns with these herbicides, however, are their inability to control existing stands of annual bluegrass and the potential for phytotoxicity to desirable turfgrasses, especially where repeated applications are made.

Moreover, recent research has shown that, where a substantial thatch layer is present, spring applications of benefin and oxadiazon can be moderately to highly injurious to the turf as soon as midsummer stress conditions occur. This effect is believed to be due to both the greater mobility of these herbicides in thatch than in soil and the susceptibility of turfgrass roots and rhizomes to injury once these herbicides come into contact with them.

Bensulide has also caused deterioration of Kentucky bluegrass where it has been applied for several years successively or in closely mowed turf during periods of summer stress. Even DCPA, one of the safest preemergence herbicides, can inhibit rhizome development and, in some instances, cause a normally rhizomatous turfgrass to behave more like a bunch-type species. Presumably, these undesirable effects can be mitigated by measures to prevent excessive thatch accumulation or to infuse sufficient quantities of soil into the thatch through topdressing or coring and subsequent reincorporation of the soil cores.

The lack of efficacy of these herbicides on existing stands of annual bluegrass requires either that postemergence herbicides be used or that cultural conditions favoring the death of annual bluegrass be encouraged during the growing season. In either case, patches of annual bluegrass should not be so large that adjacent turfgrasses cannot spread into the voids resulting when the annual bluegrass dies.

Postemergence Herbicides

These are herbicides that are applied after emergence of a target weed species. The principal postemergence herbicide for annual bluegrass control currently is endothall, which has not been characterized by consistently satisfactory results. Successful use of this material depends upon the following:

1. Achievement of adequate efficacy to selectively remove the existing annual bluegrass population.
2. An adequately distributed stand of Kentucky bluegrass or creeping bentgrass that can fill in voids resulting from the death of annual bluegrass.
3. Environmental conditions favorable for the growth of the desirable turfgrasses.

Relatively light application rates (about 0.25 to 0.5 pound of active ingredient per acre) at two-week intervals in spring can selectively suppress annual bluegrass and favor other turfgrasses, especially creeping bentgrass. At higher rates (about 1 to 4 pounds of active ingredient per acre), a general browning of the turf may occur, followed by selective recovery of Kentucky bluegrass in approximately three weeks. However, large patches of annual bluegrass are typically reinvaded after treatment because of the lack of adjacent turfgrasses for filling voids.

Recently, a granular formulation of linuron from O. M. Scott has been used successfully for selectively controlling annual bluegrass in Kentucky bluegrass turf. Again, this approach is suitable only for sites where the annual bluegrass population occurs in small patches; otherwise, large voids resulting from treatment may simply be reinfested or invaded by other weed species.

Growth Retardants

These are chemicals used to suppress seedhead formation of annual bluegrass in early spring or to suppress the growth of annual bluegrass in early fall prior to overseeding. Results from this approach have been variable.

Virtually any program involving the application of herbicides for annual bluegrass control should be considered experimental. Before implementing such a program, or several programs simultaneously, test plots covering a small portion of the infested site should be observed for a sufficient time to determine the practicability of using herbicides for this purpose. However, one reasonably conclusive statement concerning the control of annual bluegrass can be made at this time. The best program for controlling annual bluegrass is one that is designed to sustain a desired turfgrass species. When sound principles of turfgrass culture are violated, or simply ignored altogether, invasion by annual bluegrass and the accompanying problems are almost guaranteed.

USE OF SULFUR AND OTHER NUTRIENTS IN AN ANNUAL BLUEGRASS CONTROL PROGRAM

Roy L. Goss

The major thrust in turfgrass nutritional investigations has occurred principally during the last 20 years. Prior to this, fertilizers available to turfgrass managers were essentially a spinoff from the farm industry, and oldtimers can remember when most fertilizer was applied as compost, ammonium sulfate, and possibly some sources of phosphorus and potash.

Turfgrass requirements, however, vary rather widely from those for many agricultural crops. To grow excellent quality recreational turf, both balance and intensity of fertilizer applications are necessary. Careful attention to fertilizer applications is one of the best means for controlling weeds and diseases and produces turf that will perform better in heat, cold, and moisture stress.

This paper will stress the effects of nitrogen (N), phosphorus (P), sulfur (S), and potassium (K) in annual bluegrass control programs.

