24TH ILLINOIS TURFGRASS CONFERENCE

North Central Turfgrass Exposition
November 1-3, 1983

Arranged and conducted by
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SUPERINTENDENTS

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BIOLOGICAL CONTROL OF TURFGRASS DISEASES

Henry T. Wilkinson

Biological control of a disease is the reduction of disease severity by a living organism other than man. In most cases biological control is the suppression of the disease-causing organism by another non-pathogenic organism. This type of control is not an exception in nature but rather a rule of ecological homeostasis. All organisms are controlled by other organisms, and only when these controls are reduced does disease develop. For example, the turfgrass plant itself can control many would-be pathogens by vigorous, healthy growth. If this growth is reduced due to moisture or nutrient stress, certain organisms, such as the rust-causing fungi or the dollar spot-causing fungi, are able to attack the grass plant.

WHAT IS BIOLOGICAL CONTROL IN TURFGRASS?

Biological control is simply the reduction of disease severity by managing those organisms that suppress the pathogen. There are three general approaches to accomplishing this goal: 1) management of healthy turfgrass populations; 2) maintenance of a healthy soil biomass; and 3) reducing the population and activity of pathogens.

MANAGEMENT OF HEALTHY TURFGRASS POPULATIONS

The best broad-spectrum biological control program is proper plant health. Healthy plants are immune to attack by most microorganisms and are more capable of withstanding attack from those relatively few pathogens. This type of management supplies the essential growth nutrients, water, oxygen, and chemical elements, at a balanced and uniform rate. Forcing vigorous shooting and supressing root and tiller activity are examples of the type of imbalanced growth common to intensely managed turfgrass. The application of excessive nitrogen will cause increased plant tissue production and imbalance in the soil microorganisms that degrade the dead plant tissue or thatch. The end result is a weakened plant and an accumulation of thatch, both conditions that can predispose grass plants to pathogen attack.

MAINTENANCE OF A HEALTHY SOIL BIOMASS

Soil biomass refers to the total of living organisms massed in the soil. The biomass of a soil is a very complex and integrated population of organisms. The activity of the biomass dictates plant health, pathogen activity, and the processes of dead plant tissue breakdown. All management practices applied to

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turfgrass affect the biomass. Disease control is best achieved by minimizing the imbalances to the biomass. Imbalances can allow certain microorganisms to escape natural biological controls and attack turfgrass. Practices of aerating, fertilizing, and adjusting the soil pH all affect the biomass. Their uses must be judicious in order to minimize possible dramatic imbalances in the biomass that can ultimately lead to disease development.

REDUCING THE POPULATION AND ACTIVITY OF PATHOGENS

This approach to biological control is directed at reducing specific microorganisms, that is potential grass pathogens. One of the best and oldest methods of achieving this form of biological control is the use of resistant cultivars or cultivar blends. The use of resistant cultivars is directly aimed at the pathogen and has a very minimal effect on the soil biomass. A second approach is the use of microorganisms to reduce the pathogen's population or activity. This type of biological control is not new to agriculture but is undeveloped for turfgrass cultivation. For every organism there exists another organism that will control it. Research at the University of Illinois is identifying those valuable microorganisms and developing them for use in controlling disease-causing pathogens. Because they are natural soil inhabitants, their effect on the soil biomass should be minimal.

WHAT CAN BE EXPECTED FROM BIOLOGICAL CONTROL OF TURFGRASS DISEASES?

Unlike many agricultural food crops for which biological control has proved effective, the level of disease control required for turfgrass is much higher. Disease control for turfgrass is achieved when the visual symptoms of the disease are eliminated; it is not measured by the productivity of the plant. The challenge for biological control is to develop resistant cultivars, since the selected microorganisms or cultural practices are unlikely to succeed alone. However, the development of resistant cultivars is slow and not readily available to offset all disease-causing microorganisms. The turfgrass industry has been forced to rely heavily on cultural practices to maintain healthy turfgrass and on chemical pesticides to reduce pathogen activity. The advantages to developing biological controls include reduced chemical use, balanced soil biomass, and healthy turfgrass. While the challenges of developing biological controls for turfgrass diseases are great, the rewards are equally great.

TURF WATER RESEARCH AND IRRIGATION PRACTICES

Jack D. Butler and David D. Minner

An intense turfgrass water research program has been underway at Colorado State University for ten years, and several people have made significant contributions in this area. Investigations have dealt with water requirements, both from quantity and quality standpoints. Part of the research program has dealt with the influence of various maintenance practices and environmental conditions on water use. Another important part of the research program has been to determine the water requirements of various grasses and their ability to tolerate drought stress.

Meaningful water research with turf, or any other crop for that matter, is quite difficult to do, even in arid and semi-arid regions. Transferring information gained by water research in such regions to a humid area may be questioned. However, much of the information presented here would seem to have some application in the Midwest.

When discussing irrigation practices for the humid north central United States, it is important to realize that those managing turf have no control over most of the water used by the grass. In most situations, it is not proper to discuss irrigation without a discourse on drainage and other soil conditions that dramatically influence irrigation practices.

SOIL CONDITIONS AND IRRIGATION

It is quite difficult and expensive to make significant physical improvements on existing soils; golf greens and a few athletic fields are exceptions. Since soil conditions such as infiltration/percolation rates and water-holding capacities play such an important role in irrigation management, it is important that they be considered in research as well as in irrigation system design and management. More attention has been given to soil conditions when dealing with flood irrigation of deep-rooted field crops grown on uniform soils than to the use of sprinkler irrigation on shallow-rooted turfgrass usually grown on heterogeneous, disturbed soils. However, some positive changes have occurred recently. For instance, many large-acreage turf facilities have had topsoils saved and returned; and the availability of large equipment has made it possible to construct sites with good surface drainage and minimum ponding.

As might be anticipated, the difficulty of working with soil, water, and roots has resulted in little research being done below the soil surface. Now that several universities have or are building rhizotrons for root studies, some much-needed information on roots and water relations may soon become available.

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Knowledge of infiltration rates, which may vary from less than 0.1 inch to more than 20.0 inches per hour on the same golf course, can be adequately determined by using a double-ring infiltrometer. This information can then be used to determine irrigation practices such as how much water can be applied in a given amount of time before runoff. Most of our work with infiltration/percolation has been directed toward developing artificial media for golf greens and football fields. A mixture of 80 percent sand and 20 percent peat is common. However, our research indicates that this ratio of sand and peat, depending on their quality, can result in infiltration rates ranging from 0.3 inches per hour to more than 15.0 inches per hour.

Water for plant use from different soils can vary greatly. A generalization on soil water availability (Table 1) gives an idea of the amount of water that can be held for future plant use.

Table 1. Influence of Soil Texture on Water Availability

	Inches of water per foot			
Soil texture	Available	Average	Unavailable	Average
Sand	0.4 to 1.0	(0.7)	0.2 to 0.8	(0.5)
Sandy loam	0.9 to 1.3	(1.1)	0.9 to 1.4	(1.2)
Loam	1.3 to 2.0	(1.7)	1.4 to 2.0	(1.7)
Silt loam	2.0 to 2.1	(2.1)	2.0 to 2.4	(2.2)
Clay loam	1.8 to 2.1	(2.0)	2.4 to 2.7	(2.6)
Clay	1.8 to 1.9	(1.9)	2.7 to 2.9	(2.8)

There are various ways to determine soil moisture content. Of course, they vary in precision and actual usefulness as a tool for irrigating properly. Among the methods used are those as simple as probing with a screwdriver or using gypsum or nylon moisture blocks to measure electrical flow. Tensiometers may be used to measure soil suction. Also, soil samples can be taken from the field and weighed, then dried and reweighed to determine water content. Although several different ways of measuring soil moisture have been used in turf research, we have found that under our conditions, moisture blocks have worked better for turfgrass than tensiometers. Blocks measure soil moisture at much lower levels than tensiometers, and the grass performs quite well below levels measured by the tensiometers.

The key to using information on water availability, however determined, is dependent upon knowledge of the functional root depth of the turf. Functional depth with the same root system would be deeper when plant water demands are light (spring and fall) than when they are heavy (summer). Figure 1 represents functional root depth during the summer for turfgrasses grown on different soils.

Compared to Kentucky bluegrass, the rooting depth of creeping bentgrass and *poa annua* would be more shallow, and that of tall fescue would be deeper. From Table 1 and Figure 1 it is evident that a sand (average available water of 0.7 inches per foot) with a functional root depth of 2 feet (for 1.4 inches available water) would need less frequent watering but more water at one time

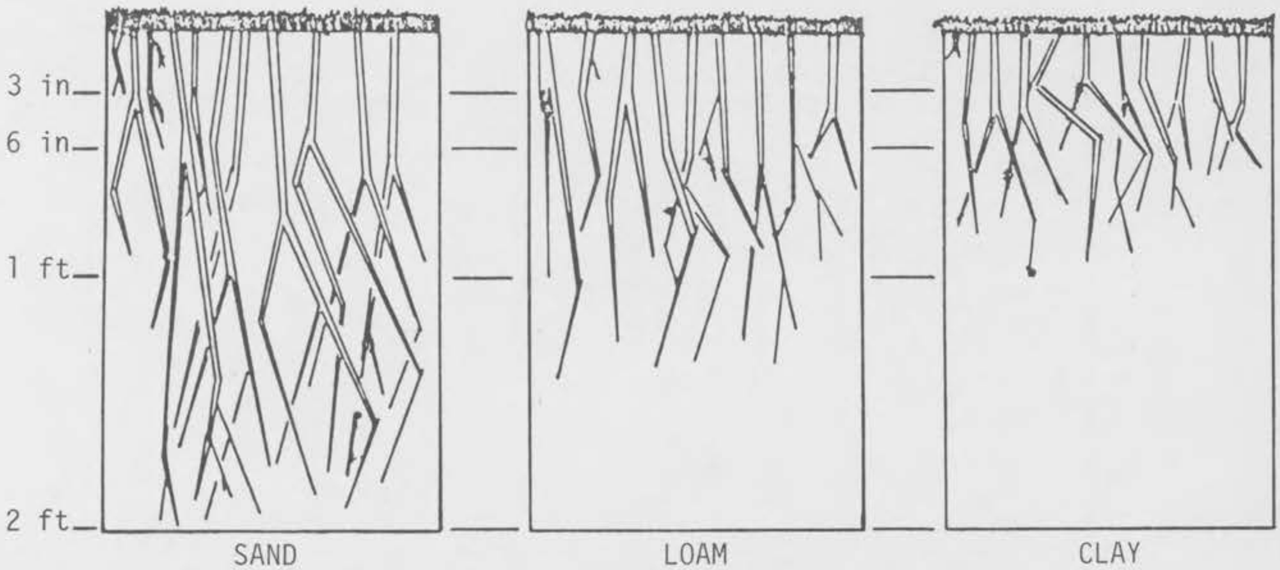

Figure 1. Representation of rooting depth of turfgrass on soils of different texture.

to replenish water in the root zone than a clay (average available water of 1.9 inches per foot) with a functional root depth of 6 inches (1.0 inches available water).

Some of the field research findings and observations that a turfgrass professional might find interesting are:

- Functional rooting of Kentucky bluegrass sod on a sandy soil reached a depth of 6 inches in about 6 weeks, whereas sod on a clay soil did not have significant functional rooting below the harvested sod layer.
- Rooting depth was influenced by water saturation of the soil during the winter months.
- Water use by turfgrass was essentially the same from sand media as from a heavy soil.
- Under severe water stress, grass grown on sand did not recover as well as that grown on a good topsoil.

ENVIRONMENTAL CONDITIONS AND MEASURING WATER USE

Throughout the rest of this discussion, the term "evapotranspiration" (ET) will be used. ET is used to describe water loss from a plant and soil surface. "E" relates to water loss from non-plant evaporation, while "T" stands for water loss from the plant during transpiration. In a dense stand of turf, essentially all water lost is from transpiration. Several factors, such as relative humidity, solar radiation, day length, air temperature, and wind velocity relate to ET. Figure 2 shows the amounts of ET for Kentucky bluegrass for July and August of 1982. This grass was supplied with water to support maximum transpiration. There were several late July days of mostly cloudy weather where the total amount

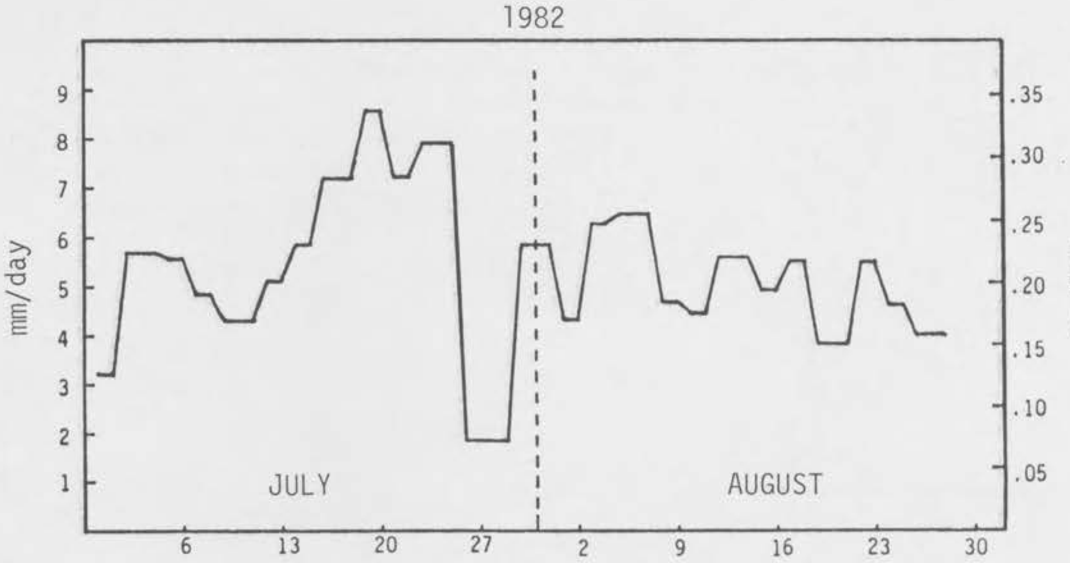

Figure 2. Maximum measured ET of Kentucky bluegrass at Fort Collins, Colorado.

of ET was between 0.05 and 0.10 inches per day; whereas only a few days earlier, ET was 0.30 to 0.35 inches per day. There are times with high solar radiation and winds when Kentucky bluegrass may show drought injury even when soils are moist. Various factors have been used to develop equations to calculate ET. One equation, the Jensen-Haise, relates to air temperature and solar radiation. It has been compared to actual weighing lysimeter measurements of ET at Colorado State University. Although the calculated and actual ET varied slightly, they were in the same range. Calculated ET allows for a practical means of keeping track of soil moisture depletion. Through an educational ET program, the Denver Water Department has been able to realize significant water savings; thus, in times of critical water shortages, turf can be kept with a minimum of water waste. Table 2 shows calculated weather and ET data for Chicago. Information in this table gives an idea of supplemental water requirements for an average year.

Table 2. Chicago Weather and Turf Water Use Data, 607-Foot Elevation

Month	Average temperature, °F	Average precipitation,* inches/day	Days of rain**	Potential ET, inches/day	Irrigation, inches/day			
					40%	60%	80%	100%
May	60	.13	12	.13	..	..	..	..
June	70	.13	11	.20	..	..	.03	.07
July	75	.10	9	.23	..	.04	.08	.13
August	74	.10	8	.20	..	.02	.06	.10
September	66	.10	9	.13	..	..	..	.03
October	55	.10	8	.07	..	..	..	..

*Highly variable
**More than 0.01 in.

A brief discussion about the use of weighing (bucket) lysimeters is in order (Figure 3). After working with deep, heavy, and difficult-to-weigh bucket lysimeters, a shift was made to those that were shallower and could be handled by one person. With weighing lysimeters, water is added for grass use periodically from every 2 to 14 days. In the research at Colorado State University, additions of water have ranged from maximum (100 percent) to 10 percent ET. Weighing lysimeters permit a uniform and accurate study of environmental, cultural, and species influences on water use. Weighing lysimeters work quite well where rain is a rarity; however, for the occasional rain or irrigation of surrounding turf, the lysimeters can be covered with metal lids to protect against unwanted water.

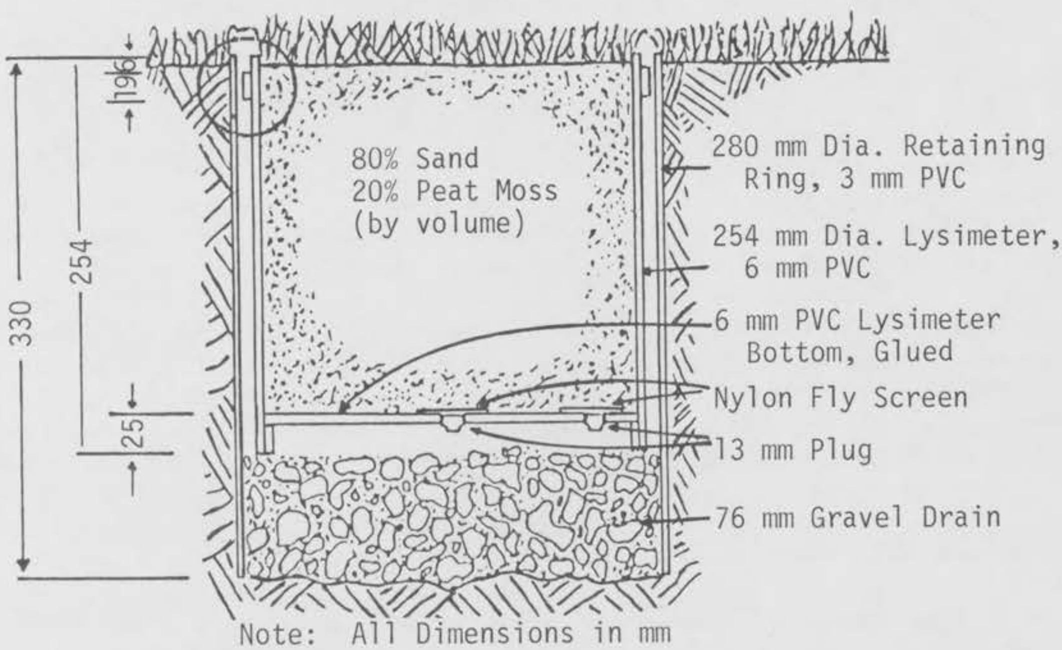

Figure 3. Schematic diagram of installed lysimeter.

The weighing lysimeter method is so simple that it could be set up on a turf installation or at one site to serve a rather large area.

In one study, measurement of water used near a driveway, in an expanse of lawn, and on the south side of a house indicated that maximum ET was near the driveway. More air movement for more water loss accounted for the frequent drought stress situation observed along walks and driveways in semi-arid climates. In more humid regions, runoff onto the turf from impervious surfaces may prevent stresses from developing.

Shade is a very common turf problem in the north central United States. The problem may be associated with light quantity and quality; also, it may be associated with too much or too little water. Research at Colorado indicates that there is a positive linear relationship of ET to the amount of light received. This then points to the reason why many sites, because of *poa annua*, powdery mildew, etc., have so many secondary problems, and why irrigation of shady areas must be handled differently than those in full sun.

CULTURAL PRACTICE AND ET RATES

This is an area that deserves much more research. With the rather infrequent and usually minor droughts that occur in the north central United States, it is likely that new cultural techniques will play a key role in achieving important turf water savings.

In addition to amounts of water required to meet turf needs, frequency of application is an important consideration. Research done in Colorado in 1982 and 1983 revealed that more frequent watering using the same amounts of water produced a better quality turf than when water was applied infrequently. With watering done at 2-, 4-, 7-, and 14-day intervals, quality declined from the 2-day to the 14-day irrigation intervals. With the rather frequent rains in the north central region, the poor performance of grasses watered at 7- and 14-day intervals might be improved if the turf was watered more frequently.

Mowing height can materially affect water use and resultant turf quality. Research has shown that although taller-cut grass may use more water than low-cut turf, it is more efficient, probably because of a better root system. Taller-cut turf also performs better under stress conditions than short-cut turf.

Fertilization of turf is sometimes avoided since it is felt that it will significantly reduce drought tolerance. Fertilization with nitrogen can increase the amount of water needed to keep a turf. However, nitrogen use up to a point can offset other turf problems such as weeds and traffic well enough that it is normally considered a desirable practice, even in dry areas of the United States.

WATER RESEARCH WITH SPECIES AND CULTIVARS

Recently there has been increased interest in refined studies of drought tolerance and ET rates of different grasses. In the Rocky Mountain region primary emphasis has been given to Kentucky bluegrass; however, perennial ryegrass, fine and tall fescue, bermudagrass, buffalograss, etc., have been studied. Warm-season grasses such as bermudagrass and buffalograss tend to be more drought-tolerant, and they have a lower maximum ET rate than Kentucky bluegrass (about 20 percent less). But good Kentucky bluegrass turf requires little water in the spring and fall when the warm-season grasses are dormant and brown. Thus, it seems unlikely that those who desire good year-round quality would replace cool-season grasses with warm-season grasses for a 20-percent water savings.

Table 3 gives the actual water use of four commonly grown cool-season turfgrasses during two summer months, based upon lysimeter measurements. These ET measurements, although important from an irrigation standpoint, are only part of the picture. Although tall fescue has an ET rate higher than Kentucky bluegrass, it is considered more drought-tolerant in the eastern United States. The deep functional root system of tall fescue is able to extract moisture to greater depths: for example, two inches of available water from a one-foot root system; whereas Kentucky bluegrass grown under similar conditions would extract a smaller amount of water (perhaps one inch of available water from a six-inch root system) because of its rather shallow root system. Also, the fact that tall fescue can recover rather quickly from moderate drought stress makes it more acceptable for certain turf situations. In cool, semiarid regions where there is little if any

Table 3. Water Use at Colorado State University by Various Grasses during July and August, 1982

Grass	ET, inches	Percentage < TF
Tall fescue	26	..
Kentucky bluegrass	22	15
Perennial ryegrass	23	14
Fine fescue	21	18

water available below the top few irrigated inches, a deep root system would be of little benefit. In fact, in dry areas, tall fescue does not seem to tolerate extended drought nearly as well as Kentucky bluegrass.

Research in 1982 and 1983 at Colorado State University with many different Kentucky bluegrasses, perennial ryegrasses, and fine fescues has pointed out that drought-tolerance ranking of grasses did not necessarily match research findings. Most drought-tolerance rankings have been derived from field observations under moderate water stress in humid climates. It seems that for arid and semiarid locations, a different listing would be appropriate.

