13TH ILLINOIS TURFGRASS CONFERENCE

November 30–December 1, 1972

Arranged and conducted by

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

In cooperation with

ILLINOIS TURFGRASS FOUNDATION

WELCOMING ADDRESS

J.B. Claar

The College of Agriculture and Cooperative Extension Service are pleased to have the Turfgrass Association here for its mid-winter meeting.

Keeping up to date is an essential ingredient of success in any business today. The College is aware of the growing turf industry of the state, and we are pleased that it has been possible this year to improve the research facilities and to set up satellite fields in order to investigate the effects of a broader range of climatic conditions. This research is crucial to the Extension program, and your support of it is greatly appreciated.

As you know, we have been experiencing a financial crunch during the past two years, and even a modest expansion of the turf program has been hard to come by.

We have appreciated the excellent cooperation that we have had from the turf industry in attending Extension programs. This is the only way that we can hope to reach the many people involved, since we have a small staff. I hope you have found that the new slide sets developed by Dr. Turgeon are useful to you. It may also be of interest to you to know that the regional Extension publication on Lawn Diseases in the Midwest was so popular that it is being revised and reprinted.

As professional people in the turf area, you probably have most frequent contact with the Department of Horticulture. I would remind you, however, of the continuing and substantial contributions that are made by the County Extension Staff to the ornamental horticulture and turfgrass field. All advisers are called on frequently by homeowners and others for information, and the specialized advisers conduct a great many educational programs in the field. The recent landscaping series developed by Bill Nelson, Extension Specialist in the Department of Horticulture, has challenged many communities to consider the aesthetics of their community and to ask themselves if the public areas of their community are designed in an attractive manner that community residents can be proud of. Therefore, let me assure you that we are deeply involved in educational programs relating to your industry. We hope to strengthen our programs in the years ahead.

We do not have any untapped reserves and expansion of turfgrass Extension and research will need to take place mainly through the hard road of securing added funds through the budget process.

It is good to have you here. Lifelong learning is the price of keeping up and staying current in any given field.

Come back often, and in the meantime, please help us through your counsel and advice concerning ways that we can be of more help to you.

J.B. Claar is Director, Cooperative Extension Service, College of Agriculture, University of Illinois.

CONTENTS

RESEARCH SESSION

TURFGRASS RENOVATION WITH HERBICIDES

A.J. Turgeon

The rejuvenation of a deteriorated turf is called renovation. It involves a wide range of activities which go beyond routine maintanance practices but which do not include complete tillage of the soil. Renovation usually requires applications of selective or non-selective herbicides for controlling unwanted vegetation. Seeding or vegetative planting is usually practiced during or after ground preparation by vertical mowing, aerating, spiking, or other means. The planting operation must be delayed until the applied herbicides have decomposed sufficiently so that new plants are not killed or severely injured by chemical residues in the soil. This "waiting period" varies widely depending upon the specific herbicide used and its persistence and availability in the soil.

SELECTIVE HERBICIDES

The specific herbicides used should be selected on the basis of the existing weed populations. If all weeds can be controlled selectively, as with most annual grasses and broadleaf weeds, then the existing desirable grasses can be salvaged. Selective herbicides include: 2, 4-D, silvex, mecoprop, and dicamba for broadleaf weeds; and DSMA, MSMA, and MAMA for annual grasses. Planting should be delayed for at least a few weeks following herbicide treatment, or until the existing weed population has completely disintegrated, in order to allow for dissipation of chemical residues in the soil.

NON-SELECTIVE HERBICIDES

Sodium arsenite has long been used for chemically burning-off vegetation prior to seeding. Cacodylic acid, an organic arsenical, has also been used for this purpose. In recent years, paraquat has largely replaced the arsenicals because of its greater effectiveness and rapid kill of vegetation at low application rates. Because paraquat is very quickly adsorbed and inactivated by soil clay particles, seeding or vegetative planting can be performed without delay. The principal limitation on the use of paraquat is its ineffectiveness in controlling rhizomatous, perennial grasses, such as quackgrass or bermudagrass. A contact herbicide, paraquat does not translocate adequately into the rhizomes. Consequently, new shoots are quickly generated from surviving rhizome tissue, even after successive applications of paraquat to the foliage.