THE IMPORTANCE AND STATUS OF SULFUR

The importance of sulfur in turfgrass management has probably been underemphasized for a number of years. Sulfur is vitally important in the formation of amino acids that go into the production of protein. Moreover, if sulfur is deficient, nitrogen cannot be properly metabolized and the turfgrass plant will not respond in either growth or color.

The amounts of indirect sources of sulfur available to turfgrasses have declined during recent years. Restrictions on the burning of high sulfur coals and other fossil fuels and the high degree of refinement of fertilizers have practically eliminated S as a contaminant, which has reduced its availability to plants (*2*).[1]

Sulfur deficiencies resemble nitrogen deficiencies to a great extent. Love (*5*) once described the initial symptoms of sulfur deficiency on 'Seaside' bentgrass and 'Pennlawn' fescue as a general paling of the leaves, after which the leaf blade took on a pale yellowish cast. Accompanying this was a faint scorching of the blade tip which advanced toward the leaf base in a thin line along each margin. The border gradually enlarged until finally the entire blade became fired and withered. Investigations at Washington State University's Western Washington Research and Extension Center at Puyallup, Washington, reveal similar symptoms but not so well defined as those reported by Love. In general, sulfur deficiency appears as a yellowish to chlorotic-appearing turf or as blotched yellow patches that appear starved for nitrogen.

Beaton (*1*) has previously reported levels of plant nutrients adequate for 'Seaside' bentgrass growth as measured by tissue analyses. He reported 0.75 percent N, 0.13

[1]Italicized numerals in parentheses refer to literature cited.

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percent P, and 0.19 percent S as being adequate for normal growth and quality. It is apparent, then, that sulfur plays as important a role in turfgrass nutrition as phosphorus.

Our investigations with turfgrass tissue have shown consistently higher levels of sulfur than phosphorus when turfgrasses were receiving adequate levels of sulfur. Without the addition of adequate levels of sulfur, the plant must derive the sulfur from residual levels in the soil, which is mineralized for the most part from organic materials. A constant drain of this sulfur through tissue removal of clippings can stress the plants for sulfur, particularly at the moderate to high levels of nitrogen application that stimulate increased growth. The author, therefore, ranks sulfur as a macronutrient at least as important as phosphorus and possibly more so.

SULFUR INVESTIGATIONS

In 1966, sulfur investigations were initiated on plots that had previously been treated with nitrogen, phosphorus, and potassium only. All clippings had been removed since 1959 at the start of these nutritional investigations. Plots received 6, 12, and 20 pounds of nitrogen; 0 and 4 pounds of P_2O_5 (phosphorus); and 0, 4 and 8 pounds of K_2O (potassium) per 1,000 square feet per year in all combinations. After the initiation of the sulfur tests, potassium was applied uniformly to all plots except the check plot, and sulfur was randomized into the treatment plan at 0, 1.15 (50 pounds per acre), and 3.45 (150 pounds per acre) pounds per year. The sulfur, in the elemental wettable source, was applied with a sprayer in two applications in the early spring of each year. Nitrogen was supplied from urea, phosphorus from reagent grade phosphoric acid, and potassium from muriate of potash. Twenty pounds of nitrogen per 1,000 square feet per year is an unrealistically high level of nitrogen to apply to turfgrasses, even in the Pacific Northwest. However, some turfgrass managers were practicing this level so it was included in the treatment program.

In this discussion 20 pounds of nitrogen per 1,000 square feet will be referred to as the high nitrogen treatment, 12 pounds per 1,000 square feet per year as the intermediate nitrogen treatment, and 6 pounds per 1,000 square feet per year as the low nitrogen treatment.

High sulfur applications (3.45 pounds per 1,000 square feet per year) significantly reduced *Poa annua* populations, but low sulfur applications (1.15 pounds per 1,000 square feet per year) increased *Poa annua* over that with no sulfur treatments. High sulfur applications over a period of 10 years caused a reduction in surface pH, which could render phosphorus less available and severely retard annual bluegrass development, although other forces currently unknown may also cause this effect. Low sulfur applications definitely stimulated growth of both annual bluegrass and bentgrass with little reduction of the soil pH. Conversely, plots receiving no sulfur had retarded growth of all grasses, probably because of a sulfur deficiency.