In work at Colorado, 55 Kentucky bluegrasses, 34 perennial ryegrasses, and 42 fine fescues were subjected to moderate and severe water stresses during 1982 and 1983. In an area with 14 inches average precipitation, stress is easily achieved by simply shutting off the water. We did not expect to find that the turf-type perennial ryegrasses performed best of the three genera studied. The ryegrasses were followed closely in drought tolerance by Kentucky bluegrass, and the fine fescues performed surprisingly poorly. The perennial ryegrass stayed green well into a drought period, and most cultivars recovered rapidly once watering was started in September. The fine fescues appeared to be more heavily thatched than either perennial ryegrass or Kentucky bluegrass; consequently, the thatch may have prevented precipitation and even irrigation water from penetrating into and being stored in the soil.

The Kentucky bluegrass cultivars that are shown in the list below recovered well after irrigation was started in September, 1982, following water stress in the summer. None of the fine fescues produced a comparable turf, although they were in good shape before the study began when quality determinations were made.

H-7	America
Majestic	Merion
Bonnieblue	Vanessa
Entensa	ISI-128
Pion	Enoble
A-20-6	

This synopsis represents only part of the turf water research that has been conducted at Colorado State University. The work presented here was chosen because it would likely be of more interest to turfgrass growers in the north central United States than would be research on buffalograss, blue grama, fairway wheatgrass, or morphological and other laboratory examinations of drought tolerance. Because of the unlikely problem of poor water quality, except perhaps from the use of sewage effluent, extensive research done in this area has not been discussed. Several universities in the north central United States are beginning to study turf water use and irrigation practices. Information gathered from this research will help the turf professional keep better turf with less input.

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TURFGRASS INSECT PEST UPDATE

Roscoe Randell

During the 1983 growing season, turfgrass insects were not of major concern. High temperatures, drought, and other climatic factors overshadowed some minor insect problems. The spring months were cold and wet, delaying insect development. The summer months after July 10 were hot and dry, causing some insect populations to decrease and others to reach damaging numbers.

SOD WEBWORM

This insect population built up during 1983, and many home lawns showed damage by mid-August. This damage was often masked by drought conditions. In surveys of microsporidia disease found in webworm adults and larvae, up to 25 to 30 percent were found to have been infected by October. This percentage should increase in 1984, killing off many larvae in July and August. But sod webworm should successfully overwinter under the snow cover and the potential for damage will remain.

CHINCH BUGS

In previous years, about the only chinch bug outbreaks in Illinois have been in Zoyziagrass lawns. This species is the southern chinch bug, which is common in the southeastern states. Reports of chinch bug activity in bluegrass were received from the northern third of the state. From descriptions and types of damage, this species may be the hairy chinch bug, a turf insect pest in Ohio and Michigan. More surveys and identification will be made in 1984.

GRUBS

Annual white grubs were less numerous in 1983 than in the five previous years. Egglaying was made difficult by the July drought conditions. The female digs a small hole and buries the egg. Well-watered lawns in annual white grub areas still exhibited severe damage from grub feeding. *Ataenius spretulus* or black turfgrass ataenius grubs appeared in some golf course fairways in July. They were delayed by cold spring temperatures. Chemicals gave excellent control where applied.

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CUTWORMS

There were fewer black cutworms on golf greens and tees than average in 1983 because fewer than the normal number of adult moths migrated into the state.

GREENBUG

Very few lawns exhibited greenbug or aphid damage during 1983.

INSECTICIDES: OLD AND NEW

Diazinon, Dursban, Dylox or Proxol, and Sevin are still available for use on turf insects. A new formulation, 50-percent wettable powder, is available for Dursban users. Turcam, a Nor-Am product, is suggested for grub control.

Oftanol received a federal label for both a 5-percent granule and a 2-pound-per-gallon liquid formulation in the fall of 1983. Triumph, an organic phosphate developed by Ciba-Geigy, is expected to be labeled in 1984.

CLIPPINGS: CATCH OR RETURN

Jack D. Butler and David D. Minner

This topic, no doubt, would be of most interest to a turf professional involved with home lawn care or with keeping other small, highly maintained turf areas. Recent discussions in a few turfgrass publications have covered the collection of clippings on golf course fairways. This presentation will be directed in part to that practice, as well as to the desirability of collecting or not collecting clippings on small turf areas.

A current trend of the working turf professional and researcher is toward minimum-maintenance turf. As little care as possible with as little reduction in turf quality as possible is a common goal. Our research with turfgrass at Colorado State University has mostly been directed toward solving water, soils, high pH, high salt, and cold-temperature problems. But a three-year study on clipping removal supported in part by the The Toro Company provided some valuable information on this subject. Information gained from that study as well as from other university research and general observations will be discussed below.

EQUIPMENT

At the present time it seems that most of the non-commercial, small rotary lawn mowers available leave the user with little alternative but to collect clippings. The rear-discharge machines so common today are not designed to return clippings. During the last few years, mulching mowers that cut clippings into small pieces so that they disappear down into the turf have become available. These mowers can work quite will provided the turf is neither too tall nor too wet. Thus, it is necessary to mow rather often.

Except with a few reel mowers, such as triplex greens mowers and mowers specially rigged by sod growers, clippings are not caught with larger mowers. Consequently, beyond equipment purchase, the decision on whether or not to collect clippings may be taken out of the hands of the turf manager and placed in those of the manufacturer.

TURF USE

In only a very few instances does it seem necessary to remove clippings based upon turf use. Clippings may need to be caught if they will be tracked into a building. On golf greens that are wet with dew, balls tend to pick up clippings and not roll true. It is a common practice on golf greens to leave the baskets off the mowers for a few days after fertilizing, especially if an insoluble-type fertilizer is used.

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HEIGHT AND FREQUENCY OF CUT

As a rule, the higher a turf is cut the more open it is, and the better clippings can disappear into it. If turf gets excessively high before mowing, it is often easier to double-mow to get the clippings down than to catch them,.

KINDS OF GRASS

The tigher the canopy produced by a turf the less likely the clippings will be to disappear into the uncut grass. Consequently, there is a greater need to collect clippings. Grasses such as bentgrass, improved bermudagrasses, and *Poa trivalis* produce a tight turf. Common Kentucky bluegrass, common perennial ryegrass, and tall fescue produce a fairly open turf.

LABOR

Clipping removal involves great labor expense. This expense may be direct or indirect. It is easy to realize the direct cost involved when the time involved with stopping the mower and dumping or bagging the clippings is considered. But indirect cost, except by lawn maintenance companies that catch clippings and haul them to the dump, are generally more difficult to visualize. An indirect expense occurs when additional labor and materials such as fertilizer are needed to replace the soil nutrients lost by clipping removal. The cost of hauling clippings by municipalities and others in the trash removal business receives more and more attention.

Several factors, such as kind of grass, fertility program, irrigation, height of cut, etc., influence clipping production. And, of course, the more clippings removed the greater the labor costs. Without fertilizing, the fresh weight of Merion Kentucky bluegrass clippings harvested at Colorado State University in 1980 was 222 pounds per 1,000 square feet per year. With 6 pounds N per 1,000 square feet, the yield was 529 pounds per 1,000 square feet per year. At 6 pounds N per 1,000 square feet in 1980, considering that the bag or basket on a single unit mower would hold 25 pounds of clippings, the mower would have had to be stopped and emptied 22 times per 1,000 square feet per year.

CLIPPINGS AS A RESOURCE

Losses sustained by dumping clippings have been the subject of only a very few articles in turfgrass publications. Use of clippings for compost or mulch is possible, but seldom practiced. There are, however, a few sizeable pelleting plants for harvested clippings associated with sod farms. Considering the large amount of quality material available and if pesticides are properly handled, clippings from golf courses could be utilized much more in the future and not wasted at a dump.

Work done at the University of Illinois provided information on the nutrient value for livestock feeding of harvested clippings. It was reported that dehydrated turfgrass (bluegrass), compared to pelleted alfalfa, contained appreciably more crude protein: 23.7 percent versus 14.9 on a dry matter basis.

SOIL FERTILITY

Research on clipping removal versus clipping return at Colorado State University indicated that clipping removal could significantly reduce soil nitrate levels. Nitrogen levels in plant tissues from turf clippings coincided with moderate and high levels of nitrogen application. With nitrogen application and clipping return, soil nitrate levels increased rather rapidly. The data collected in this study demonstrated rather clearly that clipping return could improve soil nutrition and positively affect turfgrass quality.

THATCH INFLUENCE

One of the main reasons that homeowners catch clippings is to avoid thatch problems. If lack of earthworms or cold soil are such that thatch accumulates, then additions of organic matter in the form of clippings might well contribute to the buildup. However, in most cases, thatch does not accumulate to cause a problem, so it is unlikely that the relatively small amount of growth/organic matter in the clippings will cause a thatch problem. A plot of Kentucky bluegrass was grown at the University of Illinois and fertilized with 20 pounds of N per 1,000 square feet per year for eight years. The clippings were not caught and did not accumulate enough thatch to be of concern. As was shown in the clipping return/clipping removal study at Colorado State University, collecting clippings does not increase thatch under good growing conditions.

INFLUENCE ON PESTS

Weed control is one of the reasons given for collecting clippings. No doubt more weed seed would be deposited by returning clippings than by catching them. Just how important is the difference from a practical standpoint? Most common turf weeds, by their very nature, will produce seed below the mowing height. Only a few weeds produce viable seed in the time between mowings. And many turf weeds are readily disseminated over long distances by wind and water. Cultural weed control through proper mowing will help to restrict weeds: the higher the cut the better, within reason. Fertilize for a dense stand, water appropriately, and use adapted cultivars.

As for diseases and insects, there is very little research or field observation relating clipping removal to fewer insect or disease problems on turf.

SUMMARY

From this rather lengthy discussion have emerged several reasons not to catch clippings and a few reasons whey they should be caught. Compared to the input necessary to collect and dispose of clippings, almost any other program might well be considered low maintenance. Also, the necessity and cost of replacing plant nutrients that are removed with the clippings should be considered. While clippings may have little influence on thatch accumulation, what about organic matter reduction in the soil?

As with most things, the turf professional on the job will have to decide whether or not to change practices. If this presentation has only caused a consideration of changing a management practice, it has been successful.

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MAINTAINING KENTUCKY BLUEGRASS FAIRWAYS AFTER RENOVATION

James W. Brandt

Our initial decision to renovate was due to the invasion of our common Kentucky bluegrass fairways by *poa annua*. Each year we lost more Kentucky bluegrass, then ended up trying to hold the *poa annua* in the summer stress periods. This vicious cycle is familiar to most of us trying to maintain common Kentucky bluegrass at ever-increasing rates of fertility and watering associated with the lower height of cut. *Poa annua* and Fusarium blight become the ultimate victors.

With the help of Dr. Bill Meyer, who was with Warren Turf Nurseries, we introduced several cultivars into the existing turf on our 16th fairway. Only two cultivars held their own and expanded into the existing turf. In 1978 we established a series of five trial plots in our fairways. Each series included (1) a mixture of improved turf-type ryegrasses; (2) a seeding of I-13; (3) a seeding of H-7; and (4) a mixture of improved bluegrasses including Adelphia, Baron, Glade, Nugget, Pennstar (not available), and Sydsport.

The H-7 and the I-13 were outstanding, and the I-13 was the better of the two. As a result of the trial plots, it was decided to renovate the front nine in the fall of 1979. We used Roundup prior to reseeding a mixture of 50-percent I-13 and 50-percent H-7. The back nine was renovated in the fall of 1980. We seeded at rates of 20 pounds per acre in a split overseeding.

As a result of our renovation work, we went into 1980 with fairways that ranged from 90 to less than 40 percent of the improved bluegrass mixture. Each year we lost some of the *poa annua* during the stress periods due to Anthracnose and dollar spot.

In April, May, and June of 1981, Endothal was applied at the rate of 1 quart per acre for the supression of *poa annua*. In August of 1981, Balan was used at the rate of 100 pounds per acre to try to inhibit *poa annua* germination in the voids caused by *poa annua* loss.

In 1982 Balan was applied at the rate of 90 pounds per acre in late April for crabgrass and *poa annua* control. It was applied again in late August at the rate of 140 pounds per acre for *poa annua* germination control.

Overseeding has been accomplished in areas that contained more than an estimated population of 40 percent *poa annua*.

In spite of more adverse conditions in 1983, our fairways showed a gradual and continued improvement from 1981 and 1982.

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This fall we have continued our calcium arsenate treatments and have added Betesan at the rate of 15 pounds of active ingredient per acre into our testing program.

There has been a gradual increase in the percentage of Kentucky bluegrass in the fairways. Our fertilization has included nitrogen at the rate of 4 pounds per 1,000 square feet plus 3 pounds of potash per 1,000 square feet and only very minute amounts of phosphorous per year.

We have been testing calcium arsenate as an inhibitor to the regermination of *poa annua* when the loss occurs. Up until the summer of 1983, we had encouraged the loss of *poa annua* by moisture stressing with no disease controls.

The slide presentation will depict the calcium arsenate as being a very superior material for the supression of the *poa annua*, while the Balan gave less than satisfactory results.

In 1983 we decided to spray all fairways for Anthracnose control. Strips 30 feet wide were left unsprayed in three fairways to determine the amount of control that we were obtaining. The materials used and dates and rate of application are given in Table 1. We were quite happy with the *poa annua* decline.

The areas that were almost 100 percent bluegrass remained excellent fairway turf through the high-temperature and high-humidity regime that existed in our area from mid-June to mid-August. When the cooler nights came about August 18, the Fusarium was not far behind. The areas of good bluegrass were now mottled and looked little better than the adjacent areas that were left unsprayed for *poa annua* decline.

I have learned that a spray program is only half planned if you do not include spray applications for the control of Fusarium blight in a mixed *poa annua*-bluegrass population. Future plans call for the applications of Bayleton for Fusarium blight control. We will also expand the testing program to try to find other materials that might control *poa annua* more effectively.

Our plans for 1984 include the expanded testing of *poa annua* control materials. We will continue the *poa annua* decline spray program on a greatly reduced acreage and will initiate measures for the control of fusarium blight in the fairways.

Table 1. Fairway Fungicide Treatment, Danville Country Club, 1983

Date	Material used	Rate per acre	Cost per acre	Total cost per treatment
6-14-83	Teresan 1991	2.75 pounds	$ 32.50	$ 915.00
	Daconil 2787	8.15 pounds	30.63	858.00
	Hydrowet	56 ounces	8.85	248.00
	Total		$ 72.80	$2,021.00
6-27-83	Bayleton	21.8 ounces	$ 35.36	$ 990.00
	Acti-dione TGF	15.0 ounces	8.23	230.00
	Total[1]		$ 43.59	$1,220.00
7-11-83	Bayleton	21.8 ounces	$ 35.36	$ 990.00
	Acti-dione TGF	15.0 ounces	8.23	230.00
	Hydrowet	56.0 ounces	8.85	228.00
	Total[1]		$ 51.77	$1,498.00
7-18-83	Bayleton	3.13 pounds	$ 84.54	$2,367.00
	Subdue[2]	65.34 ounces	38.30	1,072.00
	Total		$122.84	$3,439.00
8-2-83	Teresan 1991	43.56 ounces 2.72 pounds	$ 32.60	$ 915.00
Total cost all treatments			$323.84	$9,062.00

Note: The fairway spray program should have included two applications of Bayleton for Fusarium control. The projected cost for two treatments at 4 ounces per 1,000 square feet was $294.00 per acre. For the two treatments of 28 acres of fairways, the cost would have been an additional $16,456.00.

[1]This cannot be construed to be an ideal treatment for the control of Anthracnose, but it did effectively control Anthracnose-dollar spot-*poa annua* decline.

[2]Subdue was added to the intended treatment as *Pythium* infestation became very heavy in mid-July.

WARM-SEASON TURFGRASSES FOR GOLF COURSE FAIRWAYS AND TEES

John H. Dunn

The unusually hot summers of 1980 and 1983 caused renewed interest in warm-season grasses for use as golf turf in the upper South. Even admirers of the cool-season grasses probably wished they had bermuda or zoysia on fairways and tees during the record heat and drought of August, 1983.

Where did bermudagrass come from? The principal source of bermuda turf, *Cynodon dactylon* L., was an import from east African "big game" country in the 1700s. According to Dr. Robert Schery, retired director of the Lawn Institute, it was probably brought to America via Charleston, South Carolina, on one of the early slave vessels by a captain who had an eye for its forage potential. By 1800, bermudagrass was widespread over the southeastern United States.

Dr. Ray Keen, Kansas State University, tells us that several bermuda strains were observed for their turf potential at Kansas State in the 1930s and at Hays, Kansas, by the Soil Conservation Service. At about the same time, "U-3" was being evaluated by members of the U.S. Department of Agriculture staff at Beltsville, Maryland.

Dr. Keen's breeding program in the 1950s included hardy bermudagrass types collected in Kansas and Nebraska. His excellent program, now headed by Dr. Bob Carrow, has yielded the winter-hardy cultivars "Midiron" and "Midway" and a planned new joint release of the experimental S-16, tentatively called "Midmo" by the Kansas and Missouri Agricultural Experiment Stations. Dr. Keen's work helped to extend the practical northern limits of bermudagrass habitat to Missouri and Kansas. Outstanding contributions to the development of more winter-hardy types have also been made by Dr. Huffine at Oklahoma State University and more recently, Dr. Glenn Burton, who earlier developed the "Tif" series of southern bermudas.

At Missouri, Dr. Bill Lobenstein, retired State Turf Extension Specialist, collected strains of bermudagrass that showed excellent winter hardiness and long-term persistence on golf courses and lawns. These were mostly coarse strains, and Dr. Lobenstein labeled them according to the locations where they were discovered: "Algonquin" for Algonquin Country Club in St. Louis and "St. Joseph" from a lawn with northern exposure in St. Joseph, Missouri. Several professional turf managers contributed to bermudagrass collections in the upper South. Ralph Sehrt was superintendent of Westwood Country Club in St. Louis when he discovered the "Westwood" strain, which is now used on several golf courses and athletic fields in the Midwest.

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What is the nature of the beast--and some people do consider it a beast!

Bermudagrass is an aggressive grass, and given the right environmental conditions it spreads rapidly by stolons and rhizomes. These rhizomes and stolons are the source of vegetative sprigs used to establish all varieties except "Common," which is seeded. Sprigs and sod plugs may be hand planted, machine planted, or broadcast on prepared sod beds and lightly pressed into the soil with a disc plow or other implement. Careful watering and/or topdressing is needed until the new planting is well established. Weed control is not as crucial as with the less aggressive zoysia, but our work and that of others has shown that use of selected pre-emergence herbicides for annual grass control and 2,4-D for broadleaf control will speed establishment.

Bermudagrass thrives in very warm soil and air temperatures; 80°F is said to be near optimum for root development. Topgrowth is vigorous at 100°F. Water is needed for best growth, at least 20 to 25 inches annually. Bermudagrass is drought-tolerant but may not have the "staying power" of dryland species such as buffalograss.

As temperatures cool to the high 30s and low 40s on early fall evenings, bermudagrass loses color and will turn brown following heavy frost. Winter is a time of trial. Direct cold injury and more often a combination of cold temperatures and desiccation can kill bermudagrass. Our work has shown that there are wide differences in winter tolerance of genotypes, and selection of best-adapted types is a prerequisite for success with this species in the upper South.

Proper management can influence failure or success during difficult winters. Intelligent fertilization is a key for building energy reserves, and we suggest about 2 to 3 pounds N per 1,000 square feet per year on fairways, sometimes a little more on tees to promote healing of divots. Applications of 3/4 pound N should be evenly spaced from late April or early May until August to give the 2- to 3-pound total. Frequency of applications will be influenced by choice of nitrogen carriers. Fertilization with nitrogen should be stopped in late August to allow the grass to build carbohydrate reserves for winter. Potassium should be kept at high levels according to soil tests. Supplementary topdressings with potash or other potassium carriers in May and/or September at rates of 1 or 2 pounds K_2O per 1,000 square feet are often advisable. This is particularly important for selections with marginal winter hardiness in the upper South. Where soils test high in potassium or the element is applied during regular fertilization in summer, fall topdressing with potassium may be skipped. Soil phosphorus should be kept at moderate levels.

Bermudagrass on fairways and tees should be mowed at about 3/8 to 5/8 inches, one to four times per week as needed. Thatch removal is a routine part of the management program and is accomplished by verticutting (vertical slicing), usually after bermudagrass has greened up in spring. Some managers prefer verticutting before greenup to encourage early soil warming and to stimulate early growth. This may be a successful approach unless the practice occurs too early and is followed by a late spring freeze. Avoid verticutting at the first signs of greenup when new root systems are being generated. Core aerification in several directions during late spring and summer will also reduce thatch, relieve compaction, and promote air exchange between soil and atmosphere as the summer season begins.

Irrigation should be provided when necessary during the growing season and may be needed occasionally from late fall to early spring while turf is dormant if the weather is unusually dry and desiccation is a potential problem.

Crabgrass and other weeds may be controlled with pre-emergence herbicides or post-emergence applications of MSMA, DSMA, and similar products. We have had good success controlling winter weeds and cool-season grasses with glyphosate applied in late February or early March, well before spring greenup of bermudagrass.

What is the future outlook for bermudagrass? Occasional winter injury should be expected. Afterall, it is a warm-season species, and in the upper South we are testing its northern limits of adaptation. However, avoidance of marginally adapted varieties like "U-3," which is only moderately cold-hardy and susceptible to spring deadspot disease, should minimize the calamitous losses of bermudagrass that occurred in the Philadelphia area about 1960 and in St. Louis and Kansas City during the winters of 1969-70 and 1981-82. Hardier varieties such as "Midiron" are available and more are on the way.

An alternative to bermudagrass is *Zoysia japonica*, a warm-season species that, like bermudagrass, prefers warm nights and days with temperatures hovering near 100°F. Cold tolerance of this species is tops among the warm-season grasses and may be attributed to its origin in Korea-Manchuria where sub-zero temperatures in winter are common. The tough-leaf species also has good tolerance to foot traffic and generally good disease and insect tolerance in the Midwest. Established, healthy turf is dense and mostly weed-free. Zoysia will grow on a wide range of soil types, although it seems to prefer the "heavier" soils. The principal variety in midwestern areas is "Meyer," a japonica selection of moderate leaf texture. New experimental selections developed at Kansas State and by the U.S. Department of Agriculture may give some improvement over Meyer in future years.