Dalapon and amitrole are systemic herbicides generally recommended for controlling rhizomatous perennial grasses. Although readily translocated within the plants, these herbicides are generally not completely effective in killing quackgrass or bermudagrass from a single application. Multiple applications are usually required in conjunction with soil tillage for complete control. An additional factor to consider is the soil-residual activity of these herbicides following their application. Amitrole may persist for up to five weeks in the soil, and dalapon for

---

A.J. Turgeon is assistant professor, Department of Horticulture, University of Illinois

eight weeks or more. Consequently, replanting operations must be delayed for long periods following the last of several applications of these herbicides.

In recent tests, the experimental herbicide--glyphosate--was evaluated for controlling bentgrass, tall fescue and bermudagrass infestations. This herbicide was effective against bentgrass and tall fescue at 2 pounds per acre; however, bermudagrass was not completely controlled and recovery was evident 48 days following the single treatment. The short residual activity of glyphosate in the soil allowed germination from overseeding of treated areas within two weeks following its application. Although not a panacea, initial results do suggest that glyphosate may provide the turfgrass manager with more effective control of perennial grasses, without long-lasting chemical residues in the soil that interfere with replanting. Results from future research will more clearly define the role of glyphosate in turfgrass renovation.

FUNGICIDE-NITROGEN INTERACTIONS IN BENTGRASS TURF

A.R.Mazur and T.D.Hughes

UPTAKE AND ASSIMILATION OF NITRATE AND AMMONIUM

The two principal forms of nitrogen utilized by plants are nitrate and ammonium. The uptake and assimilation of nitrate and ammonium is influenced by:

1. the plant species;
2. pH of the medium;
3. the balance of other cations and anions;
4. aeration;
5. carbohydrate status of the plant;
6. stage of development of the plant.

Plant Species

It has been found that cereals (oats, rye, wheat, and barley) grow better with nitrates than with ammonia. On the other hand, sugar beet, pineapple, and potato grow better with ammonium than with nitrate nitrogen at pH's around neutrality.

pH

Nightingale made the general statement that many plants can absorb and assimilate nitrate nitrogen and grow luxuriantly over a wider pH range than is possible when nitrogen is available only as an ammonium salt. It has also been demonstrated that the absorption of nitrate and other anions was greatest from acid solutions. On the other hand, absorption of ammonium and other cations was greatest from alkaline solutions.

Balance of Anions and Cations

Ammonium uptake limits the uptake of other cations. The reduced growth rate under ammonium nutrition was determined to be the result of this competition between uptake of the ammonium and the other cations and the release of hydrogen ions during the formation of organic nitrogen compounds.

Aeration

Aeration has been shown to have a more pronounced effect on the uptake of ammonium than nitrate.

Carbohydrate Status

Evidence tends to indicate that conditions of poor light or low carbohydrate levels may become more of a limiting factor to growth and protein synthesis with ammonium than with nitrate nitrogen.

A.R. Mazur is graduate research assistant and T.D. Hughes is assistant professor, Department of Horticulture, University of Illinois.

Stage of Development

It has been suggested that the ability of plants to assimilate nitrate may only develop during the period after germination.

It is apparent from these findings that the uptake and assimilation of nitrate nitrogen is less complicated than the uptake and assimilation of ammonium nitrogen. In many cases, particularly those associated with members of the grass family, plants grew better with nitrate than ammonium nitrogen.

MINERALIZATION OF NITROGEN IN SOIL

organic $\longrightarrow NH_4 \longrightarrow NO_2 \longrightarrow NO_3$

$\longrightarrow$ ammonification $\longrightarrow$ nitrification $\longrightarrow$

$\longrightarrow$ mineralization $\longrightarrow$

Mineralization is the oxidation of organic N to nitrate and it includes the phases ammonification and nitrification.

Ammonification is carried out by a diverse range of flora which contains members of most all bacteria, fungi, and actinomycetes. This process is known as putrefaction. Nitrification, on the other hand, is carried out by principally two organisms, nitrosomonas and nitrobacteria.

As one would expect because of the limited number of organisms capable of carrying on nitrification, it is more susceptible to inhibition.

FACTORS AFFECTING NITRIFICATION

There are six principal factors affecting the nitrification process.

1. availability of NH_4;
2. temperature;
3. pH;
4. aeration-moisture ratio;
5. organic matter-root exudates;
6. various pesticides.