Since the pH of all plots receiving the high rate of nitrogen was very low (4.0 or lower), both low and high levels of sulfur applications did not affect the pH on these plots. At the intermediate level of nitrogen, the highest levels of sulfur reduced soil pH by an average of about 0.2 pH point. At the low nitrogen rate, the highest level of sulfur reduced soil pH nearly 0.5 pH point. In all cases the low level of applied sulfur had no significant effect on soil pH even after 10 consecutive years of application.

Although the effects of sulfur on turfgrass color will not be discussed in detail in this paper, there was a significant increase in color associated with sulfur applications.

If phosphorus is the questionable element with regard to the development of annual bluegrass, it is possible that lower pH levels in the immediate surface where the turfgrass plant absorbs most of its phosphorus may tie up and reduce the availability of phosphorus to annual bluegrass. It would be assumed in this case that bentgrasses can adequately survive with lower levels of phosphorus than annual bluegrasses require. Some assumptions have to be made and, since there was a significant reduction in annual bluegrass, this seems to be the best assumption.

THE EFFECTS OF PHOSPHORUS ON POA ANNUA

Phosphorus applications significantly increased *Poa annua* in all plots in our tests, which suggests that rates of phosphorus possibly as high as those used (4 pounds P_2O_5 per 1,000 square feet) or higher may be required for normal annual bluegrass development. It should be pointed out, however, that most golf course superintendents and other turfgrass managers have, in my view, consistently overapplied phosphorus. In nearly all cases in the Pacific Northwest, putting green soil tests reveal extremely high phosphorus levels.

High levels of sulfur and phosphorus tended to increase annual bluegrass populations, compared with applications of high levels of sulfur without phosphorus. At no time did the turfgrasses indicate any phosphorus deficiency with or without applied sulfur. This brings us back then to the point that low levels of phosphorus will maintain normal growth of most bentgrasses.

THE EFFECTS OF NITROGEN ON POA ANNUA

Nitrogen strongly influenced annual bluegrass populations in bentgrass putting green turf, compared with plots with no nitrogen application. Medium nitrogen rates did not suppress annual bluegrass as much as low nitrogen rates did. This has been amply documented and is common knowledge among golf course superintendents. It is our assumption that the medium rate of nitrogen applied in these tests stimulated growth of both bentgrass and annual bluegrass without causing undue stress on soil nutrient reserves and did not seriously depress soil pH. The average soil pH value for the plots treated at medium nitrogen levels was approximately 5.5, compared with near 4.4 or lower for the high nitrogen treatment range. It was also observed that there was less annual bluegrass at high nitrogen applications than at intermediate rates. Because of the acid-forming factor of high levels of urea, this observation supports the findings of Juska and Hanson (*4*) that low soil pH levels reduce *Poa annua* seedhead formation.

OTHER EFFECTS OF SULFUR

Sulfur produces other significant effects on turfgrasses indirectly related to *Poa annua* development. It has been demonstrated (*3*) that sulfur significantly reduces the severity of attack of Fusarium patch disease, caused by the fungus *Fusarium nivale*, and Ophiobolus patch, caused by the fungus *Ophiobolus graminis* var. Avenae. When these two diseases are severe, the turf is either killed or severely weakened, allowing infection routes for annual bluegrass.

When used continually at rates indicated in this paper, sulfur has also been observed to completely retard the development of bluegreen algae in putting greens.

THE EFFECTS OF POTASSIUM

No direct effect of potassium has been noted on the control of annual bluegrass in our tests. The effects are no doubt indirect but very important. Potassium performs a major role in the development of healthy tissue and strong plants that helps them resist disease attack and withstand periods of cold and drought. This adds up to stronger turf, better able to compete with annual bluegrass. We recommend that the nitrogen:potassium ratio should be approximately 3:2.

CONCLUSIONS

Probably no one single program or treatment will adequately control *Poa annua* over the long haul. Annual bluegrass control should be viewed as an integrated program. We know what good sulfur programs will do and what excess applications of phosphorus will do. We know that potassium will produce firm, healthy plants. We also know that the better preemergence herbicides will prevent germination of annual bluegrass seed. More recently we have learned that endothall is a very effective postemergence treatment for the control of annual bluegrass. Therefore, it would appear that an integrated program of good nutritional practices coupled with preemergence herbicides and endothall will point the way to putting green turf free of annual bluegrasses. No doubt, other good chemicals will come along that perhaps will do a better job, but until then we are placing high priority on the programs outlined above.