With so many good features, one might ask if this grass has any shortcomings. Unfortunately there are several, including the usual practice of establishing the grass vegetatively by sprigging or plugging. This necessary and expensive practice can be attributed to the wide variation in seedling types that occurs with seeding. In addition, zoysia has a thick seed coat that may result in a low percentage of germination. The latter problem has been largely overcome with chemical and light treatments, but variation in seedlings has discouraged propagation by seed where uniform turf is required. Following vegetative planting, growth is slow and some pampering and coaxing is needed to encourage more rapid spreading. Weed control to prevent competition to the developing turf is a requisite for quick zoysia establishment.

Later, the permanent turf may develop a heavy layer of thatch, particularly if it was overmanaged. Regular, mechanical thinning is needed to keep the turf in top condition. Zoysia loses color with heavy frost and will remain dormant for 6 to 7 months in the Midwest. Some individuals find the yellow-brown color of the dormant turf attractive in winter; others do not. Also, winter weeds may be a nuisance in the dormant turf, but these are easily controlled with herbicides.

When establishing this grass, it is best to begin with a clean, weedfree seedbed. Sprigs or plugs should be set on six-inch centers or closer, depending upon the planting technique. Planting in late spring will allow maximum spread during the summer. "Hydrosprigging" and broadcasting of sprigs, for example with a manure spreader, are among the other methods used to plant on bare soil. It's a good idea to press sprigs into the soil with a disc cultivator with wheels set straight.

Strip-sodding or plugging in existing turf is an alternative planting method but competition from other grass species will slow the spread. Research in the past five years suggests that certain growth-retardant chemicals may check the growth of competing species without serious inhibition of zoysia spread. Immediate and judicious watering of new plantings is important to prevent initial shock and insure a quick take-off. Failure to water zoysia thoroughly when planting during hot weather may slow its growth for several weeks. Mulching and/or overseeding with a perennial grass such as ryegrass may be necessary to hold soil on slopes until zoysia has filled in.

Turf developing on bare soil should be fertilized heavily with a total of 8 to 10 pounds N per 1,000 square feet over the summer until mid-to-late August. Fertilization should be discontinued at this time to allow the grass to harden for the coming winter. As noted earlier, weed control should be practiced to prevent competition during the period of fertilization. We have used 2,4-D for broadleaf control and several pre-emergence herbicides for crabgrass control in newly planted Meyer zoysia with good success at Columbia, Missouri. If the foregoing practices are followed, the turf may be well established after two summers.

Fertilization of established zoysia turf will require about 1 to 2 pounds N per 1,000 square feet over the growing season depending on use of the turf and color preference and assuming that phosphorus and potassium are kept at a moderate to high level. Golf course tees and fairways should be mowed at 3/8 to 5/8 inches with hydraulically driven reel mowers. Mechanical dethatching by vertical slicing or aeration, which is less debilitating to turf, will be necessary from time to time, but this can be minimized if moderate fertilization practices are observed.

THE NEW TALL FESCUES

John H. Dunn

Tall fescue is a cool-season grass species that originated in Europe and the Mideast. It was introduced in the United States during the early 1800s. It is a hardy grass that produces little thatch, has a tough leaf tissue, good wear tolerance, and adapts to a wide range of soil textures and pH. Tall fescue grows well in sunny or moderately shady areas and ranks ahead of other cool-season species for summer heat and drought tolerance. During most Missouri summers, deep-rooted, green tall fescue cultivars stand out like a "sore thumb" next to elite, but dried-out Kentucky bluegrasses in nonirrigated test plots at Columbia.

We have commonly recommended "Kentucky 31" tall fescue in Missouri for use on nonirrigated lawns, school grounds, and athletic fields. With proper establishment and management procedures, we can grow an attractive turf with this old tall fescue workhorse.

A fertile seedbed is important and should include ample phosphorus, potassium, and lime. For lawn turf, heavy seeding of 8 to 10 pounds per 1,000 square feet is preferred to former pasture recommendations as low as 2 to 16 pounds per acre. The heavy seeding rate will result in a denser turf that helps to compensate for a lack of rhizomes and tillers. Also, competition between plants gives finer-textured leaves and a more pleasing turf appearance. Lighter seeding rates may be used where establishment of a ground cover is the primary objective and turf appearance is of secondary importance. Yearly maintenance should include mowing turf to 2-1/2 to 3 inches for lawns and fertilizing with 3 to 4 pounds N per 1,000 square feet, mostly in the fall.

There are some serious disadvantages to culturing Ky. 31, and they should not be overlooked. It tends to become clumpy and infested with other cool-season grasses if it is not established and managed properly. Because it lacks rhizomes and abundant tillers, it cannot compete with spreaders like Kentucky bluegrass. On occasion, tall fescue may be damaged by warm weather diseases like brown patch and Fusarium blight, especially if it is watered improperly and overfertilized. Also, its leaf texture, which is coarse compared to that of Kentucky bluegrass, is objectionable to some people.

In the mid-1970s "Rebel" tall fescue, a fine-leafed, rapid-tillering cultivar, was introduced to the turf world. This has been followed in the past 1 to 3 years by an array of cultivars with similar characteristics. Introduction of the new tall fescues has brought a new dimension to use of this species for turf. (The cultivars are discussed individually below.) Most of the new cultivars produce abundant tillers, one of several advantages over cultivars with fewer tillers like Ky. 31. For example, we recommend seeding Ky. 31 at 8 to 10 pounds per 1,000 square feet. But some of our current studies and the earlier

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research of Dr. C. Reed Funk and his associates (Table 1) suggest that newer cultivars like Rebel require lower rates to establish satisfactory turf. In fact, Funk and Johnson-Cicalese suggest that heavier seeding rates may lead to increased disease incidence in a dense, overcrowded seedling turf. In spite of continued susceptibility to diseases such as Rhizoctonia and Fusarium (Table 2, July 17), "Falcon's" higher tillering rate compared with Kentucky 31 encouraged rapid recovery from disease or injury when weather became favorable (Table 2, August 8).

Table 1. Effect of Seeding Rate on Tiller Density and Turf Performance of "Rebel" and "Kentucky 31" Tall Fescue in Turf Trials Seeded September September 1978, Adelphia, New Jersey

Cultivar	Seeding rate, pounds per 1,000 square feet	Number of tillers per square foot, November 1979	Turf performance score (maximum 9)		
			1979	1980	1981
Rebel	4	1,801	6.4	7.0	7.5
	8	2,031	7.0	7.6	7.6
	12	2,013	7.2	7.5	7.5
Kentucky 31	4	945	4.3	4.3	4.2
	8	1,558	4.9	5.0	4.9
	12	1,512	5.1	5.3	4.7
LSD at 5 percent		453	0.5	1.0	0.7

Table 2. Fusarium Disease and Quality of Tall Fescue Cultivars and Experimentals, Columbia, Missouri, 1981

Entry	Fusarium patches per 24 square feet, July 17[1]	Quality August 8, (maximum 9)
Falcon	3.7	6.3
Action	3.0	4.8
Mo. WG2B	3.0	4.2
Mo. HLAE	1.7	6.2
Ky. 63G1-318	1.7	6.2
Mo. Hunt Special	1.0	6.3
Ky. 03G1-325	1.0	6.8
Kenhy	0.7	6.7
Ky. 31	0.7	6.3
Mo. LLAE	0.7	5.8
Rebel	0.7	6.0
Mo. WG3B	0.7	6.0

[1]Usually 4- to 6-inch diameter patches.

In addition to the obvious potential for use on lawns, the new fescues' improved tillering and adaptation to close mowing may also make them well-adapted to athletic fields and even golf courses. We (J. Dunn, D. Sleper, and K. Hunt) recently selected four "experimental" tall fesuces that showed good turf quality after three years of testing at 7/8-inch mowing height in a group of 84 selections. Other researchers have released or are developing cultivars that may adapt similarly for use in sports turf. Some of these newer cultivars were established on fields in the new St. Louis (Meramec) soccer park during 1982. We will be interested to see how they fare with intensive use.

Much remains to be learned about management of the newer tall fescue cultivars. During 1982, we planted 15 cultivars in 12- x 15-foot plots to study long-term effects of irrigation, fertility, and tentatively, mowing height. A mild, dry winter with enough freezing and thawing to "heave" seedlings out of the soil led to the loss of an estimated 50 to 60 percent of the original stand. However, improved tillering of these cultivars plus a cool, wet spring helped fill in the turf, and this brought the cultivars into the summer in good shape. With the exception of Kentucky 31 and Kenhy, cultivar density was estimated to be 90 to 95 percent as of September 1. We began management treatments in spring, 1984.

TALL FESCUE CULTIVARS

Adventure. A medium dark green cultivar with medium texture and density; retains color at low fertility levels better than many tall fescues currently available; has good resistance to the Rhizoctonia brown patch and Helminthosporium leaf blight diseases.

Brookston. A leafy, low-growing tall fescue with medium dark green color and medium texture and density; may have improved low-temperature hardiness; has good resistance to Helminthosporium blight.

Clemfine. Originated from germplasm selected from old turfs located in the southeastern United States; a medium green color, coarse texture, and medium-to-low density; moderately good resistance to Rhizoctonia and fair resistance to Helminthosporium blight.

Falcon. Forms an attractive, persistent turf with finer texture and higher tiller density than most tall fescue cultivars.

Galway. A moderately low-growing cultivar that has medium density and medium-coarse texture; good heat and drought tolerance and improved cold hardiness. Adapts to moderate shade as well as to full sun; moderate resistance to Rhizoctonia brown patch and Helminthosporium blight.

Houndog. Has medium dark green color and medium texture and density; good heat and drought tolerance; adapts to shade and shows good color retention in late fall; moderate resistance to Rhizoctonia brown patch and Helminthosporium blight.

Jaguar. Attractive, leafy, turf-type tall fescue cultivar of medium density and texture, dark green color, and moderately low growth habit; good heat and drought tolerance, good shade adaptation, and good color retention in late fall; good resistance to Rhizoctonia brown patch and Helminthosporium blight.

Kenhy. A synthetic from eleven derivatives of annual ryegrass with tall fescue hybrids; produces a coarse, moderately open turf with a rapid rate of leaf elongation.

Mustang. A moderately low-growing, turf-type variety with medium texture and density; good shade adaptation and good fall color and early spring greenup; excellent resistance to Helminthosporium blight and moderately good resistance to Rhizoctonia brown patch in New Jersey turf trials.

Olympic. An attractive, leafy, persistent turf-type cultivar with medium texture and density; has good heat tolerance, adapts to moderate shade, and has very good color retention in late fall; moderately good resistance to Helminthosporium blight and Rhizoctonia brown patch; retains an acceptable green color at low nitrogen fertility levels.

Rebel. Forms an attractive, leafy, persistent turf with a slower rate of vertical growth than most of the commercial cultivars.

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GROWTH RETARDANTS: PAST AND FUTURE TRENDS

Thomas W. Fermanian

Much discussion in recent years has centered on the use of plant growth regulators (PGR). I want to clarify the misconception about the name "PGR." You might have noticed in our title that the word is "retardant," not "regulator." In turf, our primary interest in using growth retardants is to inhibit the vertical shoot growth of the turfgrass plant, thus reducing the mowing requirements for quality turf. Unlike compounds that either accelerate or inhibit growth, materials used on turf only inhibit growth and are more correctly called "retardants."

Initial investigation into the possibility of chemically retarding turfgrass growth begain in the early 1950s. Maleic hydrazide (MH) was the first compound to become commercially available. MH was followed by other compounds that work in a similar fashion: chlorofluorenol, ccc, and others. Turfgrass retardants work in one of two basic ways: either by killing the terminal (apical) bud or severely inhibiting it from any further activity. Other materials simply inhibit the elongation of cells and thus slow down the extension of the leaves. Most of the early plant growth retardants fall into the former group. Maleic hydrazide and chlorofluorenol greatly inhibited the meristematic activity in the apical meristem and thus caused accelerated tillering and little vertical extension. One of the limiting factors with the early growth retardants was their great dependence on environmental conditions both at the time of application and during the period of their activity. Consistent control was not always found with these materials. The sensitivity of many of the turfgrasses to potential injury from these chemicals was highly dependent on the rate of application. At higher rates, some injury could occur.

Another factor in the use of the early growth retardants was the limited time for effective application. The period of application could be as short as one week. This does not allow enough time for a large-scale operation to apply growth retardants effectively. An example might be a highway district that is unable to cover all the right-of-ways in only the short, one-week period of time. Have we made any gains in the efficiency of turfgrass retardants? I think we have!

The strengths and weaknesses of currently labeled compounds and a few that you will probaly see in a very short period of time are shown in Table 1. You have probably heard of many of the compounds before and are aware of their great potential. This potential will only be realized once we start using them on a widespread basis. Until then, your only source of evaluation will be the limited testing that has been conducted over the past few years.

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Table 1. Turfgrass Growth Retardants and Their Properties

Tradename	Common name	Formulation	Tolerant species	Application rate, pounds of active ingredient per acre	Weeks of effective growth reduction	Seedhead suppres-sion-
MH	Maleic hydrazide	1.5S	All (except low-cut bentgrass)	2.25 to 3	4 to 8	Good
Embark	Melfluidide	2S	All (except low-cut bentgrass	0.25	4 to 8	Excellent
MON-4620*	Amidochlor	4F	Kentucky bluegrass	2.5	4 to 8	Very good
			Perennial ryegrass			
			Tall fescue			
Ethrel*	Ethephon	2S	Kentucky bluegrass	4 to 7	4 to 8	Poor
			Tall fescue			
			Hard fescue			
Cutless	EL-500	50WP or 1G	Kentucky bluegrass	1 to 1.5	6 to 10	None
			Perennial ryegrass			
			Tall fescue			
PP333*	---	50WP	Kentucky bluegrass	1 to 1.5	6 to 10	None
			Perennial ryegrass			
			Tall fescue			

*Not currently registered for use on turf.

Maleic hydrazide and MH-chlorofluorenol combinations are still available from several manufacturers. As a class, these compounds provide very good vegetative control and good seedhead suppression, but they have been hampered by a record of occasional phytotoxicity and some inconsistency.

Mefluidide, which is available as Embark from the 3M Company, has been on the market for a number of years. Embark is formulated as a solution at 2 pounds per gallon. It is effective on most turf species grown in Illinois with the exception of low-cut bentgrass. The application rate is between 1/4 and 3/8 pounds of active ingredient per acre. These rates are for vegetative control. The effective period of growth reduction with Embark will, of course, depend on the season. But for a single application, approximately four to eight weeks is appropriate. Embark is the best retardant for the suppression of seedheads. It is translocated to the crown and other meristematic regions within the plant, slowing down cell division and thus slowing down the growth of the plant. Recent experiments with Embark have shown that when surfactants are added, a lower rate retarded growth just as effectively as a higher rate without the surfactant. Combinations of Embark and either of two surfactants, X77 or XM-12, also reduce growth effectively. In addition, Embark has shown promise in combinations with other retardants to help minimize potential injury to the turf. The most effective combinations with Embark have been either EL-500 or PP-333. These combinations provide not only safe effective retardation of the turf, but also a good deal of seedhead suppression.

Another potential use for Embark is to control seedhead expression in *poa annua*. While the retardation of *poa annua* growth is probably not desirable, Embark can be an effective tool in managing *poa annua* populations. On a golf course fairway, Embark has been shown to reduce the seedhead expression of *poa annua* when applied at low rates. Rates of 1/8 to 1/16 pound per acre will give good seedhead control with minimal stress to the *poa annua*. The timing is critical for this procedure, however, and the seedheads should not be visible before application: once seedheads start to emerge, an application is no longer effective.

Ethephon (ethrel) is also effective in reducing the vertical growth of many cool-season turfgrasses. It has been under investigation for a number of years and shows good growth reduction when applied at rates of 4 to 7 pounds of active ingredient per acre. It will reduce growth for a period of four to eight weeks. Ethrel, unlike maleic hydrazide and Embark, reduces cell elongation for a very a short, compact plant. When the effects of ethrel break down, the shoots tend to elongate rapidly and can cause some scalping problems. Many questions must still be answered for ethrel to be a truly effective tool for turfgrass retardation.

The next compound that I want to talk about is from the Monsanto Comapny. At present, it has an experimental number, MON-4620. MON-4620 has two formulations: MON-4621 is a 4-pound-per-gallon flowable, and MON-4622 is a 2-percent granule formulation. Kentucky bluegrass, fine and tall fescue, and perennial ryegrass are all tolerant of MON-4620 with good range of safety. While MON-4620 seems to show activity at rates as low as 1 pound of active ingredient per acre, a rate of 2.5 pounds of active ingredient per acre is generally the most effective. MON-4620 will effectively reduce growth for a period of four to eight weeks, and seedhead suppression is very good. The mode of action of MON-4620 is to inhibit the meristematic region where it is absorbed. It is not translocated to any appreciable degree throughout the plant. After absorption through root uptake, it will generally stay in the area of the crown. This affects the quality of the stand after the breakdown of this product. The new shoots or tillers are not affected by MON-4620 and grow at a faster rate. This results in a slightly more uneven appearance. Additional mowings will help to minimize this effect.

Looking at the relative safety of this product, all formulations of MON-4620 show only slight reductions in quality as compared to the non-treated turf, while Embark shows considerably more injury. There is much controversy in measuring the injury from these materials. Generally, there is no chemical burn or injury similar to that found with fertilizer or a misapplication of a pesticide. The effect is best described as a slowing down of the greening process. Once these materials are applied, in particular MON-4620, the plant immediately stops developing or breaking out of dormancy. If they are applied too early in the spring, poor quality will result.

In comparing clippings removed from turf treated with MON-4620 to those removed from a nontreated turf, the MON-4620-treated turf produced about half the clippings found in the untreated plots. The check plots produced about 24 centimeters of clippings in an eight-week period, while the treated plots produced less than 15 centimeters of clippings in that same period. This is more understandable in terms of mowing requirements. For a possible 12 mowings, one can realize a 25- to 35-percent reduction in mowing.

Until this past year, one area of investigation that I have not had the opportunity to pursue is the effect of growth retardants on different cultivars of a turf species. Turfgrass retardants have varying degrees of effectiveness on different varieties. However, these effects have not been well identified. In Urbana in 1983, each variety in the National Kentucky Bluegrass Trial was split in half. One-half was left alone for a check, while the other half was treated with 2 pounds of MON-4620 per acre. While we did see some disease activity in the form of dollar spot, no interaction was found with the growth retardant.

Quality of the turf was rated several weeks after the application, and reduced quality was exhibited in several cultivars. An example was Wabash, although only a small number of the 84 cultivars responded to the retardant. I believe this indicates that more research of this type is needed to help identify cultivars that might be sensitive to the application of other retardants. In some cases, no height reduction was measured with the control.

The last two growth retardants to be discussed can be grouped together because their mode of action and degree of retardation is close to the same. They are not commercially available but will probably be labeled and distributed in a fairly short time. EL-500 by Elanco is available experimentally in two formulations: a 1-percent granular and a 50-percent wettable powder. Both show very good safety on most cool-season turfs. The application rate should be in the range of 1 to 1.5 pounds of active ingredient per acre. Both EL-500 and PP333, the second compound, will extend the effect of growth reduction for about two weeks over other materials. Thus, six to ten weeks of effective control is feasible. Essentially no seedhead suppresion is gained with either of these compounds.

PP333, first developed by ICI Americas, Inc. has about the same characteristics as EL-500. Experiments conducted at Purdue in 1982 showed that all formulations of both EL-500 and PP333, applied at rates of 3/4 to 1-1/2 pounds caused a significant reduction in height as compared to the control. The mode of action of these two compounds is to inhibit the synthesis of gibberalic acid, a growth-promoting hormone. This is an important factor in the use of these materials. It has been shown that if additional sources of gibberalic acid or nitrogen fertilizer are applied to the turfgrass stand after application of either compound, the effective period of growth reduction is drastically shortened. This is the first demonstration to show that the effects of a growth retardant can be reversed. This can be important if weather conditions or traffic patterns change on the site after application.

In a 1983 experiment at the University of Illinois, EL-500 was applied both alone and in combination with other growth retardants to tall fescue turf to suppress seedhead growth. Our experiments indicated that the best combination of growth retardants would be EL-500 and Embark at rates of 1/4 pound EL-500 and 3/8 pound of Embark. With the number of potential growth retardant compounds currently or soon to be available, one has a wide range of options with which to reduce the cost of mowing or managing seed production at your site.

A few words must be said about growth retardants in general. Timing of the application of any retardant is critical. Probably the best rule to follow in application timing is to wait until the turf has reached a quality with which you are satisfied. Generally, after the second mowing in the spring, the stand has greened up to the point where an application of retardant will not slow down the greening process. Pest control is also very important where turfgrass retardants are applied. The major avenue of turf pest control is through natural resistance by the turfgrass itself. When the growth rate is reduced, this natural defense is also reduced to a degree. Broadleaf weed control is essential in retarded turfgrass stands where such weeds can be a potential problem. Broadleaf herbicides can be applied at the same time as the growth retardant. In areas of high disease activity, particularly leaf spot, a form of preventative disease control should be considered. Although mowing will be reduced on retarded turf, some mowing is still required to maintain an even appearance on the stand. Expect to see enhanced color and a rapid rate of turf growth after the effective period of retardation.

In summary, I believe the following are important:

1. Several excellent turfgrass retardants are now available or soon will be.

2. Carefully match the retardant or combination of retardants to your requirements.

3. Apply the PGR after the second mowing in spring or when you are satisfied with the quality of the turf.

4. Provide any necessary pest control measures.

DISEASES OF ORNAMENTAL PLANTS

Malcolm C. Shurtleff

As part of their responsibilities, many grounds maintenance workers are required to maintain ornamentals and keep them reasonably healthy. The job is not an easy one as there are literally hundreds of species and thousands of varieties (or cultivars) of ornamental plants commonly grown in Illinois.

This discussion will be confined to herbaceous or nonwoody ornamentals such as flowers, ground covers, vines, and pot plants. We can divide the disease problems of flowers and other herbaceous ornamentals into two major groups: infectious and noninfectious. Noninfectious diseases, better called disorders, are caused by unfavorable factors in the air or soil environment, such as too much or too little water, light air movement or air humidity, some 25 essential soil nutrients, extreme acidity or alkalinity of the growing medium, pesticide or fertilizer injury, extremely high or low temperatures, other injurious chemicals in the air or soïl, plus unfavorable conditions at planting time and during establishment. Ornamentals in poor health because of unfavorable growing conditions outnumber those attacked by disease-causing organisms.