NH_4

As was stated previously, NH_4 is not usually limiting because of the wide range of organisms capable of decomposing organic matter.

Temperature

Nitrification has been shown to proceed most rapidly near 90° F. while little if any occurred below 43° F.

pH

Maximum nitrification occurs near neutrality, and proceeds very slowly in acid soils.

Aeration-Moisture

Nitrification is an aerobic process, so water-logged soil conditions not only inhibit nitrification but will result in a process known as denitrification where certain groups of soil microorganisms obtain their O_2 for respiratory activity from molecules such as NO_3. This results in a loss of N as free nitrogen gas. The optimum moisture level for nitrification is in the range of 28 to 30 percent, or near field capacity.

Organic Matter

Nitrifiers are strict autotrophs, and most organic compounds or products of organic-matter decomposition have been shown to be toxic to them. In fact, their isolation and identification was not possible until scientists found that they must be cultured on inorganic media. However, nitrification does occur in soils rich in organic matter, but often at low levels. The lower nitrate levels observed in high organic matter soils may be attributed to:

1. Increased nitrogen needs of larger microorganism populations associated with highly organic soils;

2. Localized denitrification which may be due to the depletion of O_2 by the greater microorganism activity of soils rich in organic matter.

There is a great disagreement between researchers as to the affect that growing plants and root exudates have on nitrification. Some researchers indicate plants liberate substances that favor nitrification, while others have found an inhibition of nitrification by growing plants. The greatest degree of nitrification suppression by plants has been reported to occur under sod conditions. Nitrification suppression under sod has been associated with the greater total root mass under these conditions than under other forms of vegetation.

Pesticides

Research has shown that many of our pesticides inhibit nitrification.

1. chlorate
2. borate
3. sodium arsenite
4. heavy metals (lead, mercury, etc.)
5. picloram
6. diuron
7. S-triazines
8. dithiocarbamates

Dithiocarbamates. Several fungicides and herbicides fall into this group of chemicals.

1. ferbam
2. zeram
3. zineb (parzate C)
4. nabam
5. maneb (tersam LSR)

All of these materials with the exception of nabam have been reported in lab studies to inhibit nitrification for up to a month at rates equivalent to 100 pounds per acre.

Maneb, under field crop use, has been found to affect nitrification up to four weeks from a single application at rates comparable to those that would be used on golf greens. At higher rates, inhibition persisted up to 16 weeks, and can be attributed to the persistence of the $\overset{S}{\overset{\|}{C}}\text{-}S$ group even though the fungicide itself has broken down.

S-Triazines. Even though many of these materials in the past were considered as possible sources of slow-release nitrogen fertilizers, many have been shown to be fairly potent inhibitors of nitrification.

This class of chemicals includes simazine and atrazine which are seldom used on golf courses except for non-selective weed control. On the other hand, this group also includes one of our common and widely used turf fungicides--dyrene. Dyrene, however, has been shown to be a weak nitrification inhibitor, and only at high rates do effects persist more than two weeks.

Most of this research has been conducted under field crop conditions where general pesticide use is less extensive than would be found on putting green turf. As only scant attention has been shown to golf turf conditions, studies were initiated at the University of Illinois to investigate the situation further.

FIELD STUDY: EFFECT OF FUNGICIDE TREATMENTS AND NITROGEN FORM ON THE QUALITY OF BENTGRASS TURF

The study used a split-plot design. The plots are 6 feet by 12 feet with three replications. Fourteen fungicide applications at the rate of 6 ounces per 1,000 square feet were applied weekly during the period June to September. Individual plots received the equivalent of 1 pound of nitrogen per 1,000 square feet per month from either calcium nitrite, urea, or a 50-50 mixture of the two. The whole test area received uniform applications of 2 pounds of P_2O_5 and K_2O per 1,000 square feet. Fungicides used in the study were Banamyl, Dyrene, and Tersan LSR.

Results were as follows:

1. There was no difference in turf color or density between the $CaNO_3$, urea, or 50-50 mixture of $CaNO_3$ and urea.
2. Maneb plots were heavily infested during the season with dollar spot.
3. During the final month of the study, benamyl plots had a chlorotic appearance and a correspondingly lower turf score. This is probably attributable to the higher-than-normal rates used for this study.
4. The results of tissue analysis for carbohydrate and total nitrogen will be reported at a later date.
5. Studies are also under way to determine if the fungicide treatments affected soil nitrification rates.