Finally, a precautionary note about sulfur: excessively high applications can produce injury to turfgrasses. Consequently, the highest level of sulfur indicated in this paper (3.5 pounds per 1,000 square feet per year) should be divided into at least two applications. In general, the major portion should be applied in the early spring before the onset of hot weather. The remainder can be applied in fall before winter conditions arrive. So far, we have found no serious objection to the use of moderate amounts of other sulfur-supplying materials such as ammonium sulfate, ferrous sulfate, magnesium sulfate, and so forth in addition to the normal application of sulfur.

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MAINTAINING ANNUAL BLUEGRASS

J. M. Vargas, Jr.

The problem of learning how to successfully grow annual bluegrass (*Poa annua*) is one of education or retraining. It has been considered an undesirable weed for so many years that it is hard for people to accept it as a desirable turfgrass. It is not a weed and, if managed properly, provides a satisfactory turf in the many areas of the cool-season grass belt. Many golf course superintendents either refuse to admit they have any annual bluegrass or else deliberately underestimate how much they have. Part of the reason for not admitting to having annual bluegrass is the stigma attached to it for being a weed: If it is a weed, I must be a poor superintendent if I can't control it.

The stigma attached to annual bluegrass came from educators in the universities--they were convinced it really was a weedy annual grass that died from high temperature during periods of summer heat stress. Because of this attitude, little research was done on cultural aspects, disease problems, or insect problems of annual bluegrass for fear of being labelled a heretic or being put away in a padded cell. Instead, research was done on Kentucky bluegrass and creeping bentgrass, which very few people actually had on their golf courses; the results of this research were transposed to annual bluegrass, which more often than not didn't respond the same way.

On golf courses 10 years old or older in the northern region of the cool-season grass belt, annual bluegrass is the largest single component. Although most people wouldn't admit having it, it has been successfully grown on golf course greens for years, mainly because pest control programs have been practiced on the greens, just as such programs have been neglected on the fairways.

Many a golf course superintendent has spent a great deal of time, money, and effort trying to control annual bluegrass with the arsenicals rather than trying to learn how to live with it. Most lost their fairways, many lost their jobs. The smart ones either got off arsenical programs or else never got on one. Here, too, the educators were at fault for not doing critical research on the arsenicals before recommendations were made. More critical research has been done on the arsenicals after their production has been halted than before.

In 1973 Rieke showed that soil pH was a critical factor in the effectiveness of calcium arsenate. Calcium arsenate was more effective at lower soil pH's, which helped to explain why it worked better on the low pH soils of the east coast than on the higher pH soils of the Midwest. Turgeon *et al.* (1975) showed that turfs growing in calcium arsenate soil were generally turfs growing in thatch. If both these facts had been known initially, calcium arsenate programs may have been more effective and safer, or people may have thought twice about using them at all.

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FAIRWAYS VS. GREENS

In spite of the fact that good pest control practices are carried out on annual bluegrass greens, very poor pest control practices are carried out on annual bluegrass fairways. It is difficult to understand the logic behind this. If one knows annual bluegrass greens must be treated for diseases and insect problems to maintain healthy turf, why shouldn't the same treatments have to be applied on the fairways to keep them healthy? But there is a logical explanation, and it deals with the long-accepted belief that the annual bluegrass is dying from high-temperature stress alone. As long as one is convinced high temperature is the primary reason for the grass's dying, the method of prevention will be through irrigation instead of pest control. However, it was clearly demonstrated that high temperature alone was not the reason for the death of annual bluegrass; rather, what was causing it was the fungus disease Anthracnose, which destroyed the annual bluegrass during the hot weather. In addition, an insect problem caused by the Ataenius beetle grub has also been shown to be responsible for the loss of annual bluegrass fairways during heat stress periods.

Blaming the loss of annual bluegrass on high temperature before 1975 is understandable since the facts concerning annual bluegrass survival were not known, but the information is available now and yet annual bluegrass fairways are still dying and the blame is still being placed on "that lousy annual bluegrass" that dies in the hot weather.

If we further examine the history of fairway watering, we find that at first only golf course greens were watered. The green fairways of spring were allowed to go dormant in the summertime, then to green up again with the return of fall rains. These fairways were primarily common Kentucky bluegrass, colonial bentgrass, and fine-leaf fescue. Then someone got the brilliant idea that all that was necessary to have green fairways all summer long was to water them. So fairways were irrigated and mowed closer and the Kentucky bluegrass, colonial bentgrass, and fine-leaf fescue fairways soon became soft, lush annual bluegrass fairways. What was overlooked was the pest control programs that were carried out on golf course greens to keep them healthy. Soon golf course superintendents observed common diseases like dollar spot or brown patch on their fairways and sprayed them when they became severe. The two problems that weren't recognized were Anthracnose and the Ataenius beetle grub. Their effects were assumed to be part of high-temperature killing of annual bluegrass.