Noninfectious diseases or disorders do not spread from sick to healthy plants. They arise, sometimes very suddenly, at about the same time--often on a variety of plants growing in the same general area. Before blaming an infectious disease for causing a problem, examine the cultural requirements for the plants being grown and rule out noninfectious problems, plus insect, rodent, and human injuries.

Infectious diseases are caused by microorganisms (fungi, bacteria, mycoplasmas, spiroplasmas, and nematodes), viruses, viroids, and parasitic flowering plants (such as dodder). These organisms attack plants and obtain part or all of their food at the expense of their hosts. Parasites and pathogens cause infectious diseases that often spread easily from diseased to healthy plants. Effective controls, of course, are dependent on an accurate diagnosis, and they may vary depending on the nature of the parasite or pathogen. Practically all disease control measures are preventive in nature.

Below is a key to identifying common diseases of bedding and pot plants based on the plant parts attacked: leaves, stems and branches, flowers, and underground parts. The key is followed by short discussions of individual diseases listed alphabetically from Anthracnose to Yellows, giving the most common symptoms, cause, how the causal oranism(s) overseasons and spreads, plus both cultural and chemical control suggestions.

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KEY TO IDENTIFYING DISEASES OF BEDDING AND POT PLANTS

Leaf Symptoms

Small to large, definite spots in leaves that vary in size, shape, and color.

- -- Small, dark specks are sometimes present, indicating fungal fruiting bodies; spots often roundish to angular or irregular and may have dark margins . . . . Fungus leaf spot, scab, spot anthracnose

- -- Dark, water-soaked angular spots in leaves; spots later turn gray, brown, reddish brown, or black; margins usually water-soaked . . . . Bacterial leaf spot or blight

- -- Irregular, often large, dead areas in leaves . . . Leaf blight or blotch, anthracnose

- -- Dark green to dark brown, wedge-shaped areas in leaves; leaves later wither and hang down; starts at base of plant . . . . Foliar nematode

- -- Small, water-soaked blisters on underside of leaves that later turn brown and corky . . . . Oedema

Leaves spotted or blighted; later covered with dusty mold growth

- -- Tan to gray, coarse mold . . . . .Botrytis blight or gray-mold

- -- White to light gray mold:
  - Powdery to mealy; easily wiped off . . . . .Powdery mildew
  - Powdery, white raised pustules on underleaf surface; may later turn yellow, then brown . . . . White-rust or white blister

- -- Light gray to pale purplish, downy growth on underleaf surface . . . . Downy mildew

- -- Black mold:
  - Sooty or crusty; easily wiped off . . . . Sooty mold or blotch
  - Sooty mold inside "blisters" or galls . . . . Smut

- -- Yellow, orange, reddish orange, reddish brown, chocolate brown, or black mold in raised pustules . . . . Rust

Leaves mottled light and dark green or yellow; often stunted, curled, and crinkled.

- -- May form an irregular light and dark green mosaic or mottle pattern . . . . Mosaic, mottle, crinkle, streak

- -- Yellow-green or reddish brown rings, "oakleaf," "watermark," or line patterns in leaves . . . . Ringspot or spotted wilt

Leaves and shoots are often stunted or dwarfed, erect; appear "bunchy."

- -- Younger parts uniformly yellow, sometimes red or purple . . . . Aster yellows, dwarf, or stunt

Leaves and turn yellow, wilt, wither, and die; may involve part or all of plant starting at base.

- -- Discoloration inside lower stem . . . . Wilt disease

- -- Leaves may also wilt, wither, and die from stem or crown rot, root rot, nematodes, drought or excess water, transplant shock, injury from insects or other animals, fertilizer or pesticide injury, an excess of soluble salts, frost, or other mechanical injuries . . . . Miscellaneous diseases and injuries

Stem and Branch Symptoms

Plants lack vigor, often stunted; leaves sometimes small and pale, may later wilt or turn yellow.

- -- Seedlings collapse and die; stand is poor . . . . . Damping-off, seed rot

- -- Stems of older plants are water-soaked or discolored and decayed, often just at the base . . . . Stem or crown rot, cutting rot

- -- Definitely marked, discolored, often sunken, dead areas in stem or branches; parts beyond may wither and die . . . . Canker or dieback

- -- Shoots are often dwarfed or aborted; leaves are distorted; cauliflower-like growth may appear at the soil line . . . . Leaf gall or fasciation

- -- Rough, swollen gall, flesh-colored, greenish, or dark, usually found at or near the soil line . . . . .Crown gall

-- Leaves may also wilt, wither, and die; or plants lack vigor from wilt disease, crown or root rot, bulb, corm, or tuber rot, or nematodes (see below) . . . . See also Miscellaneous diseases and injuries (above)

Flower Symptoms

Flowers are spotted, often wither or rot; may be covered with mold growth . . . . Flower or blossom blight

Flowers are blotched or streaked with white or yellow; often distorted . . . . Mosaic or flower breaking

Flowers are greenish yellow, dwarfed, aborted, or absent . . . . Aster yellows

Root, Bulb, Corm, and Tuber Symptoms

Plants lose vigor, are often stunted; may turn pale or yellow; tops may wilt and die back.

-- Roots decay; feeder roots die back; may be covered with mold . . . . Root rot

-- Bulb, corm, or tuber decays; may be covered with mold . . . . Bulb, corm, or tuber rot

-- Rough, roundish galls form on roots, corm, or tuber . . . . Crown gall

-- Root systems poor; stunted, stubby, short, discolored, or with small knotlike galls . . . . Nematodes

COMMON DISEASES OF HERBACEOUS ORNAMENTAL PLANTS

Anthracnose. See Leaf blight or blotch.

Aster Yellows. Flowers are greenish yellow, dwarfed, aborted, absent, or "leafy." Entire plants or just the younger parts are often more or less uniformly yellow (sometimes ivory-colored, red, or purple), stunted, or dwarfed. Leaves and young shoots are usually slender, yellow, and stiff. Top may appear "bunchy."

Cause: A mycoplasma that is spread by numerous species of leafhoppers and infects about 300 species of crop and weed plants.

Control: Same as for Mosaic and Yellows.

Bacterial Leaf Spot or Blight. Dark, angular, water-soaked spots or streaks appear on young leaves. Spots later turn gray, brown, or black. Margins usually remain water-soaked or translucent, sometimes surrounded by a yellow zone. Infected leaves and shoot tips are sometimes distorted; often wither and die early.

Cause: Several species of bacteria. Disease spread is most rapid in rainy and windy weather. The causal bacteria overseason primarily in diseased plant parts and sometimes in soil.

Control: Same as for Fungus leaf spot, except use sprays containing streptomycin or fixed copper. Sanitary measures are usually sufficient for control.

Blossom Blight. See Flower blight and Botrytis blight or gray-mold.

Botrytis Blight or Gray Mold; Bud, Flower, Leaf Blight. Soft, tan or brown spots or blotches appear on blossoms, young shoots, leaves, and underground parts during damp, cloudy periods. Diseased parts are often covered with a coarse, tan to gray mold in humid weather. Seedlings or young shoots often wilt and collapse. Flowers are usually distorted with irregular flecks and spots.

Cause: Botrytis fungi. These organisms survive in dead plant remains or in propagative parts. Spread is mostly by air-borne and water-splashed spores that form on the mold growth in astronomical numbers. *Botrytis* infects practically all plants.

Control: See Fungus leaf spot. Sanitary measures are often sufficient. Carefully remove diseased and fading flowers and other infected parts; gently place in a paper bag and then in the trash. Florists lengthen the storage life of cut flowes for days or weeks by holding them at 35° to 40°F and 90- to 95-percent humidity. Avoid wet mulches. Cure bulbs, corms, tubers, and rhizomes rapidly at high temperatures (85° to 100°F) before storing at the recommended temperature and humidity. Spray to protect garden plants during cool, damp weather using Benlate, Daconil 2787, Zyban, Ornalin, Botran, zineb, or maneb.

Branch Canker. See Stem or branch canker.

Bud Blight. See Botrytis blight.

Bulb, Corm, Tuber, or Rhizome Rot. Shoots fail to emerge or are weak with discolored leaves that die back from the tips. Underground parts, such as bulb, corm, tuber or rhizome, and roots, are discolored and/or decayed. Rot often starts at the bulb base (root or basal plate, bottom of the stem) and progresses upward and outward. Rot may also develop on the side or neck of the bulb, corm, or tuber. There may be no evidence of decay although affected parts are often moldy, discolored, lightweight, and soft or punky (fungal rots). Bacterial decay is usually watery, slimy, and soft to mushy or "cheesy," usually with a putrid odor. This disease complex is commonly associated with nematodes, bulb mites, and/or insects. All garden flowers started from a bulb, corm, tuber, rhizome, or root are susceptible.

Cause: Numerous fungi and a few bacteria that survive in soil or affected plant parts. Entry occurs through a wide variety of wounds: insects, nematodes, hail, freezing, harvest, cultivating, or propagating knife.

Control. Same as for Damping-off, Stem or crown rot, and Root rot. Stringent sanitary measures are essential. Control foliar diseases. Avoid all unnecessary wounds. Plant and store only sound, blemish-free bulbs, corms, tubers, rhizomes, and roots. Store in a dry, well-ventilated room at the recommended temperature and humidity. Treat bulbs, corms, tubers, and rhizomes promptly after digging with a fungicide such as Benlate. Treat again after curing thoroughly and rapidly before placing in storage, and again just before planting. The storage area should be clean. Rotted portions of iris rhizomes and calla rootstocks can often be cut out. Then dry thoroughly in the sun for a day or two before planting.

Canker. See Stem or branch canker.

Collar Rot. See Stem rot or blight.

Corm Rot. See Bulb rot.

Crinkle. See Mosaic.

Crown Gall. Rough-surfaced, soft and spongy to hard, swollen, roundish galls found at or near the soil line on stems or roots. The gall may be white to flesh-colored, greenish, or dark. Affected plants often become stunted and weak with small, pale green or yellow leaves. The disease is much more serious on woody plants that are vegetatively propagated.

Cause: A bacterium (*Agrobacterium tumefaciens*) that survives in soil or plant debris. Infection only occurs through a variety of fresh wounds (less than 24 hours old).

Control: Carefully dig up and burn affected flowers and severely diseased woody plants. Remove as many of the roots as possible. Practice a 5-year rotation before replanting susceptible plants in infested soil. Reject all plants with galls or suspicious bumps near the crown, graft union, or on roots. Avoid wounding plants when cultivating and transplanting. Maintain an acid soil (below pH 5.5) where feasible. Control soil insects. Follow recommendations of University of Illinois Extension entomologists.

Cutting Rot. See Stem rot or Root rot.

Damping-off, Seed Rot. Recently emerged seedlings may suddenly collapse, wilt, and die from a decay at the soil line and below (postemergence damping-off). The stand may be poor and patchy because the sprouting seed is killed before the shoots break through the soil surface (preemergence damping-off). Mold may grow over affected plant parts. Damage is most severe in cold, overly wet, poorly drained soils. All plants started from seed are susceptible. See also Botrytis blight and Downy mildew.

Cause: Many fungi that live indefinitely in the soil and plant refuse; some are also seed-borne. Spread occurs mainly by splashing and flowing water, insects, moving infested soil, and planting infected seed.

Control: Sow plump, vigorous seed, treated with captan (Orthocide, Captan) in warm, light, well drained soil or a sterile rooting medium. Keep the soil on the dry side. Avoid overcrowding, excess shade, too deep planting, and overfertilizing--especially with nitrogen. Water seedlings at 5- to 21-day intervals with captan, Truban, Terrazole, Banrot, captan-PCNB, Terraclor Super-X, or a captan-Subdue mix, using 1/2 to 1 pint of solution per square foot; soak flower bed soil in infected areas. Follow label instructions. Practice as long a crop rotation as practical.

"Decline." See Root rot.

Dieback. See Stem or Branch canker.

Downy Mildew. Pale green or yellow areas appear on the upper leaf surface. A light gray, downy, or pale purplish mildew forms on underside of leaves in cool, damp weather. Diseased areas enlarge and discolor causing leaves to wilt, wither, and die early. Stems and flowers are sometimes affected. Seedlings may wilt and collapse.

Cause: Fungi that live over in plant refuse and soil mostly as thick-walled spores. Spread is primarily by air- and water-borne spores.

Control: See Fungus leaf spot. Spray at about weekly intervals in cool, wet weather using zineb, maneb, mancozeb, Daconil 2787, Polyram, Subdue, or Zyban. Follow label instructions.

Dwarf. See Yellows.

Fasciation. See Leafy gall.

Flower or Blossom Blight, Ray or Inflorescence Blight. Flowers are spotted and often wither and rot. Affected parts may be covered with dense mold (often tan, gray, or black) during and following moist weather. Practically all garden flowers are susceptible to one or more flower blights. See also Botrytis blight or gray-mold.

Cause: Many fungi, especially *Botrytis*, and a few bacteria. The organisms live over in plant refuse and are spread mostly by air currents, splashing water, insects, and mites.

Control: See Botrytis blight. Sow plump, healthy seed treated with captan and spray buds and open blossoms at 3- to 5-day intervals if weather is moist. Use Benlate plus captan, zineb, maneb, mancozeb, folpet (Phaltan), Daconil 2787, Ornalin, or Chipco 2619 (Rovral). Apply a light misty spray. Rotate. Space plants. Avoid overhead sprinkling.

Flower Breaking. Flowers are irregularly blotched or streaked with white or yellow. For other symptoms, cause, and control, see Mosaic.

Foliar Nematode. Expanding, wedge-shaped to irregular yellow to dark reddish brown to black areas in leaves. Infected leaves often become distorted, crinkled or curled, die early, and often hang on. Disease progresses up stem. Plant growth is stunted. Infected buds fail to produce flowers, or they are deformed and undersized.

Cause: Two species of nematodes (*Aphelenchoides ritzemabosi* and *A. fragariae*) that overseason in dormant buds and dead leaves. Nematodes migrate up the stems in a film of water.

Control: Stringent sanitation is important. Before planting, treat soil with steam or a soil fumigant (see below). Propagate only from nematode-free plants or plant parts. Keep water off foliage whenever feasible. Control weeds. Commercial growers who are certified for handling toxic pesticides can fumigate soil before planting using methyl bromide, Vorlex, chloropicrin, Dowfume M-33 or MC-2, Vapam Soil Fumigant, etc., or apply periodic sprays or soil drenches of Parathion, Systox, Nemacur, Lannate, Phosdrin, Vydate, or Zinophos. The manufacturer's directions should be carefully followed.

Foot Rot. See Stem rot or blight.

Fungus Leaf Spot, Scab, Spot Anthracnose. Leaves of all garden plants are attacked by one or more fungi, especially when plants are crowded, shady, and wet. Spots usually occur first on the lower leaves. Spots vary in color, size, and shape. Some have distinctive margins, develop concentric zones, or are sprinkled with small, dark specks (fungus-fruiting bodies). Rough, crusty spots (scab) may form. Diseased areas enlarge and may merge to form an irregular blotch or blight. Leaves may discolor, wither, and drop early. Leaf spots are usually far more unsightly than injurious.

Cause: Fungi that overseason in fallen leaves and spread mostly by air- and water-borne spores.

Control: Where feasible, collect and compost or destroy infected leaves when found and at season's end. Maintain balanced fertility based on a soil test. If irrigating, keep water off the foliage when possible. Space plants for good air circulation. Keep down weeds. Control insects and mites that may transmit the causal fungi. Follow recommendations of University of Illinois Extension entomologists. Follow a protective fungicide control program using Benlate plus captan, zineb, maneb, mancozeb, ferbam, folpet (Phaltan), Daconil 2787, Ornalin, Chipco 2619 (Rovral), Zyban, or triforine (Funginex).

Gray Mold. See Botrytis blight.

Infectious Variegation. See Mosaic.

Inflorescence Blight. See Flower blight.

Leaf Blight or Blotch, Anthracnose, Spot Anthracnose. Leaves may be suddenly and conspicuously spotted or blighted. Diseased areas usually enlarge and merge into large, angular to irregular dead areas. Affected leaves often wilt, wither, and fall early. Small, dark specks (fungus-fruiting bodies) may form in the dead tissues. There is no sharp distinction between leaf blight or leaf blotch, anthracnose, spot anthracnose, scab, and fungus leaf spot. See also Botrytis blight.

Cause: Numerous fungi. Like leaf-spotting fungi, these organisms overseason in fallen leaves and are spread mostly by air- and water-borne spores.

Control: Same as for Fungus leaf spot. Spraying is often warranted, especially in wet seasons.

Leafy Gall or Fasciation. Symptoms vary with the plant attacked. Masses of dwarfed, thick, aborted shoots with distorted leaves or cauliflower-like growths often form near the soil line. The main stem is stunted or dwarfed, and few flowers are produced. Symptoms are sometimes confused with Crown gall.

Cause: A bacterium (*Corynbacterium fascians*) that lives over in plant refuse and soil and spreads through sowing infected seed or plants and moving infested soil.

Control: Where feasible, carefully dig up and destroy (burn) infected plants. Sow plump, disease-free seed treated with captan. Or grow healthy stock plants in clean or sterilized (pasteurized) soil. Practice at least a 3-year rotation. Maintain good cultural practices.

Mosaic, Mottle, Crinkle, Streak, Infectious Variegation, Flower Breaking. Leaves and flowers may be mottled yellow or light and dark green. Sometimes yellowish or white ring and/or line patterns may be seen. Leaves are commonly curled, puckered, and crinkled. Leaf veins may be lighter than normal or banded with dark green or yellow areas. Flowers are often blotched or streaked with white or yellow, distorted, or fail to open properly. Plants may be stunted and low in vigor. Mosaics are often confused with nutrient deficiencies or imbalances.

Cause: Many viruses. They are usually spread by insects (commonly species of aphids) and by propagating from infected plants that are symptomless or nearly so. Plants commonly show no external symptoms at temperatures above 85°F. Most viruses overseason in biennial or perennial crop and weed plants and insects.

Control: Start with virus-free plant materials. Propagate only from healthy plants. Destroy severely diseased plants when first found; they will not recover. Control weeds and insects.

Mottle. See Mosaic.

Nematodes. These minute (most are less than 1/10 inch long), slender, nearly transparent round worms can be found almost everywhere. All plants are fed upon by at least one of the more than 1,500 species of plant-parasitic nematodes. As many as 20,000 individual nemas can be found in one pint of soil. Very high populations must be present to impair the ability of the roots to absorb water and nutrients. Nematodes seldom kill plants; but they are a serious nursery and florist pest, greatly curtailing the growth and vigor of plants.

Nematode feeding wounds provide easy entrance for fungi and bacteria. Nemas may also transmit certain viruses from plant to plant. Fortunately, most nematode species are harmless; some are even beneficial, feeding on plant-parasitic nematodes, destructive insects, protozoa, or other soil pests.

Symptoms. Plants with large populations of parasitic nematodes often show symptoms typical of drought or excess moisture, nutrient imbalance, or other types of injury or disease. Growth is reduced; leaves are stunted and pale green or yellow. Plants decline slowly in vigor and often wilt on bright days. Root systems are reduced, "stubby," or excessively branched; often discolored and decayed. Such plants do not respond as well to fertilizing, watering, pinching back, or thinning as do healthy plants. Infected perennials are also more susceptible to winter injury, drought, serious insect damage, diseases, and nutrient deficiences.

Cause: Many species that overseason in soil or diseased plant material. Nematodes are easily spread by infested soil, contaminated garden tools, and all kinds of containers, running water, shoes, animal feet, and infected plant material. Nematodes can only be identified and their damage evaluated by having *living* roots, together with about a quart of surrounding soil, examined by a competent nematologist. Most land-grant universities, such as the University of Illinois at Urbana-Champaign, provide a nematode assay service, and will make suggestions for control. There is usually a charge for this service.

Control: Where possible, start plants in sterilized (pastuerized) soil. Use nematode-free plant material. Nemacur, diazinon, Vydate, or other insecticide-nematicide combinations may be applied or injected into the soil throughout the root zone area. This is best done by a commercial applicator who is properly equipped and licensed. Before planting or renovating a plant bed, take soil samples, have them analyzed by a nematologist, and follow suggestions in the report. If plant-parasitic nemas are found, treat the soil before planting with Telone, Dorlone, or use a multi-purpose soil fumigant such as methyl bromide, chloropicrin, Vorlex, Dowfume M-33 or MC-2, or Stauffer Vapam Soil Fumigant. Soil fumigants control all types of soil-borne disease organisms, insects, mites, and weed seeds as well as nematodes. These chemicals should be applied by a licensed and experienced pesticide applicator with the necessary equipment and know-how. Keep plants vigorous through proper preparation of the planting site, fertilizing, watering, spacing, clean cultivation, crop rotation, pruning, transplanting, and other suggested maintenance practices. Sound cultural practices are generally much more satisfactory than trying to eliminate high populations of these pests once a perennial bed is established.

Oedema or Edema. Minute, water-soaked "blisters," "warts," or galls form mostly on underleaf surfaces of succulent indoor plants. The pimplelike blisters rupture, become corky and rust-colored, tan, or brown.

Cause: Excessive soil moisture when transpiration is retarded by cool temperatures, high humidity, low light, poor air circulation, and crowding of plants.

Control: Use a well-drained soil mix and avoid overwatering, especially during cool, overcast damp weather. Water only when soil surface is dry. Improve air circulation, space plants, avoid overfertilizing, and increase light.

Powdery Mildew. White or gray patches of mildew appear on leaves, buds, young shoots, and even flowers. Affected parts may be distorted and curled. If severe, leaves often discolor and wither. Small, dark specks (fungus-fruiting bodies) often form in the mildew growth late in the season. Disease is most common on crowded, shaded plants when cool, damp nights follow warm, dry days.

Cause: Numerous fungi that overseason on fallen leaves, in buds, or on greenhouse plants and spread mostly by air-borne spores.

Control: Same as for Fungus leaf spot. Avoid overfertilizing with nitrogen and overcrowding. Resistant varieties are available for a few flowers. If needed, follow a spray program, starting when mildew first appears. Apply Benlate, Karathane, triforine (Funginex), Bayleton, Acti-dione PM, or sulfur following label directions.

Ray Blight. See Flower blight.

Rhizome Rot. See Stem rot or blight and Root rot.