GREENHOUSE STUDY: EFFECT OF NITRATE VS. AMMONIUM NITROGEN ON THE GROWTH OF PENCROSS CREEPING BENTGRASS

The study used a randomized complete block design. There were six replications of the three nitrogen treatments. Nutrient solutions containing either 100 ppm NO_3-nitrogen, 100 ppm NH_4-nitrogen, or 50 ppm NO_3-nitrogen and 50 ppm NH_4-nitrogen were prepared in the manner described by Hoagland. The pH was checked daily and maintained at ±0.2 of a unit during the study. Nutrient solutions were changed every six days and the systems were backflushed with deionized water to insure no conversion of ammonium to nitrate in the ammonium treatments. The nitrate and ammonium ions in the nutrient solutions were monitored every second day to insure that nitrification wasn't taking place in the solutions containing ammonium ions.

Results were as follows:

1. Dry weights of plants receiving nitrate or a mixture of nitrate and ammonium were significantly greater than those receiving ammonium alone.
2. Results of tissue analysis for carbohydrates and total nitrogen will be reported at a later date.

1972 TURF FUNGICIDE RESULTS

T.H. Bowyer and M.C. Shurtleff

Three fungicide experiments were conducted in 1972 at the University of Illinois Ornamental Horticulture Research Center on South Lincoln Avenue in Urbana. The experimental areas contained three creeping bentgrasses maintained at a height of 1/4 inch. Fungicides were all applied in five gallons of water per 1,000 square feet using a wheel-mounted boom sprayer (Spray-Hawk) at 25 psi pressure. Disease severity was evaluated on July 11, August 16, 23, and 30 in terms of area of diseased turf per plot. The only disease appearing in the experimental areas was Sclerotinia dollar spot (*S. homeocarpa*).

Protective fungicide treatments (Tables 1 and 2) were laid out in a completely randomized design with each treatment replicated four times. In the systemic fungicide experiment (Table 3), individual plots were 10 by 25 feet without replication.

Table 1. Fungicide Control of Sclerotinia Dollar Spot on Washington (C-50) Creeping Bentgrass (Individual Plots 5 by 6 Feet With a Total Plot Area of 2,100 Square Feet)

Fungicide	Rate[a/] (oz./1,000 sq. ft.)	Application interval (days)[a/]	Disease rating[b/]	
			7/11	8/11
Dyrene.	4	7	.0a	.0a
Tersan SP	4	7	.9a	1.3e
Tersan LSR.	4	7	1.3ab	1.2e
Tersan 1991	6	14	.0a	.1ab
Topsin M.	6	14	.0a	.0a
Fungo 50.	1	7	.0a	.0a
Daconil 2787 WP	4	14	.0a	.5cd
Fore.	6	7	.1a	.4bcd
Tobaz	2	14	.0a	.0a
Koban	3	7	.4a	.6d
Dikar	4	14	2.1b	2.9g
Cleary 3336	3	7	.0a	.1ab
Fungo 50 + Dyrene	3	14	.0a	.0a
Fungo 50 + Daconil 2787 . .	6	14	.0a	.2abc
Fungo 50 + maneb.	4	14	.0a	.1ab
Mertect WP.	2	7	...	...
Control	..	..	.5a	1.8f

a/ Rate of application and application intervals were determined by label instruction or manufacturer's recommendation.

b/ The plots were rated on a scale of 0-5 (0 = no dollar spot; 5 = severe dollar spot). Treatments were compared by Bayes LSD. Treatment ratings followed by the same letter were not significantly different. Bayes LSD 0.05 = 1.6 (7/11); Bayes LSD 0.05 = 0.3 (8/16).

T.H. Bowyer is graduate extension assistant and M.C. Shurtleff is professor, Department of Plant Pathology, University of Illinois.