EXPENSIVE?

If dollar spot and brown patch were the only major diseases on annual bluegrass fairways, the statement that it is too expensive to spray for diseases would be understandable, even if I don't agree. What is meant is that dollar spot and brown patch are unsightly but occur slowly enough that they can be treated on a curative basis. But we are no longer talking about dollar spot and brown patch, we are talking about large dead areas of the fairway caused by Anthracnose and the Ataenius beetle grub, areas that must be treated if you expect "to have green grass on the fairways." With that in mind, here is the part I don't understand.

From $50,000 to $500,000 are spent to install an irrigation system "to have green grass in the fairways." Thousands of dollars each year are spent on water "to have green grass on the fairways." In addition, thousands of dollars are spent on miscellaneous equipment and supplies such as aerifiers, spikers, and vertical mowers "to have green grass on the fairways." From a few thousand up to 15 or so thousand dollars are spent for the finest mowing equipment "to have well-manicured green grass on the fairways." Between $3,000 and $15,000 are spent to fertilize the fairways "to have green grass." But you can't spend between $5,000 and $10,000 a year to treat the fairways for disease and insect problems because "it is too expensive" to treat on a preventative basis. Over half a million dollars are invested for the purpose of "having green grass on the fairways," but you can't spend $5,000 to $10,000 a year to protect it.

You wouldn't think of not watering on a hot day because it was too expensive. Why? Your answer would be something like, "Because the grass would die." And yet it is "too expensive" to treat with pesticides to prevent the grass from dying. What difference does it make whether the grass dies from drought or disease, or whether money for fairways is spent on water or fungicide? There is no difference, and you know it.

Put the cost of fungicides and insecticides in your budget. Present a strong case for them. Ask your employers if they want "to have green grass on the fairways" all summer long. If they turn you down, fine, shame on them; but if you don't put it in the budget because you think it is too expensive, then shame on you.

CULTURAL PROGRAM

I recommend the following cultural program for annual bluegrass fairways:

Mowing height--1/2 to 5/8 inches.
Watering--infrequently and deep during cool weather.
--light and often during warm weather; include syringing when necessary during warm periods of the day.
Fertility--nitrogen (see fertility schedule, next page).
--phosphorus and potassium, as needed according soil test
Fungicide program--see fungicide schedule.
Insecticide--apply to areas of fairway where the insects are a problem; once the problem is present, insecticide schedules should be set up to treat affected areas annually.

There are four major diseases on *Poa* that occur during the growing season: Anthracnose, dollar spot, Pythium blight, and brown patch. Anthracnose is the most serious of these, and trying to grow *Poa* without controlling it is futile. Following the fungicide schedule should provide adequate control of all these disease problems.

The fertilization schedule is designed so that nitrogen applications will aid in the control of dollar spot and Anthracnose, which are not shown on the charts. The chart is based on fertilizing with water-soluble nitrogen. Other less frequent schedules are possible with water-insoluble nitrogen, but it is impossible to make up general charts for this since the release of nitrogen is dependent upon many variables, such as soil type, soil moisture, soil organic matter, and weather (temperature and rainfall).

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Annual Bluegrass Nitrogen Fertility Schedule (pounds of nitrogen per 1,000 square feet)

Region	April 1	April 15	May 1	May 15	June 1	June 15	July 1	July 15	August 1	August 15	September 1	September 15	October 1	October 15	November 1	November 15	December 1	December 15
Southern:																		
High maintenance				1/2		1/2		1/2		1/2		1						1
Low maintenance						1/2						1						1
Diseases[a]	Fusarium patch					Brown patch———									Fusarium patch———			
								Pythium blight———							Typhula blight———			
Middle:																		
High maintenance						1/2		1/2		1/2		1				1		
Low maintenance						1/2						1				1		
Diseases[a]								Brown patch———										
									Pythium blight—									
												Fusarium patch———						
	Fusarium patch———											Typhula blight———						
Northern:																		
High maintenance						1/2		1/2		1						1		
Low maintenance						1/2				1						1		
Diseases[a]		Fusarium patch						Brown patch———			Fusarium patch							
								Pythium blight										

[a]Time of season when excess nitrogen fertility will increase the severity of the disease listed; not necessarily the time of year the disease occurs.