Ringspot, Spotted Wilt. Leaves often exhibit pale green, yellow, reddish brown, or dead concentric rings or peculiar line patterns. Centers of rings may be a normal green or yellow. Young leaves are often malformed. Plants are usually stunted.

Cause: Viruses. These are usually spread by insects (mostly thrips), nematodes, and by propagating from infected plants that may be symptomless. Plants commonly appear free of disease at temperatures above 85°F.

Control: Same as for Mosaic.

Root Rot, "Decline," Cutting Rot. Leaves are stunted, may turn pale green or yellow. Plants tend to wilt or die back; do not respond normally to water and fertilizer. Young plants wilt and collapse (see Damping-off). Affected plants are more subject to drought and wind injury and may blow over or collapse. Roots decay and die back; may be covered with white, gray, black, or brown mold. Decay is water-soaked, mushy, spongy, or firm. Disease is usually most serious on annual garden plants in cold, wet, poorly drained soils. See also Botrytis blight or gray-mold. Practically all plants are attacked by one or more root rots.

Cause: Numerous fungi and a few bacteria. These organisms often live indefinitely in soil and plant refuse. They are spread in infected planting stock or by moving infested soil. Contaminated tools are also transmitting agents.

Control: Same as for Damping-off and Stem or crown rot.

Rosette. See Yellows.

Rust. Bright yellow, orange, reddish brown, chocolate-brown, or black, powdery pustules appear mostly on underleaf surfaces and stems. Rusted leaves often discolor, wither, and drop early. If severe, plants may be stunted or even killed.

Cause: Many fungi. Some rust fungi has as many as five different spore forms in a single season's disease cycle, and they may attack more than one host plant (called an alternate host). The dusty spores are easily air-borne. Rust fungi overseason in infected plant parts.

Control: Collect and destroy infected parts when first seen. Space plants. Keep down weeds, especially those showing rust. Grow resistant varieties and species when available. Plant only healthy stock. Spray or dust several times, 7 to 14 days apart, starting about two weeks before rust pustules usually appear. Suggested fungicides to use include zineb, maneb, mancozeb, Polyram, ferbam, Plantvax, Bayleton, Baycor, or triforine (Funginex). Check manufacturer's directions as printed on the container label.

Scab. See Fungus leaf spot.

Seed Rot. See Damping-off.

Smut (Leaf, Stem, Anther). Pale "blisters" containing sooty masses of spores appear on leaves, stems, flower parts, bulbs, and/or seeds when plants are near maturity. Diseased parts may wither and die. Plants may be stunted.

Cause: Fungi that overseason in plant refuse, seed, and other propagative parts. Spread is mainly by air- and water-borne spores and infected planting stock.

Control: Pick off and destroy infected parts before the blisters open. Avoid sprinkling the foliage. Use disease-free transplants. Treat seed with Vitavax plus captan. Grow resistant varieties where available.

Sooty Mold or Blotch. Black, sooty mold or crusty blotches appear on leaves and stems. The sooty growth can be rubbed off easily and causes little damage.

Cause: Several fungi that grow on insect secretions and spread primarily by air- and water-born spores.

Control: Check sooty molds by controlling insects. Follow recommendations of University of Illinois Extension entomologists.

Southern Blight. See Stem rot or blight.

Spot Anthracnose. See Fungus leaf spot.

Spotted Wilt. See Ringspot.

Stalk Rot. See Stem rot or blight.

Stem, Crown (Foot or Collar), Stalk, or Rhizome Rot, Stem Blight, Southern Blight. Plants are generally weak with small, pale green leaves. Later, the leaves may wilt or turn yellow, wither, and die. Base of stem (crown, foot, or collar) and roots may be water-soaked, discolored, and decayed. Tan to black bodies (sclerotia) may form in the cottony growth or inside stems. Entire plants or branches gradually or suddenly wilt and often die early.

Cause: Many fungi and a few bacteria that may live indefinitely in soil and/or plant refuse. Spread is the same as for Damping-off.

Control: Same as for Damping-off. Stringent sanitary measures are important. Collect and burn plant debris at season's end (do not compost), or turn under deeply and cleanly. Valuable plants may often be saved by taking tip cuttings to start new plants.

Stem or Branch Canker, Dieback, Stem Blight. Definitely marked, oval to irregular, often sunken or cracked, discolored dead areas (cankers) in stems and branches. If the canker enlarges and girdles the stem, parts beyond make little growth, later wilt, wither, and die back from the tip. Leaves on infected branches are often pale and curl upward. Cankers are most common on plants weakened by insect or nematode attack, root rot, mechanical injury, severe weather stresses, and nutritional imbalances. It is often difficult to distinguish a canker disease from a stem or crown rot. See also Stem rot or blight.

Cause: Many fungi and a few bacteria that usually overseason in diseased plant parts and are spread by propagation, air- and water-borne spores, and contaminated tools.

Control: Carefully prune out and burn all infected and dead plant parts, cutting one to several inches behind the canker. Include all discolored tissue. Keep plants vigorous through proper fertilization, watering during droughts, and winter protection. Otherwise, same as for Damping-off and Stem rot.

Streak. See Mosaic.

Stunt. See Yellows.

Tuber Rot. See Bulb rot.

White-Rust or White Blister. Pale yellow areas appear on the upper leaf surfaces. Shiny, white, dusty pustules that may turn yellow or brown with age will form on the undersides of leaves that may die early. Flowers and stems are sometimes distorted.

Cause: *Albugo* fungi that overseason in seed and plant refuse.

Control: See Fungus leaf spot. Sanitary measures are most important. Control weeds including mustards, shepherd's-purse, charlock, lambsquarters, pigweed, and wild sweet potato vine. Sprays as for Fungus leaf spot or Leaf blight should be helpful.

Wilt Disease. There are three common types of wilt that may look identical but are caused by different organisms. These are Fusarium wilt, Verticillium wilt, and bacterial wilt. The wilt-producing organism invades the water- and food-conducting vessels (vascular system) inside the roots and stems causing them to be plugged and killed or nonfunctional. The result is a permanent wilting, withering, and dying of certain branches, stems, or the entire plant. Discolored (brown, black, green, gray) streaks are evident when infected stems or branches are cut lengthwise. Plants are usually stunted, often turn pale green to yellow then brown, starting at the base (commonly Fusarium or Verticillium wilt) or with young leaves (bacterial wilt). With bacterial wilt, the vascular discoloration is often slimy, sometimes yellowish. One or more different wilts affect most garden plants.

Cause: Fungi (mostly *Fusarium* and *Verticillium* species) and several bacteria. These soil-borne organisms often enter the roots primarily through insect, nematode, and other wounds. The wilt organisms are spread by propagating from infected plants, sowing infected seed, moving infested soil, and by contaminated tools.

Control: Grow resistant varieties and species where available. Propagate from and grow only healthy stock plants raised in well-drained, fertile, sterilized (pasteurized) soil. Control soil insects, nematodes, and weeds. Avoid wounding roots and stem bases when planting or cultivating. Dig up and destroy severely diseased plants, including as many roots as possible.

Yellows, Rosette, Dwarf, or Stunt. Symptoms vary with the virus/plant combination and weather factors. Entire plants or younger parts are often yellow, stunted, or dwarfed. Leaves and shoots are usually slender, yellow, erect, and may appear bunchy. Symptoms are often confused with Aster yellows.

Cause: Numerous viruses and several viroids. They are spread by insects (primarily leafhoppers and a few aphids) and by propagating from infected stock that appears normal.

Control: Same as for Mosaic. Asters, dahlias, and certain other very susceptible flowers are often grown under fine cheesecloth (22 threads per inch) or wire screening (18 threads per inch) to keep out leafhoppers and other insects.

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Report on Plant Diseases (RPDs) that supplement the above can be obtained at a cost of 15 cents each by sending a check to: Extension Plant Pathology, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801.

AVAILABLE *REPORTS ON PLANT DISEASES* COVERING DISEASES OF ORNAMENTAL PLANTS

607 - Bacterial Diseases of Geraniums

608 - Virus Diseases of Geranium

609 - Tulip Fire or Botrytis Blight

610 - Black Spot of Rose

611 - Powdery Mildew of Roses

612 - Gladiolus Viruses

613 - Leaf Spots, Anthracnose, and Scab of Pansy and Violet

614 - Common Viruses of Orchids

615 - Damping-off and Root Rots of House Plants and Garden Flowers

616 - Bacterial Diseases of Dieffenbachia and Philodendron

617 - Powdery Mildews of Ornamentals

623 - Botrytis Blight or Gray Mold of Ornamental Plants

626 - Rose Cane Cankers

627 - Hollyhock Rust

628 - Iris Leaf Spot

629 - Oedema or Corky Scab

630 - Rose Rusts

631 - Red Spot or Leaf Blotch of Peonies

632 - Rose Viruses

633 - Crown, Rhizome, and Bulb Rots of Iris

634 - Tulip Breaking or Mosaic

635 - Snapdragon Rust

638 - Firethorn (Pyracanthe Scab)

639 - Azalea Leaf and Flower Gall

640 - Stem Blight of Vinca Minor

644 - Spray Chart for Some Important Diseases of Woody Ornamentals in Illinois

645 - Pot Plant Disease Control Guide

646 - Disease Control Programs for Flowers and Other Nonwoody Ornamentals

649 - Pachysandra Leaf and Stem Blight

650 - Fusarium Wilt Diseases of Herbaceous Ornamentals

651 - Gladiolus Corm Rots

1002 - Fungicides, Disinfectants, Grain Preservatives, Surfactants, and Soil-Disinfesting Chemicals

1006 - Crown Gall

1008 - Sclerotinia Disease, White Mold, or Watery Soft Rot

1010 - Verticillium Wilt Disease

1100 - Collecting and Shipping Soil Samples for Nematode Analysis

1101 - Root-knot Nematodes

1102 - Foliar Nematode Diseases of Ornamentals

1103 - Lesion Nematodes

CULTURAL PRACTICES FOR PLAYING FIELDS

J.R. Watson

Those charged with care of turf on football and other playing fields are concerned with three major areas: the condition of the grass, the firmness and uniformity of footing from the playing standpoint, and color and grooming from a spectator's standpoint. The condition of athletic field turfgrass always reflects past management practices. Good or bad management shows most during the spring of the year except perhaps on color television.

Play. From a playing standpoint, good athletic field turfgrass should be tough, wear-resistant, and not easily torn by cleats. It should be soft and resilient enough to prevent abrasions when players fall, yet firm enough to permit good footing. It should be clipped short enough to prevent hanging of cleats or shoes, yet tall enough to ensure healthy plant growth and rapid recovery when torn by shoe cleats. In cold or cool climates, Kentucky bluegrass mixed with perennial ryegrass cut to 1 to 1-1/2 inches will meet these qualifications. Likewise, the new fine-leaf tall fescues may qualify under certain conditions. Adapted cultivars of each species should be selected. Consultation with local turf specialists such as Extension personnel, golf course superintendents, and seedsmen is beneficial.

Firmness and uniformity of footing are usually present if the condition of the turfgrass is satisfactory. But with or without good grass, a firm, even, and resilient footing is absolutely necessary and should be mandatory on all playing fields. Skinned areas of baseball infields provide these conditions. The same general techniques and procedures may be employed to assure footing on football fields. Players recover from skin abrasions relatively easily -- certainly more easility than from twisted knees and ankles. Dust may be controlled on bare areas by the use of water. Turf cover is, of course, preferred.

Spectator Appeal. With the advent of color telecasting of major sporting events, field color and grooming have taken on new significance. Spectators and parents of junior and senior high school players have come to expect uniformity and compatibility of color. Color is important from an aesthetic standpoint and, right or wrong, it is apparently one of the major criteria by which the general public judges the quality of turf.

Mowing to produce a pattern or "ribboning" effect is a rather standard procedure on most major league playing fields. George Toma, Groundskeeper for the Kansas City Royals and Chiefs, was an early proponent of this technique and used it effectively to improve the appearance of his fields. On football fields, each five-yard strip is cut in an opposite direction. Another technique sometimes used when the grass loses color or goes dormant is to color alternate five-yard strips with a different colorant, a diluted solution of the same colorant, or the same colorant to which some white has been added. Both techniques enhance the appearance of the field and have earned well-deserved praise and recognition for the turf managers who have used them.

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Poor Fields. Good turfgrass conditions, firm, uniform footing, and a pleasing color are characteristics of a good football field. Poor fields are also readily recognized under most circumstances. Annual weeds, undesirable grasses, and clover often make up a major part of the vegetation. The center of the field often is bare and the soil is bumpy, uneven, and usually compacted and poorly aerated. Compacted and poorly aerated soil supports only shallow-rooted, tender grasses that are easily torn by cleats during play. Injury to players, particularly around the ankles and knees, is more likely to happen on this type of turf.

Quite often, weedy turfgrass indicates mismanagement of water, improper fertilization, and soil compaction. Mismanagement of water occurs when it is applied at rates incompatible with soil properties: infiltration rate (won't go in); percolation rate (won't go through); or storage capacity (holds too much or too little). Improper fertilization may mean the wrong pH, too little total fertilizer, an improper balance of the major fertilizer elements (nitrogen, phosphorus, and potassium), or a deficiency or excess of trace elements.

Fertilization is the process of supplementing the soil nutrients according to the growth requirements of the grass and the prevailing use conditions. No element should be applied in excess of the needs of the plants. This is particularly true of the soluble or inorganic types of nitrogen such as ammonium nitrate, ammonium sulfate, and urea. Soluble forms of nitrogen give a plant a "quick" start and a spurt of growth. But when supplied in excess, nitrogen produces tender, succulent growth that increases the chances for player injury and makes the turfgrass more susceptible to attacks of insects and disease-producing organisms. One exception is when a quick "pick-up" in color or growth is needed at mid-season or for special events such as homecoming or bowl games.

Grasses. Kentucky bluegrass (Touchdown, Parade, Adelphi, Rugby, Victa, and others) and perennial ryegrass (NK200, Pennfine, Manhattan, Game) are considered among the best grasses for athletic fields. Blends of each species composed of superior, well-adapted cultivars are preferred to a single cultivar. Sometimes, blends of Kentucky bluegrass and ryegrass or Kentucky bluegrass and fine-leaf, tall fescue may be preferred. Consult local authorities for percentages of each species and for the rate of seeding per 1,000 square feet.

Tall fescue, when used alone and seeded at low rates, tends to clump after a few years; hence, is not desirable under most conditions. It should be recommended only for special situations. If used, seed at a rate of 10 to 12 pounds per 1,000 square feet and plan to overseed each spring at a rate of 3 to 5 pounds per 1,000 square feet. Also, under most conditions, blending with Kentucky bluegrass is beneficial. Fine-leaf, tall fescue is especially suitable for fields that cannot be irrigated. However, do not overlook red or chewings fescue blended with Kentucky bluegrass for these situations.

Perennial ryegrass is a temporary but increasingly permanent grass that may be used to advantage on areas that tend to become thinned out by concentrated play. Seed ryegrass after each game on these areas. Pre-germination will speed establishment. The light apple-green color of the early domestic ryegrass types was incompatible with the dark green color of many Kentucky bluegrasses and was objectionable from a viewing standpoint. This is not true of the "new" currently-available types. Therefore, uniformity of color may be improved by selecting strains such as NK-200, Pennfine, Manhatten, Yorktown, Game, and others that possess a darker color than domestic ryegrass. Consideration should always be given to these new improved cultivars.

Sodding is an effective means of establishing an athletic field; however, timing is critical on football fields. They should be sodded by June if play is anticipated in September. Late sodding in July or August may fail to establish sufficient root systems to support play. This is especially true when adequate moisture is not present and high temperatures prevail for extended periods.

CULTURAL PRACTICES

Good athletic field turfgrass must be cultivated and aerated, fertilized, watered, and mowed properly. In addition, programs to control disease, insects, weeds, and often, soil compaction and thatch should be developed and used as needed. Attention to these fundamentals will ensure the establishment, development, and maintenance of tough, wear-resistant turfgrass. Cultivation, fertilization, controlled watering, and proper mowing are so closely interrelated that it is difficult to separate their individual effects. Nonetheless, they are the essentials in the production of good athletic turfgrass.

Improvement of Physical Condition

Cultivation (aeration). Cultivate the field with some type of aerating equipment at least twice lengthwise and once across the field. Add sufficient weight to ensure penetration to a depth of two to three inches. In many cases, it may be necessary to sprinkle in order to bring the soil to the proper moisture level for maximum penetration. Soil should be moist but not soggy. Cultivation alleviates soil compaction and aids the interchange of gases, particularly oxygen and carbon dioxide, between the soil and the atmosphere. Aeration also permits placement of calcium, phosphorus, and potassium in the zone of root growth, thus aiding in the development of deep root systems.

Football fields that are cultivated in early spring do not necessarily require topdressing to fill in aeration holes. Roots and stems of the grass fill in these holes readily, and by mid-summer there is no evidence of pitting. Cultivation of baseball fields will be determined by playing schedules and the rapidity with which the grass is growing.

Topdressing. On fields where topdressing is required, consideration should be given to the type of materials used. A mixture similar to that used for putting greens may be considered. Good topdressing material usually includes a mixture of 80- to 90-percent sand, of which 75 to 85 percent is medium sand (0.25 to 0.50mm), with the remainder between 0.15 mm and 1.0 mm; 10 to 12 percent clay; and, under some conditions, a similar content of peat or other sources of organic matter. Where play is exceptionally heavy, just straight, "dirty," medium sand is often used. Silt is undesirable and quantities greater than the amount of clay should not be used.

Peats are the preferred form of organic matter. Properly processed sphagnum, raw sedge, or cultivated peat are satisfactory. They should contain 90 percent or more organic matter. Other types of organic matter that may be used are well-decomposed leaves, gin trash, sawdust, ground corn cobs, straw, and any other readily available source of organic refuse. Manure or raw sewage sludge can also be used since they decompose readily. When decomposing, however, these materials have an offensive odor that may make them objectionable in many cases. Proper composting will eliminate this condition. Neither of these materials should be used later than eight weeks prior to play on the field. Manures may be a potential source of tetanus, so their use as a surface dressing should be avoided, unless the materials are sterilized.

If a combination of topdressing materials is used, it should be thoroughly mixed with a grinder or mixer. After mixing, the material should be screened through a one-quarter-inch mesh screen. Sterilization, either by chemical or heat, is desirable to kill weed seeds.

This topdressing mixture should be used to fill and level depressions during and at the close of the playing season. If used as a topping over the entire field, it may have to be applied in the spring. In this case, the field should be topped after cultivation and fertilization.

Fertilization. Fertilizers are applied to supplement the natural nutrient supplies in the soil rather than to constitute the only source of nutrients. In addition, fertilizer balances the soil nutrient supply with the needs of the plant. Fertilization of athletic field turfgrass begins with the determination of the plant food supplies in the soil. This is accomplished by obtaining a properly interpreted soil test. The soil test will provide a record of the soil reaction (pH) and the levels of phosphorus, potash, calcium, and magnesium. In addition, most tests will show soluble salts if they are present in toxic levels.

Knowledge of the soil reserves, coupled with the knowledge of the requirements of the turfgrass and the intensity of usage expected will serve as a basis for development of the fertilization program. Keep in mind that turfgrasses require several times as much nitrogen as phosphorus and potash during the growing season. Soil tests usually do not give an accurate evaluation of available nitrogen, so color, growth, vigor, and condition of the grass must be used as a guide for nitrogen fertilization.

In general, bluegrasses will need 4 to 6 pounds of nitrogen, 2 to 3 pounds of phosphorus, and 3 to 4 pounds of potash annually. Lime, if needed, should be applied in amounts indicated by soil tests. Lime (calcium) is an important plant nutrient that also renders other elements more available. Lime when pH reaches 6.2. A pH of 6.5 to 7.2 is most desirable for athletic field turfgrasses.

Intensity of use is also a major factor when developing a fertilizer program. More fertilizer, especially nitrogen, is required on heavily used fields.

Timing of fertilizer applications must be keyed to growth activity and the necessity of obtaining color for special events. Complete fertilizers should be applied in late summer or early fall before the season starts. A "late" application of a complete fertilizer is beneficial and may preclude the spring feeding. The early fall feeding is needed in either case. Organic (slow release) forms of nitrogen are suggested for supplemental feedings. Inorganic (quickly available) sources of nitrogen are suggested for use when the turfgrass needs a quick pick-up in growth or color.

Watering. Controlled watering is one of the most important considerations in the development of good turfgrass. Water must be applied on the basis of turfgrass need (evapotranspiration) and according to soil properties. Judicious use of water coupled with aeration and proper fertilization develops deep-rooted turf that is wear-resistant, tough, and not easily torn by players' cleats. Removal of excess water through surface and internal drainage is necessary. Plants growing in waterlogged soil cannot function properly because of the reduced amount of oxygen available to the root systems.

With new seedlings, the field should be sprinkled lightly each day until the seed germinates and is well established. Thereafter, the amount of water applied should be increased as needed, and the frequency of application adjusted to conform with soil characteristics.

Soils differ in their ability to absorb and hold moisture. Water should not be applied in excess of the amount a given soil can take in and hold. If the soil is not wet to the required depth (depth of root zone), wait until the moisture has percolated downward and apply additional water.

Consideration should be given to the installation of automatic watering systems on old fields as well as new. The improved quality of the turfgrass, along with the savings in labor and water cost and the control such as system permits are sufficient to warrant installation.

Mowing. Reel-type mowers are preferred for athletic fields. For young turf it is essential that the mower be sharp and properly adjusted. Mature turfgrass will be maintained in a far more satisfactory condition if the mower is kept in the same condition. New seedlings should not be cut until they are approximately 2 inches in height. Only about 1/4 inch of leaf surface should be removed at any one clipping.

Mature football turf may be maintained at a height of 1 to 1-1/2 inches or under unusual conditions, 2 inches. During summer months, 2- to 3-inch heights are advantageous.

A few weeks prior to fall play, adjust the height of cut to that preferred by the coach and players. Do not make the reductions in one clipping: gradually reduce the height of cut by 1/4 inch at successive mowings. Increase the frequency of cutting if necessary. Generally, turf that has been properly managed will require mowing at least twice a week in early fall.

Grooming. Two of the more important grooming techniques relate to the collection of clippings and to the sweeping or bagging of blades, stems, leaves, and plant parts torn up or severed during games. Collection and removal of excess clippings serves a sanitary purpose as well as an aesthetic one. Routine collection of all clippings will add greatly to the appearance of the field. Collection and removal of plant parts improves appearance and permits easier assessment of game damage.