Table 2. Fungicide Control of Sclerotinia Dollar Spot on Penncross Creeping Bentgrass Using Different Forumlations, Rates, and Spray Intervals of Daconil 2787 (Individual Plots 6 by 10 Feet With a Total Plot Area of 1,900 Square Feet)

Fungicide	Rate[a] (1,000 sq. ft.)	Application interval (days)[a]	Disease rating[b] 7/11	8/11
Daconil 2787 WP.	4 oz.	10	.0a	.9a
Daconil 2787 WP.	4 oz.	14	2.8c	3.5d
Daconil 2787 6F.	1/4 pt.	7	.0a	.5a
Daconil 2787 6F.	1/4 pt.	10	.0a	2.2bc
Daconil 2787 6F.	1/4 pt.	14	.0a	1.9b
Daconil 2787 6F.	1/4 pt.	21	.6a	2.6c
Daconil 2787 6F.	1/8 pt.	10	1.6b	1.8b
Control.	...	..	3.8d	4.7e

a/ Rates of application and application intervals were determined by label instruction or manufacturer's recommendation.

b/ The plots were rated on a scale of 0-5 (0 = no dollar spot; 5 = severe dollar spot). Treatments were compared by Bayes LSD. Treatment ratings followed by the same letter were not significantly different. Bayes LSD 0.05 = 0.8 (7/11), Bayes LSD 0.05 = 0.4 (8/16).

Table 3. Systemic Fungicide Control of Sclerotinia Dollar Spot on Seaside Creeping Bentgrass (Individual, Non-Replicated Plots 10 by 25 Feet, With a Total Plot Area of 1,750 Square Feet); Only Two Applications Were Made for the Season, 6/7 and 6/21

Fungicide	Rate[a] (oz./1,000 sq. ft.)	Disease rating[b] 7/11	8/16	8/23	8/30
Cleary 3336.	4	.0	.1	1.0	1.5
Fungo 50	2	.5	.5	1.0	1.5
Tersan 1991.	8	.0	.1	.0	.0
Topsin M	8	.0	.1	.1	.1
R-24952 (Stauffer)	4	5.0	3.0	4.5	4.0
Mertect flowable	3	...	...	...	...
Control.	..	3.0	.1	3.0	3.5

a/ Rate of application was determined by label instruction or manufacturer's recommendation.

b/ The plots were rated on a scale of 0-5 (0 = no dollar spot; 5 = severe dollar spot).

Outstanding control of Sclerotinia dollar spot was provided by Daconil 2787, Cleary 3336, Dyrene, Fungo 50, Fungo 50 + Dyrene, Fungo 50 + maneb, Tersan 1991, Tobaz, and Topsin M (Tables 1 and 2). Fungicides giving poor or no control were Dikar, Koban, Tersan LSR, and Tersan SP (Table 1).

Dikar is *not* formulated as a turf fungicide and none of the four products is suggested for use to control Sclerotinia dollar spot. Since Tersan LSR and Fore both contain maneb as the active ingredient, it is assumed that Fore gave superior control because of the higher rate (6 ounces) used (Table 1). A protective spray interval of 10 days or more is considered too long for Daconil 2787 to maintain good control (Tables 1 and 2), regardless of the formulation used. In past years, on a seven-day spray schedule, Daconil 2787 has given essentially perfect control of Sclerotinia dollar spot.

Of the systemic fungicides applied, Cleary 3336 (50 percent dimethyl-thiophanate), Fungo 50 (50 percent dimethyl-thiophanate), Tersan 1991 (50 percent benomyl), and Topsin M (70 percent dimethyl-thiophanate) gave good to excellent control of Sclerotinia dollar spot eight weeks after the last application. Tersan 1991 and Topsin M were still controlling the disease 10 weeks after the last application when the plots were given a final rating (Table 3). In 1970, Tersan 1991 was still giving superior control of Sclerotinia dollar spot a full three months after the last application and at a much lower rate (1 ounce) than used in this experiment.

Both Mertect flowable and WP formulations at the rates applied, proved phytotoxic and were not rated (Tables 1 and 3).

VEGETATIVE ESTABLISHMENT OF KENTUCKY BLUEGRASS

E.G. Solon and A.J. Turgeon

In recent years, the turf industry has seen the introduction of some desirable Kentucky bluegrass cultivars which have a low degree of apomixis. As a result of this inability to produce true to type seed, more attention is being given to the use of vegetative methods for the establishment of such cultivars. In using vegetative methods, one has the possibiltiy of using either plugs (cut sections of sod) or rhizomes (shredded sod). The use of plugs provides mature turfgrass plants, allowing the application of herbicides that would be highly injurious to rhizomes or seedling turfgrasses.