Fungicide Schedule for Annual Bluegrass Greens, Tees, and Fairways in Cool-Season Grass Belt Region 1

Region	March 1	March 15	April 1	April 15	May 1	May 15	June 1	June 15	July 1	July 15	Aug. 1	Aug. 15	Sept. 1	Sept. 15	Oct. 1	Oct. 15	Nov. 1	Nov. 15	Dec. 1	Dec. 15	Jan. 1	Jan. 15
Southern:																						
High maintenance			S	NS	NS	S			NS	NS	S		NS	NS	NS	NS	NS	NS				
Low maintenance						NS	S		NS	NS	S		NS									
Diseases	Fusarium patch				Dollar spot							Dollar spot —						Fusarium patch —				
							Brown patch —															
					Anthracnose —																	
								Pythium blight —												Typhula blight		
Middle:																						
High maintenance				NS	NS	NS	S		NS	NS	S		NS	NS	NS	NS	NS					
Low maintenance						NS	S		NS	NS	S		NS		NS							
Diseases	Fusarium patch													Fusarium patch								
							Dollar spot —															
								Brown patch														
								Anthracnose —														
										Pythium blight									Typhula blight			
Northern:																						
High maintenance					NS	NS	S		NS	NS	S		NS	NS	NS	NS						
Low maintenance							NS	S		NS	S		NS									
Diseases	Fusarium patch							Dollar spot —														
	Typhula blight									Brown patch												
							Anthracnose —															
										Pythium blight			Fusarium patch —									
																	Typhula blight —					

NS = nonsystemic or contact fungicide.
S = systemic fungicide (benzimidazole).

LIVING WITH *POA ANNUA*

R. Williams

My philosophy on *Poa annua* as a golf turfgrass for fairways is simply stated: until the research people can develop a practical, efficient, and safe method of eliminating *Poa* from bentgrass turf, I will continue to make every effort to live with *Poa annua*. However, I would prefer 100 percent bentgrass as a fairway turf.

I well recall the use of sodium arsenite to scorch fairways followed by overseeding with bentgrass. Within two to three years the *Poa* was back again and the golfers were pretty upset. The lead arsenate programs gave varying degrees of success, but this material is no longer available. The calcium arsenate programs produced results ranging from successful control to complete disaster; many of the superintendents who tried this method lost their jobs when the golfers became unhappy with the unpredictable results.

Several new chemicals are being advertised as specific controls for *Poa*. Frankly, I have not heard anyone report yet that these products are effective on bentgrass-*Poa* fairways. When a breakthrough to control *Poa* in this situation does occur I am sure we will all be delighted.

FAIRWAY TURF

The main weakness with *Poa annua* as a fairway turf is its characteristic shallow root system, sometimes rooted only in the biomass of thatch rather than in the soil. The *Poa* plant has very low drought and heat tolerance, is disease prone, and has poor resistance to golf cart and foot traffic. At the same time, it does make a good playing surface and certainly is persistent because of its heavy seeding capability. Most golfers don't care what species of fairway turfgrass they are playing on, but they are concerned with the playability and the aesthetics of the turf.

If we decide to try to live with *Poa annua*, several adjustments in our maintenance program will allow us to provide a satisfactory playing turf throughout the season.

Irrigation

If the *Poa* plant in a fairway is supplied with adequate moisture for transpiration on a hot or arid day, the plant will survive. This means that the required moisture must be available within *Poa*'s shallow root zone at the time of stress. I try to live with *Poa* by making light, frequent applications of water. Automatic irrigation is ideal for this purpose. My normal fairway irrigation program calls for approximately 10 to 15 minutes of irrigation almost every night. What I'm trying to do is keep the soil and thatch moisture content at a constant level, replacing daily only that moisture lost through evapotranspiration. For the longest lasting effect during the day, we also irrigate between 3 a.m. and 5 a.m. The early morning application removes any accumulation of guttation water on the grass plant leaves, which may help prevent disease.

R. Williams is Superintendent, Bob O'Link Golf Club, Highland Park, Illinois.

Aerification

Our irrigation program dictates that we keep the soil surface open for water penetration and uniformity. To do this, we rely on frequent aerification with spoons, knives, and discs, depending on the season.