Vertical mowing to control grain and to reduce thatch may be required. Grass may be cut lightly in this manner at any time. However, if deep cutting or renovating is to be practiced, then the grass should be growing actively.

For best results, one mower should be set aside, preferably a reel type, and used exclusively on the field. Always keep mowing equipment sharp, properly adjusted, oiled, and greased. Rely on service facilities available from the manufacturer to see that equipment performs satisfactorily.

Programs for Disease, Insect, and Weed Control

Disease. For the most part, control of disease on athletic fields and playing grounds is not as critical as that on a putting green, for example. Leafspot is serious during spring months and may cause loss of grass. Chemicals are available if their use is deemed advisable. Check with your turfgrass distributor and follow manufacturer's recommendations for use.

Insects. Insects that attack grass may be classified in two groups: (1) surface feeders, those insects such as sodweb worms, cutworms, and army worms that eat the leaves; and (2) subsurface feeders such as grubs and bill bugs that eat the roots of grass. For root feeders, water control materials in thoroughly.

Chemicals are available for control of both groups of insects. For surface feeders, apply insecticide in the afternoon, leave material on overnight, then water in thoroughly.

When spraying insecticides on shrubs and flowers that may be in the vicinity, do not use a sprayer in which 2,4-D or similar materials have been used. These materials are difficult to clean out of a sprayer and may damage shrubs and flowers.

Weeds. Chemicals are available for control of most weeds. When both pre- and post-emergence types are used correctly, broadleaf weeds and crabgrass will be selectively removed from permanent grasses without damage to the desirable grass. Chemicals should be considered only as tools or aids in a permanent weed control program. Weeds invade turfgrass areas only when the grass is weakened for some reason. The first step in a successful weed control program is to correct the basic cause or reason for the presence of weeds, then use chemicals to eliminate them. Grass may be weakened because of inadequate fertility, poor mowing, poor drainage, or damage from disease or insects.

Early spring is the preferred time to treat as weeds are young and growing actively. This is particularly true of knotweed and chickweed. Chemicals for both pre- and post-emergence control of crabgrass and other weeds are also available.

New chemicals are being developed constantly for control of disease, insects, and weeds. Keep in touch with your local turfgrass supply house for new materials and always follow manufacturer's recommendations for their use.

SUMMARY OF RECOMMENDATIONS FOR ONE SEASON

1. Cultivate the field twice lengthwise and once crosswise when grass is growing actively.

2. Break up soil plugs, fill, level, and grade with topdressing mixture. This may also be required during the playing season and should always be done at the end of the playing season.

3. Apply fertilizer and lime according to recommendations based on properly interpreted soil tests. Use nitrogen to control the rate and level of growth.

4. Seed or sod thin, unthrifty, and bare areas. Use pregerminated seed during the season and when rapid establishment is necessary.

5. After seeding, top lightly with topdressing mixture. This is to cover seed and should be done unless the field has been aerated or scarified prior to seeding. Seed contact with soil is necessary for establishment. Topdressing newly lain sod is beneficial and helps to avoid desiccation along the edges.

6. Roll lightly to press seed in contact with soil and sprinkle slightly.

7. Water as per discussion.

8. Mow as per discussion.

9. Apply additional nitrogen as per discussion.

10. Develop programs for disease, insect, and weed control when needed.

ILLINOIS PEST UPDATE: PLANT DISEASES

Malcolm C. Shurtleff

Not as much has changed in 1983 as in the previous two years. Thanks to research by Dr. Richard Smiley at Cornell University, we now know that Fusarium blight is not caused by species of *Fusarium*, but by two other fungi. He was able to inoculate grass in the field with these "new" fungi and reproduce symptoms of the disease, something that had not been done before. Now that scientists can reproduce the disease and know something concerning its etiology, we should be able to attack its "Achilles heel" more effectively and hence develop more efficient control measures. Here in Illinois, Dr. Hank Wilkinson is actively cooperating with Dr. Smiley and repeating some of his research under local conditions.

Sclerotinia dollar spot is now known to be caused by two fungi. Since we now have very effective control measures against this disease, we don't expect any major breakthroughs in the future.

Our cultural and chemical control recommendations are not expected to change much in 1984. However, a number of new fungicides have been introduced to the turfgrass trade in the past several years. They include Bayleton, Vorlan, Duosan, Rubigan, Koban, Subdue, and its seed treatment counterpart, Apron.

In the future we can expect manufacturers to recommend that their turfgrass product(s) be used in combination with a competitor's product to give broader spectrum disease control. We are seeing this rather recent phenomenon (unknown 10 or 15 years ago) in corn and soybean weed control ads on television and in trade magazines. It will probably take a few more years of research before we will see this widespread practice for turf. Of course, golf course superintendants have been using a variety of fungicide combinations for many years. The manufacturers are finally realizing that to show their products at their best they need a friendly boost from a competitor's fungicide. More research, however, must be done to ensure that the products are fully compatible and will provide synergistic (not antagonistic) control under a wide range of environmental conditions on the various turfgrass species and cultivars commonly grown in Illinois and other states.

We are also noticing a greater appreciation of placement in the use of fungicides. For example, a soil drench (one inch of water plus fungicide per 1,000 square feet or about 600 gallons) is needed to control leaf smuts and Fusarium blight. (I wonder what we'll call this disease now that *Fusarium roseum* f. sp. *cerealis* "culmorum" and *F. tricinctum* f. sp. poae are not the primary pathogens?)

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For the control of strictly foliar diseases like powdery mildew and rusts, two gallons of spray applied over 1,000 square feet is sufficient to cover the entire grass surface. For diseases in which the causal fungi survive in the thatch, such as Helminthosporium leaf spot and melting-out, Sclerotinia dollar spot, red thread and pink patch, Rhizoctonia brown patch, snow molds, and Pythium blight, 5 to 10 gallons of spray is needed to cover the grass surface and also wet the thatch. The thicker the thatch the more spray must be applied. Little information is available concerning use of air blast sprayers to control diseases of turfgrasses.

What else does the future hold? We expect to see Vorlan and Rubigan expand their labels. Perhaps we'll see another new fungicide or two to control *Pythium*. We'll have better and more resistant grass cultivars to choose from. But will this resistance last and for how long? I think we'll have more effective cultural disease controls, too, as we learn to manage thatch better, and I think we'll have long-lasting nitrogen fertilizers that provide uniform growth of grass throughout the season. Will Dr. Wilkinson's beneficial bacteria that are antagonistic to various turfgrass pathogens have a place? Since several of these organisms are apparently part of the normal thatch flora, we hope so. By breaking down thatch plus controlling diseases using fewer fungicide applications, these bacteria may be the big disease break-through of the 1980s. Only time will tell.

We live in an exciting age of turfgrass disease control. I foresee less dependence on the use of fungicides and more on a new type of turfgrass management based on ecological principles of soil and grass. I expect we'll also discover some new diseases in the future as Dr. Wilkinson discovered yellow ring and its cause in 1983. The cause of the *Poa annua* blight syndrome needs further research, as does the "necrotic ringspot" disease in Wisconsin and the Nigrospora blight that was reported from Wisconsin, Minnesota, Michigan, and New York.

The future looks exciting: 1983 was a great year but we expect 1984 to be even better!

BID SPECIFICATIONS AND CONTRACT INSURANCE REQUIREMENTS

Dennis Hovde and Thomas R. Nenoff

WHO'S IN CHARGE?

When bidding on work or signing a contract, there are two main areas of concern:

1. What insurance is required of the contractor to protect himself?

2. What insurance is required of the contractor to protect the owner and the project?

Things to consider with regard to both areas are:

1. What exactly do the requirements mean?

2. Does your current program meet the specs?

3. Can your program be expanded to meet the specs?

4. What will the additional coverage cost?

5. Are the requirements reasonable?

Who is responsible for evaluation of specs?

1. Architects and owners who put them out

2. Contractor

3. Insurance broker

It is the responsibility of the architect and owner to be sure the requirements are clear and reasonable and that operators comply with them.

It is the responsibility of the contractor to secure all of the documents outlining the insurance requirements and to discuss them with his or her agent or broker.

It is the responsibility of the broker or agent to evaluate the requirements for appropriations, feasibility, and cost. He or she then recommends to the contractor ways to meet the requirements, options, and costs.

Typically a construction contract or purchase order will contain language pertaining to the assumption or transfer of one party's responsibilities to another. This is commonly referred to as the hold-harmless and indemnification

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agreement(s). These agreements can be written so broadly that they can be illegal or uninsurable within the constraints of your existing insurance contracts. It is extremely important that your agent reviews these agreements prior to bidding or execution (purchase order) and advises you whether or not the contract is insurable and at what cost.

There are many other areas of concern relating to the review of insurance requirements found within contract specifications. Following are examples of various items to be checked:

1. Bid bonds, consent forms to provide final bonds, and performance and payment bonds.

2. Builder's risk, installation floater. Who is responsible for deductible? Who is responsible for material?

3. High excess of umbrella limits. Certain contracts may call for limits of liability insurance beyond what is currently being provided in existing insurance contracts.

4. Contractual liability. "Hold-harmless"/indemnification agreements; assumption of liabilities found in all written contracts.

5. Owners' and architects' contingent (protective) liability. Separate insurance contract written for specific limits of liability in the name of the owner and/or architect.

6. Special additional coverages

    - Waiver of subrogation
    - Personal injury protection
    - Elimination of exclusions within standard insurance contracts
    - Additional insured requirements
    - "X, C, and U": explosion, collapse, and underground requirements

7. Railroad protective liability: separate insurance agreement usually provided when working on or near a railroad right of way.

There are a number of other coverage items or concerns that can be found in construction contracts. The more you know about your contract, the better your ability to recognize ahead of time the risks and profit potential of the work itself. Your insurance agent is a valuable consultant to your business and should be treated as such by your company.

AGENT'S RESPONSIBILITY

Agent should provide the following services:

1. Study of all job contracts for insurance purposes

2. Coordinate a safety engineering program as soon as possible

3. Handle all subcontractor's insurance certificates.

4. Provide a breakdown of insurance costs for the following items:

   A. Bonds
   B. Builder's risk, fire, extended coverage, and V.M.M.
   C. Builder's risk, all-risk with deductibles
   D. Contractual liability
   E. Excess limits
   F. Owner and architect's contingent liability
   G. Personal injury
   H. Special hazards

5. Check for uninsurable hazards:

   A. Hold-harmless agreements
   B. High limits on care, custody, and control

6. Examine your contract to subcontractors.

7. Review certificates of insurance for subcontractors and suppliers.

JOB QUOTE CHECKLIST

SAMPLE

CONTRACTOR: ______________________ BID DATE: __________

OWNER: ______________________ ESTIMATE: __________

JOB: ______________________

LOCATION: ______________________

PRIMARY LIMITS REQUIRED:

W.C.E.L.: __________

G.L.: __________

AUTO: __________

UMBRELLA: __________

C/OPS TERM: __________

OTHER: __________

JOINT VENTURE INSURANCE

W.C.: __________ PREM.: __________

AUTO: __________ PREM.: __________

G.L.: __________ PREM.: __________

UMB.: __________ PREM.: __________

Same Coverages/Limits as U/L? ______

Separate Policies __________

Master Policies __________

BUILDER'S RISK COVERAGE (Always All-Risk-Completed Value unless specified)

Limit: __________ Term: __________ Canc. Clause: __________

Flood ______ Quake ______ Collapse ______ Occupancy Clause Deleted __________

Scaffolding/Temp. Structures __________ Property in Transit/Other Locations __________

# of Stories ______ Occupied? ______ # of Buildings ______ # of Units ______

New Construction ______ Renovation/Remodeling ______ Interior Renovation Only ______

Const. of Floors __________ Const. of Roof __________

Cost. of Walls ______________________

Other: ______________________

____

____

Difference in Conditions Only __________ Covering: __________

Deductible(s): __________ Sub-limit (if applicable): __________

Rate: ______ annual/other: ______ Premium: ______ annual/other: ______

Quoted By: __________ Date: __________

OWNER'S PROTECTIVE/ADDITIONAL INSURED QUOTE:

OCP ________ Additional Insured ________ Limits: ________ BI ________ PD

Naming: Owner ____________________ Charge: ____________________

Architect ____________________ Charge: ____________________

Engineer ____________________ Charge: ____________________

General ____________________ Charge: ____________________

Other ____________________ Charge: ____________________

____________________ Charge: ____________________

Cancellation Clause: ____________________ Premium: ____________________

Quoted By: ____________________ Date: ____________________

Excess OCP: ____________ Limit: ____________ Premium: ____________

Quoted By: ____________________ Date: ____________________

RAILROAD PROTECTIVE COVERAGE

Name of Railroad: ____________________ Name of Railroad: ____________________

Limits: ____________________ Limits: ____________________

Contract Amt. w/in 50': ____________ Contract Amt. w/in 50': ____________

Type of Work w/in 50': ____________ Type of Work w/in 50': ____________

Freights: ________ Pass.: ________ Freights: ________ Pass.: ________

Quoted By: ________ Date: ________ Quoted By: ________ Date: ________

Charge to Delete R/R Excl.: ____________ Charge to Delete R/R Excl.: ____________

Quoted By: ________ Date: ________ Quoted By: ________ Date: ________

MISCELLANEOUS:

____

____

____

____

INSURANCE QUOTED TO: ____________________ BY: ____________________

EXTENDING THE USE OF SOD

Henry T. Wilkinson

During the past decade, public awareness of and concern for the esthetics and quality of the environment have increased dramatically. Education, modern communications, and inflation have spawned consumers that demand greater quality of merchandise and service for their invested dollars. The turf industry deals directly with these educated consumers. More dollars are invested now than ever before in the maintenance of turfgrass. The consumer is demanding high-quality turf based on investment rather than on biology. For example, demands for high-quality sod to be established and maintained on marginal agricultural soils has increased with renewed interest in urban development. The demand has been met by hundreds of companies specializing in lawn establishment and maintenance. Because the consumer is now paying for services that were previously not provided or even considered, expectations have increased: the lawn should be lush, green, and carpet-thick all season long.

Intensively managed turfgrass is greatly predisposed to problems such as stress and disease, and sodded lawns seem to have more problems than seeded lawns. But the development of disease in sodded lawns is a result rather than the cause of aberrant grass growth, since the same pathogens that attack a sodded lawn will also attack a seeded lawn.

The susceptibility of sod results from the conditions under which it is forced to grow, not on the quality of the sod when it is initially transplanted. Proper establishment of sod is a key in extending its use to meet consumer demands. Diseases such as Fusarium blight syndrome, yellow patch, and yellow ring are associated with the lower crown and roots of the grass plant. Heat and drought stress are also harmful to sod when they affect the crowns and roots of the grass plant. If the growth and vigor of grass roots, rhizomes, and crowns are managed properly, the sod can be used successfully with lasting results.

There are three basic phases in establishing a sodded turf: 1) sod production; 2) sod bed preparation; and 3) post-transplant management. Variables in each of the three phases can enhance the successful establishment of sod.

The sod producer or farmer can select the soil type on which to raise the sod from seed: usually the best mineral and peat soils. As research continues on the relation of sod to sod bed soil, we will learn more about the impact of different soils on growing sod and the performance of sod on different sod bed soils.

The blend of grass cultivars for sod should be selected carefully for the conditions under which the sod will be grown. The cultivar blend is the only variable in sod establishment that cannot be changed without starting the process

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of sod establishment anew. The chemical program for sod production and the age of marketed sod are also very important variables. For example, excessive nitrogen, phosphorus, and potassium applied to grass can produce excessive thatch and a weakened root system in less than two years. The longer sod is grown under a high-management program, the more tenuous is its ability to establish after transplanting.

The second phase, sod bed preparation, is too often neglected even though the sod bed must support the vital roots, rhizomes, and crowns of the turfgrass. While not easily changed, the soil type is the most critical variable. Some changes can be made, but they can be very costly. It is important to understand the soil type in order to decide which cultivation method(s) to employ and how to manage soil moisture so the turfgrass can root. The texture, structure, and porosity of a soil will greatly affect the rooting of sod. Heterogeneous textures with some structure are usually porous enough for moisture and oxygen movement in the soil so that roots can penetrate.

Preparing soil for sod involves leveling to insure good sod-soil contact. Fine-textured soils often lack particle heterogeneity and have poor structure and very small pores. They may hold too much water, leaving it unavailable to the grass, or too little oxygen or a high level of resistance to sod-root penetration. To manage this soil type, carefully planned cultivation and fertilization practices must be used. Appropriate cultivation can create large soil pores to increase the availability of water and oxygen for root growth. The poorer the soil, the more carefully planned the sod establishment must be.

The nutritional status of the sod bed soil must also be considered prior to transplanting the sod. Generally, we recommend that fertilizer should be incorporated into the sod bed soil as needed, rather than applying it to the sod after it is transplanted. The rate and type of fertilizer should be based on a soil analysis. A key to establishing sod is to encourage the grass plants to develop roots that penetrate the soil profile.

Sod beds are usually devoid of vegetation or covered with a dead turf. While not conclusively tested, a dead turf layer under transplanted sod merely compounds the difficulty of sod establishment. The dead layer interferes with oxygen and water movement and extends the distance that sod roots must grow to reach the soil and nutrients. The dead turfgrass could also be a source of many facultative parasites that can attack and weaken grass that is already experiencing difficulty in rooting.

The third phase of sod establishment, post-transplant management, can be divided into periods of critical management (8 weeks) and long-term management (>8 weeks).

During the first 8 weeks after transplanting, soil moisture, heat, and sod-to-soil contact are crucial. Ongoing research at the University of Illinois is working to determine guidelines, but preliminary results show that the greatest sod rooting occurs when sod is laid onto moistened soil and then watered daily. This program will minimize heat stress and dessication of the sod and encourage newly forming roots to penetrate the sod bed. No fertilizer should be applied to the turf after it is transplanted or before it has successfully rooted. Another practice that has proven very useful is to roll the transplanted sod with a light roller (200 to 300 pounds) from 24 to 48 hours after transplanting. The time delay between transplanting and rolling allows the sod and soil moisture levels to equalize. This creates a uniform soil profile for rooting. You can imagine the impact a layer of dead sod would have on attempts to create a uniform soil profile.

Three basic management concerns are involved in long-term management: 1) nutrient status; 2) cultural practices; and 3) pest control. The scope of this paper will not permit lengthy discussion of these matters, but suffice it to say that the approaches, methods, and materials used in turf management differ with location and operators.

The grass plant has evolved with a predictable set of requirements for growth: the crowns, roots, and rhizomes, that is, the subterranean tissues, are most vital for longevity and quality of turfgrass. If long-term management practices are directed more at promoting root and rhizome development and less at shoot and leaf growth and quality, the sod will be more resistant to stress, grow longer, and still maintain reasonable quality.

FALL ESTABLISHMENT AND RENOVATION WITH COOL-SEASON TURFGRASSES

Herbert L. Portz

This paper will look at the turfgrass itself: what's good both for its establishment and future care. Architects, landscapers, and contractors should be aware of my bias ahead of time. I may not properly include some of the problems, such as financial concerns, labor, insurance, weather, and equipment breakdowns, that these professionals may face. Or I may not fully appreciate demanding customers, be it the homeowner, the building superintendent, the groundskeeper, or state or government specifications. The turfgrass, however, cannot speak for itself, so that is my duty today.

ESTABLISHMENT OR RENOVATION

"Establishment or reestablishment" might be described briefly as starting a new seeding after complete disturbance of existing cover or soil, whereas "renovation" is to improve the present turfgrass without major disturbance of soil or cover.

Which of these alternatives is used depends primarily on the condition of the site after construction. Actually, both may occur on different parts of the lawn or turfgrass area. Fall is the preferred time for seeding of cool-season turfgrasses for good seedling establishment without major weed problems. Spring is second, with summer the least desirable. Temporary grasses such as the ryegrasses might be used when late spring or summer seeding is required or for a quick, inexpensive cover. Permanent grasses such as Kentucky bluegrass and the fescues are preferred if conditions are adequate and the homeowner or turf manager is aware of the cost and ready for subsequent maintenance of the turf. Again, the future care of the turfgrass should be considered: it doesn't pay to seed an expensive, high-maintenance, "fancy" grass if there is no follow-up. We now, however, have lawn care services for the disinterested, busy, or lazy homeowner.

SITE EVALUATION

Every fall our Southern Illinois University students in the Turfgrass Management class renovate or reestablish two lawns. We start with site evaluation in the first laboratory period of the fall semester, take soil samples, and even glyphosate if needed. Site evaluation includes:

1. Checking soil type, physical condition, soil nutrient needs, and slope and drainage.

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2. Determining present and future use.

3. Noting rocks, debris, trees (their condition and shading), and undesirable grasses and weeds.

4. Describing the status of present turf: percentage of cover, species, and probable causes of turf deterioration.

SITE PREPARATION

Sometimes site preparation begins even before construction begins, with matters such as building location, determining which trees are to be removed, land contouring, etc. This discussion, however, is primarily about site preparation for turfgrass establishment or renovation after construction. Site preparation includes:

Tree Removal or Saving

Remove or thin heavily wooded areas unless a non-grassed area is to be maintained. Then remove undesirable species, including trees with full, low canopies and late leaf drop such as oaks, surface-rooted trees such as maple or beech that will interfere with later maintenance, and undesirable fruit producers such as sweet gum, female gingko, or mulberry. Protect trees that you want to save. In general, avoid covering roots more than 3 to 6 inches and extend this restriction somewhat beyond the drip line. Soil removal is similar: remove very little soil for surface-rooted species. Figure 1 illustrates how to build a retaining wall for an elevated tree, and Figure 2 indicates how to avoid excessive soil cover. Move trees to desirable locations if feasible. Rather large trees can be relocated if care is taken and if the species has the proper root characteristics, etc. Many times, however, it is safer and cheaper to start with smaller nursery trees that can be selected for their disease or insect resistance and other desirable characteristics. Turfgrass has a better chance to establish with less root and light competition.

Problem species.

- White oaks whose tap roots prevent them from being moved. Their heavy canopies also make them undesirable over turfgrass.

- Black oaks, most of which have fibrous surface roots, especially red, pin, and black oaks.

- Maples, which have many surface roots, especially silver, amur, and red maples.

- Gum and beech trees, which have extensive shallow and surface roots.

Desirable species.

These trees are more compatible with growing turfgrass because of their particular taproots and more open canopies.