Research work with vegetative establishment of Kentucky bluegrasses at the University of Illinois has involved three general studies to date.

I. The effect of plug size and plug spacing in combination with fertility treatments on the rate of establishment of A-20 Kentucky bluegrass:

On June 22, 1972, A-20 plugs of 1 square inch and 4 square inches were planted on 6- and 12-inch centers in 6- by 10-foot plots. Each plot was divided into three sections so that fertility treatments of 1/2, 1, and 2 pounds of N per 1,000 square feet per month could be applied. Rapid development of purslane and other annual weeds necessitated treating the plots with 2,4-D (1/2 pound per acre) and dicamba (1/8 pound per acre) approximately three weeks after planting. Weed control was excellent with no apparent injury to the plugs. The plots were mowed every fifth day during the active growing season starting the fifth week after planting. Mowing height was 2-1/2 inches. Irrigation was applied as needed to prevent wilting of the turf.

Results from this study have shown that spacing was more critical than plug size on the rate of establishment. The fertility treatment of 2 pounds of N produces slightly faster cover than the other treatments. It also showed less damage from a rust infestation with the one half pound of N treatment having the most damage.

II. The effect of herbicides and companion grasses as aids to establishment:

Four herbicides (Balon, 3 pounds per acre; Betasan, 10 pounds per acre; Dacthal, 12 pounds per acre; and calcium arsenate 523 pounds per acre) and three companion grasses (perennial ryegrass, red fescue, and Kenblue Kentucky bluegrass) were evaluated on their effects on the percent cover of A-20 plug. The plots were planted June 22, 1972, using 2-inch plugs spaced 12 inches apart with a fertility treatment of 1 pound of N per 1,000 square feet per month.

All of the herbicides provided good control of annual grasses. Betason gave poorer control of annual broad-leaved weeds (primarily purslane) than the others. Evaluation of percent cover five months after planting showed Balan and Betason plots had

---

E.G. Solon is graduate research assistant, and A.J. Turgeon is assistant professor, Department of Horticulture, University of Illinois.

approximately 15 percent less cover than the control, while Cacthol and calcium arsenate plots showed no effect when compared to the control.

Each of the companion grasses provided 100 percent cover, but less than 10 percent of the plots were A-20 at five months after planting.

III. The effect of rhizomes obtained from shredded sod as a method of establishment:

On July 6, 1972, rhizomes were applied at rates of 2, 5, and 8 bushels per 1,000 square feet to the soil surface and then top-dressed with soil at 0, 4, or 1/2 cubic yards per 1,000 square feet.

Four months after rhizomizing we had approximately 40 percent cover at the 8-bushel rate with less than 15 percent cover at the 2-bushel rate. Since the rhizomizing was initiated during July when stress conditions are greatest in this part of the country, it is quite possible better results could be obtained if the operation was performed in spring or fall when stress conditions would be decreased.

Future research work will involve more detailed evaluation of the effects of herbicides on vegetative establishment. Greenhouse studies will be undertaken to evaluate herbicidal effects on individual plants. This will be followed up with field studies in which areas to be plugged will be seeded with *Poa annua* and then treated with herbicides to evaluate their overall performance on *Poa annua* control and on percent cover of the plugs.

CHEMICAL GROWTH RETARDATION OF TURF

O.W. Dicks and A.J. Turgeon

Substances that reduce the growth and development of a plant are referred to as chemical growth retardants. Growth usually refers in quantitative terms to an irreversible increase in size or volume, while development refers qualitatively to an increase in plant complexity. In the turfgrass community, it is important to know how these chemicals will effect the physiology of the plant. In a tall fescue plant, there are three types of growth--shoot, root, and tillering; while in a Kentucky bluegrass plant, there are four--the same three as for tall fescue with the addition of rhizome growth. In most cases the main purpose for applying a growth retardant is to reduce the vertical shoot elongation. However, also of interest is the effect the chemical has on the remaining types of growth. Since the total recuperative capacity of a plant depends on all types of growth, it should be understood that reducing or stopping growth in one or more of these phases may severely decrease the capacity of the plant to survive environmental stresses.