During July and August I prefer using triangular knives and aerifying right after a good rain. When we do the fall aerifying, usually in early September, we also do some spot overseeding with a combination of bentgrass and perennial ryegrass. Several clubs in our area have had excellent response with this program.

Height of cut

Next to watering, perhaps the most significant factor for holding the *Poa* in the fairways is the height of cut. In our procedure, the mechanic places the mower unit on a 4-foot-square steel plate and then accurately adjusts the setting with a ruler. I have found that *Poa*-bentgrass fairways mowed within the range of 7/8 to 1-1/8 inches will survive much better than within the 5/8- to 3/4-inch range. But will the golfer stand for fairways mowed 7/8 to 1-1/8 inch? My answer is definitely yes, provided the turf has the density to support the ball and allow a clean hit. In fact, every year when the touring professionals are in the area, a number of them play our course. I have made a point to ask them what they think of the lies they are getting and how the ball is responding. They invariably reply, "Super, just like sitting on a tee"--and this is when we are at the 1-inch height. I firmly believe that the turf must be dense enough to fully support the ball.

We start mowing fairways in the spring at 7/8-inch height, move up to 1 inch about the middle of June, and, if it looks like a difficult season for turfgrass, we'll go up to 1-1/8 inches by the middle of July. We then move back down in two steps starting around the middle of August. Another safeguard we employ is to skip mowing fairways altogether when the temperatures get into the 90's. Sometimes this might mean skipping several days or even a week. Otherwise, mowing frequency is three to four times a week. We try to do all of our fairway mowing in the early morning or evening hours. Afternoon mowing during the summer is out completely.

Too often we have had to go along with the low handicap golfers who insist on 1/2-inch fairways just because "that's what the professionals want." But golf professionals do not necessarily want a 1/2-inch lie. What they want is a clean lie where grass blades will not stand up between clubface and ball--surely you have noticed that golf professionals use a wood tee on the par three holes instead of hitting from the closecropped tee turf. It is time we place more emphasis on density and playability rather than height of cut.

My theory on height of cut for *Poa*-bentgrass fairways is that there must be a compromise between what is best for the golfer and what is best for the turfgrass. Both must give a little to keep everyone happy. Over the years I have made a constant effort to inform the golfers that, if they will accept a slightly higher cut on fairways, they can then expect minimal loss of *Poa annua*. We seldom hear any further discussion on the subject. Most of us who have bentgrass-*Poa* fairways have been our own worst enemies in yielding to the pressure for a 1/2-inch cut.

Fertilization

Fertility, of course, plays a significant role in providing a dense turf. We use approximately 2 pounds of actual nitrogen, 1 pound of phosphorus, and 2 pounds of potash per thousand square feet each year. We have been applying about 800 pounds of milorganite per acre in the dormant winter season, then applying urea, superphosphate, and sulfate of potash as supplements. This program has been effective, efficient, and most economical. In fact, my fairway fertilizer expense this past year was $3,600 for approximately 35 acres, or roughly $100 per acre.

Disease control

Modern disease control ranks as high as all other factors in living with *Poa annua*. We have used a strong preventive disease-control program on our fairways for several years. In 1977 we used 14 fungicide applications, rotating 3 different prescriptions:

1. Daconil at 1 gallon per acre.
2. Combination of PMAS at 1 quart per acre with Thiram at 5 pounds per acre.
3. Acti-Dione TGF at 2 packages per acre.

The rotation of the three formulations was determined by the weather, phytotoxicity, and the type of disease organism that might be expected.

PUTTING GREENS

When it comes to *Poa annua* on putting greens, I have a different attitude and a different approach. I detest having to tolerate *Poa* in our greens, yet I have not found a painless method of eradication. *Poa* is particularly bad for golf on putting greens when it is seeding; when it is not seeding, however, we have greens with as much as 20 or 30 percent *Poa* going unnoticed. My long-range program for fighting *Poa annua* in our greens is to resod the greens with *Poa*-free bentgrass grown in our nursery. We are currently evaluating both 'Evansville' and Penn State's PBCB strains.

CONCLUSION

Let me conclude with a couple of observations on *Poa annua*. First, I have noted that some of our courses with the poorest irrigation systems have the highest percentage of bentgrass in their fairways, provided they have been overseeded with bentgrass. I've also noticed that with the single-row irrigation systems there is a higher percentage of bentgrass along the outer edges of the fairway and into the rough, where less water is applied than on the center of the fairway. Both of these observations seem to indicate that we should use a little water on fairways without killing the *Poa*.