- Redbud, locust, pagoda, Gingko, and most ash.

- Smaller ornamentals and shrubs such as crabapple, etc.

Grading and Saving Topsoil

Grading the site includes both excavation and grading for desirable building location and slope. The topsoil should first be removed and stockpiled before excavation. The subsequent subsoil should be placed in a separate pile for later removal or judicious fill around the foundation. Don't grade subsoil over good topsoil.

Clean-up of Wood, Concrete, and Other Debris

Buried wood may bring termites and also makes for difficult seeding later. Buried concrete can cause a dry spot in the lawn or prevent proper tree placement or growth.

Installation of Utilities and Sidewalks

Major utilities and sidewalks should be installed prior to seeding if possible. Shallow TV cables, telephone, and gas lines are best installed after seeding or at depths greater than 4 to 5 inches.

SEEDBED PREPARATION

Undisturbed areas should be checked for thatch or undesirable species. Remove excess thatch and dead material. Scattered clumps or undesirable species might best be killed by the use of glyphosate (Roundup). Untreated areas should be mowed very low (scalped) before seeding. Return the top soil to disturbed areas before final grading or leveling. New topsoil may be needed.

Lime and fertilize according to soil tests. Both should be incorporated 4 to 5 inches if possible. If the operation is renovation, one should verticut or aerify to help incorporate the amendments.

For final seedbed preparation, a light raking or smoothing will give a level surface. This provides a good surface and prevents future scalping.

SELECTION OF COOL-SEASON GRASSES

The major cool-season turfgrass species for the upper Midwest are Kentucky bluegrass and the shade-tolerant red fescues. The fast-germinating, turf-type ryegrasses are subject to thinning due to heat and disease but they can be reseeded frequently. They have good wear tolerance for sports such as soccer. The more drought- and heat-tolerant tall fescues are well-adapted to the southern portions of the region and require less maintenance. They have good wear tolerance and disease resistance, and new finer-textured cultivars are now available. Although not considered a cool-season grass, zoysiagrass has excellent summer qualities for the Transition Zone. Zoysiagrass is dormant in the winter but seldom suffers winterkill even in the North. Additional information, including

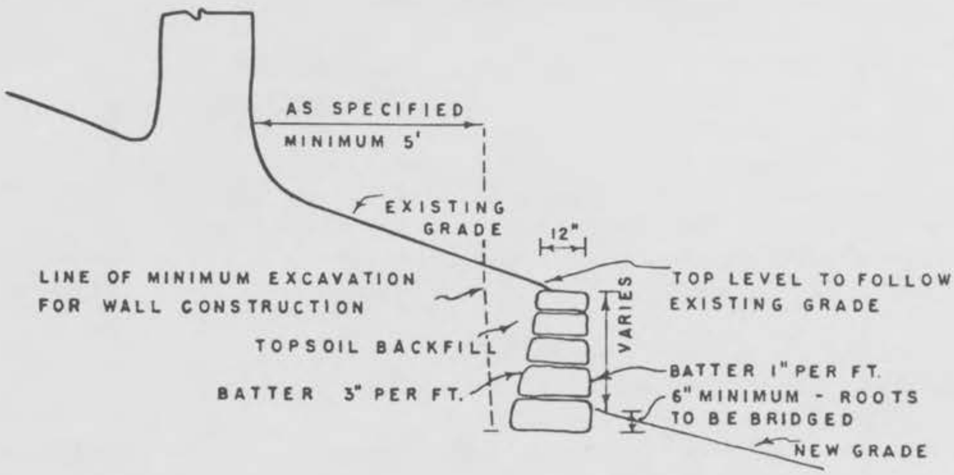

Figure 1. Retaining wall for an elevated tree.

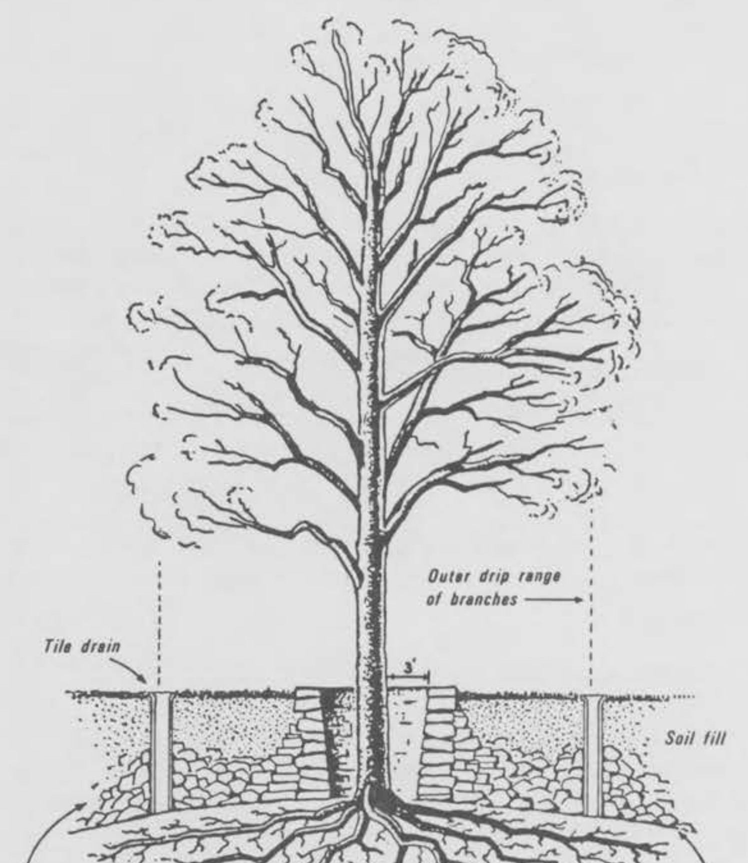

Figure 2. Avoiding excessive soil cover over tree roots.

cultivar characteristics and useful blends and mixtures, is given in *Turfgrass Selection for Illinois* (Fermanian).

Recognizing the desire of many homeowners and park superintendents for tree shade, they should select shade-tolerant turfgrass species or even ground covers for more dense shade. Several choices are shown in Table 1.

Table 1. Relative Shade Adaptation of Some Common Cool-Season Turfgrasses and Ground Covers

Shade tolerance	Ground cover	Cool-season turfgrass
Excellent	Pachysandra	Red fescue
Good	English ivy Periwinkle	Rough bluegrass, creeping bentgrass, tall fescue, Chewings fescue
Medium	Ajuga	Kentucky bluegrass,[a] perennial ryegrass
Poor	Spreading juniper Cotoneaster	Kentucky bluegrass

[a]Several moderately shade-tolerant cultivars are Glade, Bensun, Parade, Touchdown, and Nugget.

Let's look at one of the older seed mixtures that was included just a few years ago in state public school specifications for seeding a football field (Table 2).

Table 2. Materials for Fertilizing and Seeding Football Fields

Material	Percentage by weight
Korean lespedeza	5
Italian ryegrass	10
Kentucky bluegrass	10
Bermudagrass	15
White clover	15
Canadian bluegrass	20
Redtop	25

Note: These specifications are included in Sections 2.01 and 2.02 of the Illinois Department of Transportation's 1979 standard specifications (IDT).

This seed mixture was actually used. I obtained a sample of it, and it contained legumes and unadapted grass species such as bermudagrass, Canadian bluegrass, and redtop. I was called in to help establish a new field using a more appropriate mixture.

More up-to-date seeding mixtures are specified by the Illinois Department of Transportation for highways, roadsides, and reststops (Hanson et al.). Erosion control and low maintenance are two major criteria that the mixtures must meet. A portion of the specification is shown in Table 3.

Table 3. Illinois Department of Transportation Seeding Mixtures

Class	Seeds	Pounds per acre	Season to use
I	Kentucky bluegrass	50	Fall
	Perennial ryegrass	20	Fall
	Redtop or creeping red fescue	10	Fall
	Oats, spring	48	Fall
II	Ky. 31 or Alta fescue	50	Fall
	Perennial ryegrass	20	Fall
	Redtop or creeping red fescue	10	Fall
	Oats, spring	48	Fall
III	Crown vetch	20	Fall
	Winter vetch	40	Fall
	Crown vetch	20	Spring
	Perennial ryegrass	10	Spring
	Lespedeza, ladino, alfalfa, or white Dutch clover[a]	5	Spring

Source: IDT Article 642.07: Seeding Mixtures.
[a]Lespedeza should not be sown north of U.S. 136.

I contacted a local architect to see how he kept up to date on appropriate seeding mixtures to include in his specifications. He indicated two sources: a local retired landscape architect and MASTERSPEC 2. These recommendations are put out by Production Systems for Architects and Engineers (PSAE Div.) and updated yearly. A sample of a mixture published in February, 1983, is noted in Table 4.

Considerable updating is still needed in appropriate species as well as correct spelling and designation of botanical names. Redtop has not been considered an appropriate grass for a quality lawn mixture for a number of years. It is still useful for waterway conservation and roadside seedings where minimal maintenance is practiced. Red fescue or creeping red fescue *(Festuca ruba* is also appropriate and is usually recommended over Chewings fescue *(Festuca rubra* var. *commutata)*, although a mixture of these two is acceptable. As a species name, "perenne" should not be capitalized, and "Agostis" should be *"Agrostis."* The indicated tolerances for germination and purity are appropriate and are established by the Official Seed Analysts of North America.

Several updated turfgrass mixtures are given in Table 5. For specific areas, one could further select appropriate cultivars based on local trials. Many new, improved cultivars of red fescue, perennial ryegrass, and tall fescue are now available.

Table 4. Schedule of Grass Seed Mixtures: Mixture A for Sunny to Partial Shade Areas

Percentage of weight	Common name	Botanical name	Minimum percentage of germination	Minimum percentage of pure shade	Maximum percentage of weed seed
50	Kentucky bluegrass	*Poa pratensis*	80	85	0.50
30	Chewings red fescue	*Festuca rubra* var.	85	98	0.50
10	Perennial ryegrass	*Loluim perenne*	90	98	0.50
10	Redtop	*Agrostis alba*	85	92	1.00

Table 5. Turfgrass Seed Mixtures for Northern Cool Regions

Turfgrasses	Percentage of weight	Seeding rate, pounds per 1,000 square feet
Home lawns (wide range of conditions)		
Kentucky bluegrass (2 cultivars)	50	2 to 4
Red fescue (especially for shaded areas)	50	
Kentucky bluegrass (2 cultivars)	40	
Red fescue	40	3 to 4
Perennial ryegrass (improved cultivar)	20	
Kentucky bluegrass (3+cultivars)	100	2
Heavy duty areas (playgrounds, parks, athletic fields)		
Ky. 31 or Improved tall fescue	80 to 90	5 to 7
Kentucky bluegrass (2 cultivars)	20 to 10	
For temporary use (summer cover, erosion control)		
Perennial ryegrass	100	5
Oats	100	3 to 5
Rye	100	3 to 5

"Upgrade" is an example of a locally-blended Kentucky bluegrass. In July, 1983, we tested a 10-pound sample from lot No. 83-10 distributed by Belleville Seed House, Belleville, Illinois. The results of our analysis are as follows:

Table 6. "Upgrade," a Blend of Premium Bluegrasses

Variety	Percentage of blend	Percentage of germination	Percentage of composition
Baron	40	85	Pure seed: 97.65
Adelphi	20	85	Weeds: 0.01
Glade	20	85	Other crop: 0.26
Parade	20	85	Inert: 2.08

SEEDING AND SODDING PRACTICES

Specific seeding practices have been covered in some detail by others at this conference. I will briefly list the major steps:

1. To insure uniform coverage, distribute one-half of the seed in one direction and one-half in the opposite direction. If seeds vary in size, sow the various sizes separately.

2. In newly established or reestablished lawns, light raking or dragging is necessary to cover seed. Clean straw should be used for mulching, and then the seedbed should be rolled. This insures firmness, good seed/soil contact, and helps hold the straw. Netting is also desirable to hold the straw, and immediate irrigation can help as well.

3. For renovated lawns, several machines are available to incorporate the seed: a) A Rogers Seeder, either a small self-propelled or a larger tractor-mounted implement that includes a verticutter attachment, is ideal for a combination of seeding and incorporation. Although there may be an early row-effect, this disappears as seedlings mature. b) A fixed-tine verticutter (not a flail-type power rake) is another excellent machine to incorporate seed. If excessive thatch is present, most of the dead material will need to be removed first. It is not necessary to remove a thin layer of thatch or dead clippings; this material will act as a mulch. Distribute seed as in step 1 above, then verticut two or more times in different directions until seed is incorporated into soil. c) Where previous sod was thin, a Fuerst or other type harrow can be used for incorporating seed. d) Where compaction has been severe, an aerifier (coring machine) can be used. A tractor-mounted Dedoes machine has also been found useful.

4. Water is the final requirement. Once irrigation has been started or intermittent rains have begun, irrigation should be continued until full seedling establishment. Almost daily light watering is needed for a late summer or early fall seeding.

5. Hydroseeding or hydrostolonizing is ideal for larger sites or roadside areas. Almost all amendments, herbicides, seed, and fiber mulch can be applied at one time in a water slurry.

6. Sodding for an "instant" lawn is great but costly. Sodding of roadside slopes, waterways, and athletic fields is most common. Even sodding parts of a lawn, such as under down spouts, on steep slopes, and in water channels, is worth the effort to prevent early erosion. Preparation for sodding is similar to new establishment, and special care should be used in laying and post-treatment of sod.

7. Or you can always go to cement block!

SUMMARY

1. Save the topsoil.

2. Remove, save, and protect or move trees.

3. Select seed to establish or renovate turfgrass stands.

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UNDERSTANDING THE BASICS OF FERTILIZER BURN

David J. Wehner

Turfgrass managers often become very involved in day-to-day business operations and tend to forget some of the basics of turfgrass science. The purpose of this presentation is to help the turfgrass manager understand the basics of fertilizer burn. You may remember that a fertilizer you were using burned the turf on a given date and, at the same time, remember that you used the same fertilizer on another day and the turf was not injured; or that slow-release, ureaformaldehyde fertilizers do not cause a burn, while urea can. Clearly, an understanding of what causes fertilizer burn is needed to be able to predict when a fertilizer burn may occur.

Fertilizer burn is a type of foliar burn. Foliar burn is defined as injury to shoot tissue caused by dehydration from contact with high concentrations of chemicals. In the case of fertilizer burn, the high concentration of chemicals would be the fertilizer particles or solution applied to the turf. Fertilizer burn appears as a bleached area on the turfgrass leaf where the particle or droplet came in contact with the blade. The bleached appearance is due to the death of cells that were dehydrated because the fertilizer particle or droplet drew water out of the cells. the cuticle of the turfgrass leaf allows water to be withdrawn from the cell but does not allow the passage of large molecules, such as the proteins and enzymes that make up the protoplasm.

The first thought that comes to mind regarding fertilizer burn is salt index. The higher the salt index of a fertilizer, the more likely the material will burn the foliage. Ammonium nitrate has a higher salt index than urea and will therefore be more likely to burn the turf. Salt index is defined as the ratio of the increase in osmotic pressure to the increase produced by the same weight of sodium nitrate. More often we refer to the partial salt index, which is the salt index per unit of nutrient applied. The salt indexes and partial salt indexes of potassium chloride (muriate of potash) and potassium sulfate (sulfate of potash) are listed below:

	Salt index	Patial salt index
Potassium chloride	116	1.94
Potassium sulfate	46	0.85

It is apparent from these numbers that potassium chloride is more likely to cause a fertilizer burn than potassium sulfate. The difficulty with relying totally on the salt index to understand the nature of fertilizer burn can be demonstrated by looking at ammonium nitrate and urea, two nitrogen sources. When ammonium nitrate is put into water, it dissociates into an ammonium ion and a nitrate ion. It is a true salt. When urea is put into water, it dissolves from a solid state, but the molecules of urea do not dissociate. They remain as urea molecules in solution. Urea is not a salt. If urea is not a salt, then

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why does it have a salt index, and why does it cause fertilizer burn? We must go back to the definition of salt index to understand fertilizer burn. The definition states that the salt index is the ratio of the increase in osmotic pressure to that caused by the same weight of sodium nitrate. The key words of the definition are "osmotic pressure." The higher the osmotic pressure of the solution, the higher the chance of causing turfgrass burn when it is applied to the leaf surface. By understanding the concept of osmotic pressure, fertilizer burn can be understood.

Osmotic pressure is difficult to define in everyday terms. The osmotic pressure of a solution is determined with laboratory equipment as the pressure needed to prevent the flow of solvent across a semipermeable membrane separating pure solvent from the solution. Figure 1 helps explain this idea.

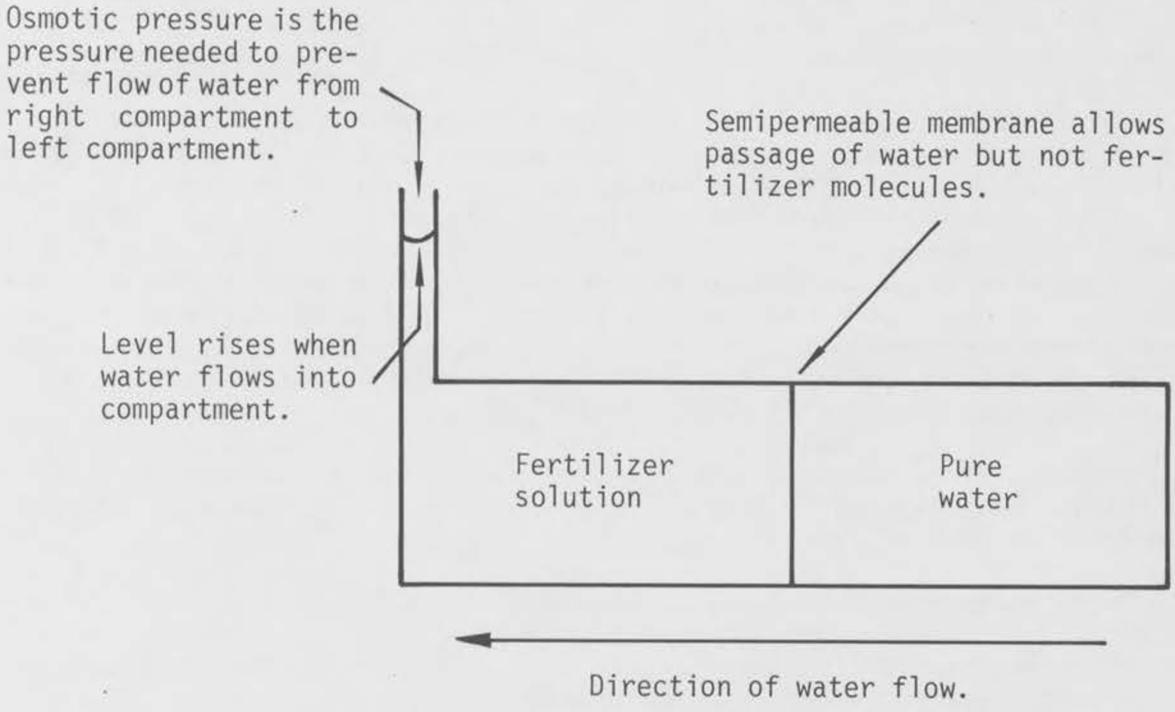

Figure 1.

Water will flow from the right side of the apparatus to the left side because of the attraction of the fertilizer molecules for the water. If we allow the volume of solution in the left side to increase, the solution would rise in the tube at the top of the apparatus. We can prevent the solution from rising in the tube by applying pressure on the solution. Since the volume of the chamber cannot change, the flow of water from the right side to the left side of the apparatus will stop if we do not let the solution rise in the tube. The pressure needed to prevent the flow of the solution from right to left is called the osmotic pressure of the solution.

The osmotic pressure of a solution depends on the number of ions or molecules in solution. The more ions or molecules in solution, the higher the osmotic pressure. The higher the osmotic pressure, the more likely a solution will burn the turf. We can now go back and look at the solutions of ammonium nitrate and urea. Ammonium nitrate molecules contain two nitrogen atoms, as would a molecule of urea. When we add these molecules to water though, the urea molecule does not dissociate, while the ammonium nitrate molecule does. This is illustrated below:

NH_4NO_3 (solid) ----------- $NH_4^+ + NO_3^-$ (in water)
Ammonium nitrate

NH_2CONH_2 (solid)----------- NH_2CONH_2 (in water)
Urea

It follows then that a solution of ammonium nitrate will have twice as many particles in solution as a solution of urea (although both supply the same amount of nitrogen). Thus, the osmotic pressure of the ammonium nitrate solution will be higher than the osmotic pressure of the urea solution, and the ammonium nitrate solution will be more likely to burn the turfgrass plant.

The osmotic pressures of solutions must be measured in a laboratory because most solutions are non-ideal. That is, there are interactions between the solute and the solvent that cannot be calculated mathematically. The turfgrass manager should remember that the osmotic pressure of the solution will increase as the concentration of fertilizer in the spray increases. The concentration increases if more nitrogen is added to the spray tank or if the amount of water is reduced. The standard spray volume in the lawn care industry is 4 gallons of water per 1,000 square feet. The possibility of burning the turf increases if the spray volume is reduced to 2 gallons per 1,000 square feet and nitrogen application rate is kept the same.

We have talked about the osmotic pressure of the spray solution. Now we must consider the plant-water status, since the possibility for turfgrass burn changes with weather conditions and conditions that affect plant-water status.

The plant's water status will depend on the amount of water available to the plant and the demands being placed on the plant by the environment. The amount of water available to the plant in turn is determined by the extent of the root system and the water-holding capacity of the soil in which it is growing. As expected, the rate at which water is being lost from the plant is affected by temperature, humidity, and wind. The plant will use more water on hot, windy, dry days than on cool days. We can expect then that the possibility of burning a turfgrass through fertilizer application will be greater on days when the plant is already under stress and cannot withstand loss of water through its cuticle. If the water supply is adequate, then the possibility of burning the plant is reduced.

There are several ways to reduce the risk of burn when using a fertilizer. First, granular fertilizers should be applied to dry foliage so that the particles will not stick to the leaf surface and cause a concentrated salt solution to remain on the plant. Second, use fertilizers with a low salt index during periods of the year when fertilizer burn is most likely to occur. Third, with liquid applications, increase the amount of water used to apply the fertilizer. This will lower the osmotic strength of the solution and reduce burn potential. Fourth, irrigate immediately after fertilizer application.