From the standpoint of the entire community, there are other factors of interest to be looked at in evaluating a growth retardant. Reduced turf density, severe phytotoxic effects, or discoloration are probably undesirable. A non-uniform retarding effect of all species in the turf or a short period of effective retardation would certainly be important drawbacks. Further, an increase in the weed population as a direct effect of the chemical or indirectly as a result of reduced turf density would also be an important consideration.

Traditionally, growth retardants have given general growth reduction to the entire plant. Today, however, we are looking for those chemicals showing specificity of type of growth retardation. Ultimately, a chemical growth retardant should be long lasting, effective over a wide range of species, and effective in retarding a specific type of growth without reducing turf density or showing phytotoxic symptoms.

Now under study are several growth-retarding chemicals of common use as well as newly formulated experimental compounds. The study is designed to show the year-round effect of MH, chlorflurenol, and several experimental compounds on tall fescue and Kentucky bluegrass turfs. Four field studies have been completed, representing four different application periods. Prior to all chemical applications, each plot was moved at 1-3/4 inches. Kentucky bluegrass plots were irrigated as needed, while tall fescue plots were not. Measurements of height and phytotoxic ratings were taken weekly for all studies.

For the study initiated April 17, 1972, growth reduction was greatest in both species of grass three to four weeks after application. M-I at 4 pounds per acre showed the greatest growth reduction in comparison to the unmowed check, while MH and chlorflurenol were least effective on Kentucky bluegrass and tall fescue respectively. Phytotoxic discoloration was greatest for both species three weeks after application. Both chlorflurenol at 3 pounds per acre and M-I at 2 pounds per acre gave similar high phytotoxic ratings while MH yielded the lowest.

O.W. Dicks is graduate research assistant and A.J. Turgeon is assistant professor, Department of Horticulture, University of Illinois.

In the May 24, 1972 study, growth reduction was greatest in both species of grass 2 weeks after application. M-I at 4 pounds per acre showed the greatest growth reduction while MH and chlorflurenol were least effective on Kentucky bluegrass and tall fescue respectively. Phytotoxic discoloration was greatest three weeks after application for both species. Maintain at 3 pounds per acre and M-I at 4 pounds per acre gave similar high phytotoxic ratings, while MH yielded the lowest.

For the July 21, 1972 study, growth reduction was greatest three to four weeks and four to five weeks after application on Kentucky bluegrass and tall fescue respectively. Similar high growth reduction responses were shown on Kentucky bluegrass for M-I, M-II and M-III at 4, 4, and 1/8 pounds per acre respectively, while M-I at 4 pounds alone showed greatest reduction in fescue plots. Highest phytotoxic symptoms closely paralleled the time periods of growth reduction for both species of grass. M-II and M-III at 4 and 1/8 pounds respectively showed the greatest phytotoxic symptoms, while both rates of Sustar showed the least discoloration.

In the fourth study of September 15, 1972, the greatest growth reduction occurred in both species four weeks after treatment. M-I, M-II and M-III at 4, 4, and 1/4 pounds respectively gave similarly high growth reduction, while least reduction was shown by MH on Kentucky bluegrass and M-IV at 3 pounds per acre on tall fescue. Greatest phytotoxic symptoms were exhibited in both species after four weeks. In tall fescue M-III at 1/4 pound per acre gave the highest ratings, while M-IV at both 3 and 6 pounds gave no phytotoxic symptoms. On Kentucky bluegrass M-I, M-II, M-III at 4, 4, and 1/4 pounds respectively, and chlorflurenol at 3 pounds gave the highest ratings, while MH at 4 pounds and M-IV at 3 pounds gave the lowest ratings.

A fifth field study is currently underway using the same chemicals as were used in the September 15 study. This area will be retreated this coming spring such that the area will represent three types of treatment--late fall, early spring, and double-treated. This study will culminate a year's look at these chemicals applied during these different time periods.

SLOW-RELEASE FERTILIZERS FOR TURF

T.D.Hughes

There are a number of fertilizer materials that release plant nutrients at reduced rates in comparison to readily soluble materials. The purchase prices of these materials is much greater, but the turfgrass manager, in a sense, is fortunate in that costs are often not the decisive factor. The slow-release materials are a part of what is termed "specialty fertilizers." They are used primarily on ornamental crops, and are not used universally on all crops including food, feed, or fiber crops where purchase costs are prohibitive.