Golfers in the Chicago area pretty much judge our greenskeeping ability on the basis of how well the greens putt and on whether we are able to hold the fairway turf throughout the season. They are pretty intolerant with even moderate loss of grass on fairways. So, I believe, most of us superintendents are doing whatever we can to live with *Poa* in our fairways until the reasearch and industry people can find a method or material for its selective eradication.

COMBATTING ANNUAL BLUEGRASS WITH CREEPING BENTGRASS

Wolfgang Mueller

Over 90 percent of Onwentsia's grasses are bentgrass. This percentage has been achieved during the past six years through a specific program.

First, we have installed over 12,000 feet of drain-tile and plan to install 6,000 feet more over the next two years. All piping was backfilled with a cover of at least 10 inches of pea gravel.

In conjunction with this extensive drainage program we started an overseeding project with 'Seaside,' 'Astoria,' and 'Highland' bentgrass. We began the overseeding program in May, 1972, at the rate of 75 pounds of seed per acre (25 pounds of each of the three bentgrasses), all certified seed material. A McCormick drill seeder was used. Unfortunately, the overall results of this overseeding were disappointing. The new seedlings had to compete with the existing *Poa annua* and with extremely wet ground conditions due to heavy rainfalls. I realized then that timing was the most important factor in this particular overseeding program.

Our next strategy was to take advantage of the weak conditions of *Poa annua* in the end of July and early August to aerate all our greens, tees, and fairways, overseeding them at the rate of 60 pounds per acre of certified 'Seaside' bentgrass only. This time our efforts were rewarded with good germination and strong seedlings.

We repeated this process the two following years at the rate of 30 pounds of certified 'Seaside' per acre, keeping in mind the correct timing--the end of July and the beginning of August.

The next three years we limited ourselves to aerating the greens, tees, and fairways at the end of July and the beginning of August. It had been our experience that to aerate at any other time would only promote the *Poa annua*'s reseeding.

In our program we are on a low fertility regime, using about 1.2 pounds of actual nitrogen for fairways and about 2 to 2.5 pounds of actual nitrogen for greens and tees. We apply about 120 pounds of potash per acre every other year.

Because of our existing water sources and system, our water practices are very limited. Unlikely as it seems, I believe this is a major factor in the success of our bentgrass, since water-loving *Poa annua* is not able to survive under these conditions. Even during very hot and dry periods we water our greens and tees only once a week. Our fairways are watered every 10 days, for we can water only four fairways a night.

We are on a preventive fungicide program and spray our fairways approximately four times a season. We spray our greens and tees every second week.

Wolfgang Mueller is Superintendent, Onwentsia Club, Lake Forest, Illinois.

Our greens are cut at 1/8 inch, the tees at 3/8 inch, and the fairways at 5/8 inch. These heights of cut provide good playing conditions and do not allow *Poa annua* to flourish.

Before I finish, I would like to share with you a letter written 50 years ago. It seems to bridge the span of time and methods and to fully endorse our less than revolutionary approach to the *Poa annua* problem. The letter is addressed to the *Bulletin of the United States Golf Association Green Section*, Washington D.C. (Vol. 7, No. 9):

"Gentlemen,

"In reference to *Poa annua* in putting greens.

"We have two greens of bent of the Inverness strain. These two greens have been a great disappointment but have improved as *Poa annua* came in.

"We have several old greens, seeded in 1921 with the good Lord knows what, but with considerable clover, and these also have improved as regards putting as they have been invaded with *Poa annua*.

"At present we have six creeping bent greens of a good strain. We will have nine or ten more greens next year of the same strain of bent.

"While *Poa annua* has improved the putting qualities of the old greens, we do not think that they compare with the new greens. Therefore we are fighting out all *Poa annua* from the good bent greens.

"What we do is cut it out with a hole cutter just as soon as we see it, and replace with a plug from the bent nursery. From thirty to fifty plugs are needed to keep a green clean of *Poa annua*, chickweed, etc., most of the plugs of course being used during the spring and early summer."

This letter is signed by Spencer M. Duty, Chairman, Green Committee, The Canterbury Golf Club, Cleveland, Ohio, August 25, 1927.