By understanding the concept of osmotic pressure and the factors that influence the plant-water status, it is possible to use fertilizers safely during periods when the risk of fertilizer burn is quite high. Generally, fertilizer damage is not serious in terms of the plant's survival. However, it may be the source of customer dissatisfaction and lost accounts.

WHAT'S NEW IN CRABGRASS CONTROL?

Herbert L. Portz

INTRODUCTION

This paper will briefly review some of the standard practices in controlling crabgrass and then focus on several of the newer herbicides and combinations being tested. Smooth and large crabgrass (*Digitaria* spp.) and goosegrass or silver crabgrass (*Eleusine indica* L.) are prevalent in both the North and the South. The Transition Zone, from Maryland and Virginia to Kansas and Oklahoma, however, has the most severe infestations and has often been dubbed the "Crabgrass Belt."

One might first mention the difficulty of doing crabgrass research. Crabgrass is a prolific seed producer with seeds a little larger than those of Kentucky bluegrass. These plentiful seeds seem to germinate and grow everywhere, but when one harvests and cleans seed for research purposes or when one buys and sows expensive crabgrass seed, the researcher often gets very poor germination. Dr. Karnak of the University of Georgia and others have indicated that "For some unexplained reason, the crabgrass seeds sown into the plot are never germinated, even after repeated scalpings and irrigation." I have had similar problems when seeding crabgrass on my turf herbicide research plots. Yet in adjacent Kentucky bluegrass experimental plots under low cutting heights and summer irrigation, crabgrass readily germinates.

Crabgrass seed has dormancy factors that probably require aging or fluctuations in temperature and moisture; these occur under normal conditions yearly on top of and in the soil. After breaking of seed dormancy, the major germination requirement besides moisture is light. Thus, the shading from high cut alone is a major deterrant to crabgrass germination. Therefore, low cut coupled with disease or an otherwise poor turfgrass stand allows sunlight to trigger germination. Also, the longevity of crabgrass seed either on top of or buried in the soil is considerable: it merely waits for the right conditions.

BEST CONTROL: A DENSE STAND OF TURFGRASSES

The competition of a vigorous, dense stand of turfgrass can effectively control most crabgrass. This involves proper fertilization, cutting, and other management factors along with use of adapted species and disease-resistant cultivars. Many factors, however, such as hot weather, the growth cycle, and thinned stands due to diseases or insects may favor the crabgrass. Figure 1 shows that when Kentucky bluegrass is growing slowly or is nearly dormant in summer, crabgrass has its major growth spurt: once germinated, it grows extremely well during hot, dry weather.

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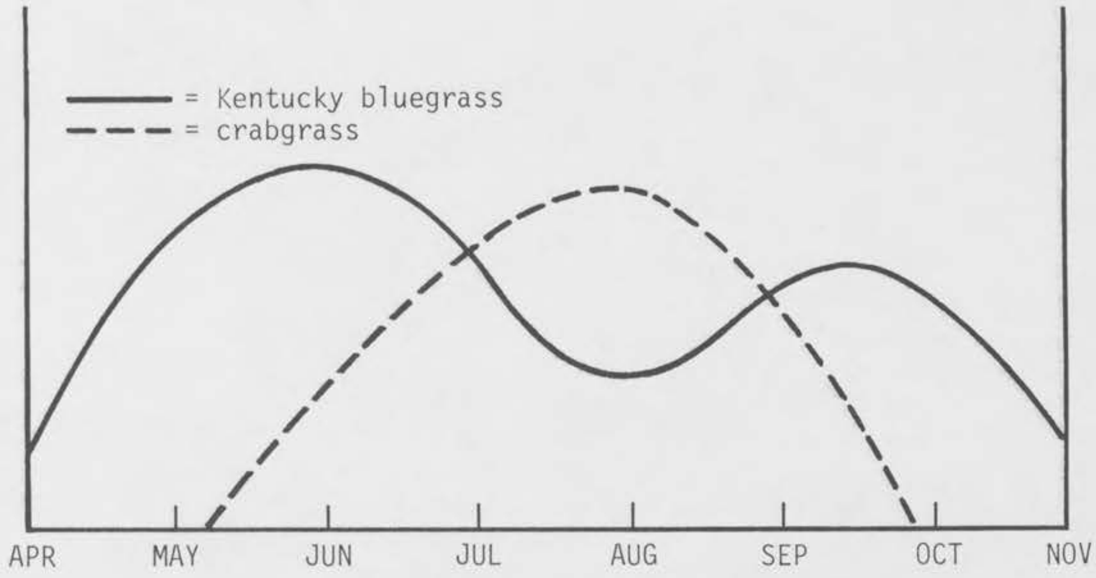

Figure 1. Growth cycle patterns of Kentucky bluegrass, a cool-season turfgrass, and crabgrass, a weedy summer grass in the north central United States.

Results from a Kentucky bluegrass experiment involving irrigation versus no irrigation and low cut (1-1/4 inches) versus high cut (2-1/4 inches) indicate the effect of these two treatments on crabgrass incidence (Table 1). In 1980 Fusarium blight severely thinned the low-cut plots (several cultivars in particular), allowing crabgrass encroachment under irrigation. This was especially noted in the following year, 1981: crabgrass invaded neither the nonirrigated high-cut plots nor the nonirrigated low-cut plots.

EFFICACY STUDIES: PREEMERGENCE HERBICIDES

Since we noted problems in crabgrass germination and uniformity, many trial plots are now located on old turf areas such as the Rocket Laboratory at Purdue and old lawns where turfgrass is sparse. My personal choice is where moles have "plowed" the turf in their search for grubs and earthworms. My home lawn at Pinecrest south of Carbondale has been used for crabgrass herbicide research for the last three years!

We will first look at the five common preemergence herbicides that are the major commercial products used today for crabgrass control and note several characteristics and uses of each:

Benefin (Balan)

Granular 2G and some liquid forms, both used with fertilizers. Thins stands of fine fescues, bentgrasses, and annual bluegrass. Two applications 6 to 8 weeks apart recommended for season-long control.

Table 1. Management and Other Factors Affecting Crabgrass Encroachment in Kentucky Bluegrass, Southern Illinois University, Carbondale, 1980 and 1981

	Irrigated				Nonirrigated			
	Low cut[a]		High cut		Low cut		High cut	
Cultivar	1980	1981	1980	1981	1980	1981	1980	1981
Adelphi	6.0	5.3	7.0	9.0				
Baron	6.0	4.2	6.0	7.7				
Bensun	6.0	3.2	6.3	8.0				
Bristol	6.7	4.2	7.0	8.0				
Common	5.3F	2.5	5.7	7.0				
Parade	6.3	5.2	7.0	7.5				
Touchdown	6.3F	5.7	6.0	7.5				
Majestic	6.7	4.5	7.0	8.0				
Vantage	5.7	2.3	6.7	7.5				
Average	6.0	4.1	6.5	7.8	3.2D	6.6	4.5D	7.9
		Crabgrass	No crabgrass			No crabgrass		

Note: Rating: 9 = excellent quality, no weeds; 1 = all dead or dormant. F = severe Fusarium blight; D = drouthy and partially dormant condition.
[a]Cutting height: low = 1-1/4 inches; high = 2-1/4 inches.

Bensulide (Betasan, Presan, Lescosan, Betamac, and Others

Both granular and liquid forms available. Safe for all cool-season turfgrasses including bentgrasses, however, phototoxic to establishing stolons and seedlings of bermudagrass and zoysiagrass. Longer residual effect but two applications desirable; only one in succeeding years.

DCPA (Dacthal)

Both granular and wettable powder forms available. May injure fine fescues and bentgrasses. Cleared for use on many garden plants and flowers. Usually requires two applications 6 to 8 weeks apart for season-long control.

Oxadiazon (Ronstar)

Mostly granular but new flowables are produced. Not used on fine fescues or bentgrasses; significant thinning of perennial ryegrasses may occur. Overtreatment may cause temporary discoloration. Most effective preemergence chemical for goosegrass control. Can reduce rate in succeeding years.

Siduron (Tupersan)

Both granular and wettable powder forms available. Safe on all cool-season turfgrasses including many bentgrasses such as Penncross, C-1, C-7, and C-19 except on short-cut putting greens. Even two applications seldom give season-long control. Its major use is for new seedings of cool-season turfgrasses and zoysiagrass. Half rates of 4 to 6 pounds active ingredient per acre are used with a second application at 2 to 4 pounds.

As shown in Table 2, siduron is the only herbicide that can be used when seeding zoysiagrass. Several others are useful when using vegetative propagation.

Table 2. Herbicide Treatments and Propagation Methods for Establishing Zoysiagrass in a Prepared Seedbed, Carbondale, Illinois, June 18, 1980

Herbicide treatment	Active ingredient per acre, pounds	Percentage of ground cover on October 2 (15 weeks)		
		Seeded	Stolonized	Plugged
Siduron	10.00	90.0a	80.0a	78.3ab
Simazine	0.75	1.7e	75.0a	83.3a
Siduron/simazine	8.00/0.50	5.0de	68.3a	73.3abc
DCPA	10.00	10.0de	38.3b	51.7d
MSMA + 2,4-D/ dicamba	1.00 2x	61.7b	65.0a	65.0bcd
Check	0.75/0.25	22.7c	36.7b	55.0cd

Note: Means within columns followed by the same letter are not significantly different at the 5-percent level as determined by Duncan's Multiple Range Test.

Results from preemergence herbicide applications in 1982 on a tall fescue/Kentucky bluegrass turf are shown in Table 3. DCPA gave the best season-long crabgrass control with two applications being superior to one: 88.8 percent versus 78.8 percent control. Butachlor and siduron gave the poorest. Young zoysiagrass plants seeded in June, 1982, were treated with various preemergence herbicides in 1983 (Table 4). Although bensulide gave the best control, it was also the most phytotoxic. The phytotoxicity had been noted previously when stolonizing zoysiagrass or bermudagrass. In addition to the standards, several new herbicides and combinations were tested on a tall fescue/Kentucky bluegrass turf at Pinecrest in 1983 (Table 5). It was a relatively dry year, with occasional light showers and several dewy mornings in the summer, but most of the herbicides gave incomplete crabgrass control. A new combination, a mixture of granular benefin and trifluralin at a rate of 4 pounds active ingredient per acre gave the best crabgrass control, with a rating of 8.2. Two applications of DCPA and one of bensulide produced ratings of 7.9 and 7.8, respectively.

PHYTOTOXICITY AND ROOT AND RHIZOME DAMAGE TO TURFGRASSES

Along with crabgrass control, one should observe the detrimental effects on the turfgrass plants. Phytotoxicity may only appear as a slight discoloration, but when it is severe or persists, the lawn owner is not pleased. Furthermore, there may be thinning and even root damage. This actually opens the turf to more crabgrass pressure as well as reducing the turf quality. In Table 6, Karnak and Cooper note not only crabgrass control but the phytotoxicity and thinning of Kentucky bluegrass with various preemergence herbicides. A combination bensulide/napropamide and napropamide alone were the most phytotoxic and resulted in the most severe thinning and the poorest crabgrass control. Benefin was next

Table 3. Percentage of Control of Crabgrass with Different Preemergence Herbicides in Tall Fescue/Kentucky Bluegrass, Pinecrest, Southern Illinois, 1982

Herbicide	Pounds of active ingredient per acre	Percentage of crabgrass control		
		June 15	July 13	Aug. 3
Butachlor (Machette)	7.5[a]	18.0	10.0	10.0
DCPA (Dacthal)	10.0	63.8	73.8	78.8
Bensulide (Betasan)	10.0	83.5	52.8	25.0
Siduron (Tupersan)	10.0	13.8	35.0	13.8
Butachlor	7.5 + 2.5[b]	13.8	7.5	12.5
DCPA	10.0 + 5.0	85.0	83.8	88.8
Bensulide	10.0 + 5.0	67.5	77.5	56.2
Siduron	10.0 + 5.0	25.0	31.2	21.2
Check	Water only	6.2	5.0	10.0

[a]Treatment applied April 2 (in a light rain).
[b]Second treatment applied May 4.

Table 4. Control of Crabgrass in Zoysiagrass with Several Preemergence Herbicides, Pinecrest, Southern Illinois, 1983

Herbicide	Pounds of active ingredient per acre	Rating, May 26 (7 weeks)	
		Crabgrass[a]	Phytotoxicity[b]
Benefin (Balan)	2.0	3.0	2.0
Bensulide (Betasan)	7.5	7.0	3.7
DCPA (Dacthal)	10.0	6.7	2.7
Oxadiazon (Ronstar G)	3.0	5.3	1.7
Trifluralin (Treflan)	1.0	2.7	1.0
B/t (Balan/Treflan)	3.0	5.3	2.7
Napropamide (Devrinol)	4.0	6.7	2.0
Check		1.0	1.0

NOTE: Zoyziagrass: "Midwest blend" seeded in June, 1982, and treated with siduron at seeding.
[a]Rating of crabgrass control: 9 = complete control; 1 = no control.
[b]Rating of phytotoxicity: 9 = complete kill; 1 = none.

Table 5. Control of Crabgrass with Standard and Newer Preemergence Herbicides in Tall Fescue/Kentucky Bluegrass Turf, Pinecrest, Southern Illinois, 1983

Herbicide	Formulation	Pounds of active ingredient per acre	Crabgrass control[a]		
			7 weeks	12 weeks	21 weeks
Benefin	2.5 g	2[b]	7.3	7.3	7.0
Bensulide	4EC	7.5	8.3	7.7	7.8
DCPA	75 WP	10	8.7	8.0	6.5
Oxadiazon	2 G	3	6.3	6.0	5.8
Siduron	50 WP	12	2.7	4.3	3.0
Benefin	2.5 G	2 + 1.5[c]	6.7	7.7	4.7
Bensulide	4 EC	7.5 + 5	5.7	7.0	5.8
DCPA	7.5 WP	10 + 7	9.0	8.7	7.9
Oxadiazon	2 G	3 + 2	8.0	6.0	7.0
Siduron	50 WP	12 + 8	4.7	6.7	3.0
Check			1.3	3.0	1.3
Trifluralin	5 G	1	4.7	5.7	5.0
Trifluralin	5 G	2	6.0	6.7	7.2
Trifluralin/ benefin	1.33/0.67 2 G	1	7.0	7.3	7.0
T/b	2 G	2	8.3	7.7	7.0
T/b	2 G	4	9.0	7.7	8.2
Napropamide	50 WP	2 + 2	4.7	3.7	2.7

[a]Rating of crabgrass control: 9 = complete control; 1 = no control.
[b]First application April 9; good rainfall following application.
[c]Second application May 27/28, 3 days after first rating.

in phytotoxicity with oxadiazon showing considerable phytotoxicity and particular discoloration at rates of 3 and 4 pounds of active ingredient per acre. Note that treatment was applied very late, July 31. One would expect more severe phytotoxicity during the warmer days, but crabgrass control was excellent.

N.E. Christians of Iowa State University studied the effect of three preemergence herbicides on root and clipping weights and rhizome length of Kentucky bluegrass (Table 7). He observed some cultivar differences, especially between "Newport" and "Enmundi," insofar as oxadiazon affected rhizome length and clipping weight. Both oxidiazon and bensulide reduced root weights of all cultivars as rates were increased. Dr. Christians observed that since oxadiazon provides excellent control of goosegrass and has a fairly long residual, it could be a very useful preemergence herbicide if somewhat tolerant Kentucky bluegrass cultivars such as "Enmundi" are used.

Many new herbicides for preemergence control are being tested. They include new products, new combinations, and new formulations, especially granular, pelleted, and flowables. A few of them and their general phytotoxicity and crabgrass control efficacies are noted in Table 8.

Table 6. Phytotoxicity, Thinning, and Crabgrass Control with Six Preemergence Herbicides on Kentucky Bluegrass Turf, Ohio State University, 1981

Herbicide and formulation		Pounds of active ingredient per acre	Phytotoxicity[a]	Thinning[b]	Control
Oxadiazon	2G	2.0	5.5	7.3	90
Oxadiazon		3.0	4.2	6.3	95
Oxadiazon		4.0	4.5	6.0	100
Benefin	2.5 G	2.0	3.8	6.0	85
Siduron	50 WP	10.0	5.8	9.0	90
DCPA	75 WP	10.5	6.2	9.0	92
Bensulide	7 G	7.5	5.2	8.7	95
Napropamide	5 G	1.0	3.3	4.7	75
Bensulide/ napropamide	7 G 5 G	5.0 1.0	3.0	2.3	82

Source: K.J. Karnak and R.J. Cooper.
Note: Treatment applied July 31, 1981.
[a]Phytotoxicity: 9 = none, dark green; 1 = yellow to brown. Data taken Aug. 19, 1981.
[b]Thinning: 9 = dense; 1 = thin. Data taken Oct. 9, 1981.

Table 7. Effect of Three Preemergence Herbicides on Root and Clipping Weight and Rhizome Length of Kentucky Bluegrass Over a 7-Week Period, Iowa State University, 1982

Treatment	Kilograms of ingredient per hectare	Root weight per pot, grams[a]	Clipping weight, milligrams		Rhizome length, centimeters[b]	
			Newport	Enmundi	Newport	Enmundi
Control	...	1.4	330	310	No difference	
DCPA	11.8	1.2	310	240		
DCPA	16.8	1.5	320	270		
Oxadiazon	2.2	1.2	350	270	12.4	8.1
	4.5	1.0[c]	270	200[c]	10.9	9.6
	9.0	0.8[c]	230[c]	300	7.5	8.6
Bensulide	8.4	0.6[c]	240	210[c]	No difference	
	15.7	0.4[c]	250	280		
LSD 1 percent		0.3	80	80		

Source: N.E. Christians. 1982. Preemergence herbicide effects on four Kentucky bluegrass cultivars. *Horticulture Science*. 17(6):911-912.
[a]Average of four cultivars: Newport, Park, Baron, Enmundi.
[b]Interpolated from published figures.
[c]Figures show significantly lower weights than check.

Table 8. New Preemergence Herbicides Compared to Standards, Iowa State University, 1982

Herbicide, description	Company	General summary Phototoxicity	Control[a]
Benefin/Pel Tech[b] 10	Anderson's	0	Medium
Benefin/Pel Tech 20	Anderson's	0	Medium to good
Ronstar/Pel Tech 20	Anderson's	0	Medium to good
Ronstar 50 WP	Rhone Poulenc, Inc.	+	Very good
ANDG 1-82	Anderson's	++	Poor
Dacthal 6F	Diamond Shamrock	0	Good
Betasan 4E		0 to +	Very good

Source: N.E. Christians.
[a]Crabgrass control (by count): very good = 0 to 4; good = 5 to 6; medium = 16 to 52; poor = 107 to 166 (actually caused grass thinning and allowed additional crabgrass as compared to control).
[b]The active ingredient in Pel Tech is oxadiazon in dispersable pellets.

COMBINATIONS AND NEW POSTEMERGENCE HERBICIDES

Our arsenal for postemergence crabgrass control is not as large as for preemergence: after all, the herbicides must differentiate between two growing grasses. The arsonates, such as MSMA and DSMA, are still effective if crabgrass is small, preferably 2 to 4 leaves, but treatment must be repeated 2 to 3 times at intervals of 7 to 10 days. One of the major products, Daconate, has been tested in combination with several broadleaf herbicides, as noted in Table 9, with excellent results. A new HOE herbicide now called "Whip" also shows promise (Table 10). Combinations with growth retardants and other chemicals are also being tested. We continue to test new herbicides, new formulations, and new combinations for more effective control of annual weedy grasses, especially crabgrass, which is one of the worst weeds in our region.

SUMMARY: CRABGRASS CONTROL

1. For a dense stand of turfgrasses:

   - Use adapted turfgrass species and cultivars.

   - Mow at proper height: 2+ inches up to 4 inches if homeowner doesn't object.

   - Use either no irrigation or go all the way.

2. Preemergence herbicides require:

   - Timely first application in April or May (when forsythia starts to drop petals).

   - Second application in 6 weeks for season-long control.

- Most effective to date are: DCPA, bensulide, oxadiazon, and several new combinations.

- Repeat applications in following years may be reduced, such as with bensulide, oxadiazon.

3. Postemergence herbicides:

- Use arsonates (MSMA, DSMA, etc.) when crabgrass is small.

- Need two to three applications, 7 to 10 days apart.

- Combinations of arsonates with MCPP, 2,4-D, and dicamba.

- New compounds, such as HOE (now called "Whip") and others, perhaps with double-duty growth retardants in the future!

Table 9. Postemergence Crabgrass Control in "Common" Kentucky Bluegrass Turf, University of Missouri, Columbia, 1982

Chemical	Pounds of active ingredient per acre		Percentage of crabgrass control[a]
	Application 1	Application 2	
Daconate + Trexan	2.0 + 1.5	Dac. 2.0[b]	99 A[c]
Daconate + MCPP/2,4-D	2.0 + 2.0	Dac. 2.0	98 A
Daconate	2.0	Dac. 2.0	97 A
Daconate + MCPP/2,4-D	2.0 + 3.0	Dac. 2.0	96 A
Daconate + Trexan	2.0 + 1.5		96 A
Daconate + MCPP/2,4-D	2.0 + 2.0		88 A
Daconate	2.0		43 B
Trexan	1.5		13 C
MCPP/2,4-D	2.0		13 C
Control			0 C

Source: J. Dunn.
[a]Percentage of control, August 11; chemical applied June 10.
[b]Followup application of Daconate on June 20.
[c]Means followed by the same letter are not different according to Duncan's Multiple Range test, $P<0.05$.

Table 10. New Postemergence Products for Crabgrass Control, Purdue University, 1982

Treatment	Pounds of active ingredient per acre	Kentucky bluegrass phytotoxicity, Experiment 1, July 16[a]	Percentage of crabgrass control[b]	
			Experiment 1, September 7	Experiment 2, September 29
HOE (Whip)	0.15	7.3	10	6
HOE (Whip)	0.25	7.0	10	8
HOE (Whip)	0.40	...	...	...
HOE (Whip)	0.25 + 0.25	5.7	10	...
Daconate/MCPP/ 2,4-D	2 + 2	8.3	6.7	10
Daconate	2	8.0	3	10
Control		7.7	3	2

Source: R.P. Freeborg.

Note: Experiment 1: First application July 6; second application of HOE and Daconate/MCPP/2,4-D on July 16. Experiment 2: First application August 23; second application of Daconate/MCPP/2,4-D on September 2.

[a]Phytotoxicity: 10 = none, 1 = all brown.

[b]Crabgrass control: 10 = 100 percent; 0 = no control.