The following questions should be raised: (1) Is the turfgrass manager more fortunate because he can usually afford to purchase these more expensive materials? and (2) Is the turfgrass manager usually capable of proper employment of these materials? There is no uniform answer to these questions, and the disturbing aspect of the problem is that the turfgrass manager who can least afford mistakes is usually the one who is most likely to make them. Not necessarily because he purchases a bill of goods that cannot possibly yield good results, but more often because he improperly uses the materials that he purchases. As a matter of fact, excellent products improperly used will yield poor results.

By this time, it should be obvious that knowledge is an important ingredient in making decisions about slow-release fertilization as well as other management factors. Too often, it is the missing ingredient, but we must remember that we are very young in terms of our scientific approach to our problems, and this situation will gradually correct itself as we grow and mature.

With respect to slow-release fertilizers, our knowledge is incomplete. Too often we have been guilty of conducting field studies that are not coupled with laboratory studies. We learn only what happens in a particular season, in a particular soil or growth medium, and we end up praying that we can predict what will happen to various slow-release materials when applied to soil, then, and only then,can we make truly accurate predictions.

Slow-release fertilizers are those that are water-soluble, coated materials. This term is commonly used improperly. Slowly soluble fertilizers require some microbiological or soil chemical action for release. Most of the non-readily soluble materials that are used for turfgrass fertilization are slowly soluble. Urea-aldehyde condensation products are slowly soluble, synthetic organics; and natural organics also fall into the slowly-soluble category.

Rates of release of plant nutrients in plant available forms are influenced by several factors. One of the most important factors is temperature. Urea-formaldehyde and the natural organics are affected to a large extent by temperature because of the requirements for microbial activity in the degradation process. Thus, most of

T.D. Hughes is assistant professor, Department of Horticulture, University of Illinois.

these materials release nutrients rather slowly under cool temperatures. Less drastic affects exist for slow-release materials that have coatings of various types and on isobutylidene diurea. Moisture and aeration also have an effect on rates of release from these materials because of the influence on microbial activities in soil. Other factors such as soil pH and particle size are also important.

It is difficult to understand the influence of all the various factors that are involved. Complex mechanisms are involved, and have not been thoroughly investigated. It is this type of study that is currently being conducted and, hopefully, will yield worthwhile information.

RELATIONSHIP OF THATCH TO INSECTICIDES USED FOR TURF

Roscoe Randell

Annual applications of the following insecticides to bluegrass turf over a three-year period did not create a thatch build-up: diazinon, Gardona, trichlorfon (Dylox), fenthion (Baytex), and carbaryl (Sevin). Chlordane applied annually did create noticeable thatch after three years.

Dieldrin and chlordane applied three times a year over a five-year period resulted in a build-up of thatch on the soil surface in bluegrass turf. One inch of thatch was present in all replicates of chlordane and dieldrin. No build-up occurred in plots treated with carbaryl (Sevin) three times yearly for the past five years. Untreated plots exhibited no thatch accumulation.

The thatch build-up in the dieldrin and chlordane plots had an effect on the location of insecticides in the soil. Almost all of the insecticide residue had accumulated in the thatch layer (see table).

Insecticide Residue Levels in Insecticide-Thatch Plots, April, 1972

Site of residue sample	Chlordane, ppm	Dieldrin, ppm
Thatch layer	661.4-1,201.7	210.3 -348.3
0-1-inch depth	4.9- 5.7	1.6 - 2.9
4-5-inch depth	0.3- 1.2	0.15- 0.78

Roscoe Randell is assistant professor, Agricultural Entomology, Illinois Natural History Survey.

GOLF COURSE TURF SESSION

FLOODING EFFECTS AND SUBMERGENCE TOLERANCE OF TURFGRASSES

James B. Beard

1972 can be summarized as the year of too much water as far as turfgrass culture is concerned. Flooding has been a severe problem, particularly since it has been a common practice to locate parks, golf courses, and recreational areas in low-land, flood plains adjacent to rivers. The three primary types of damage associated with flooding are soil erosion, soil salt and debris deposition, and turfgrass injury from submersion.

SOIL EROSION

Soil erosion associated with flooding occurs in locations where there are high-velocity water flows. This damage can be minimized by the proper design and construction of dikes, diversion ditches, and waterways. Repair of damaged areas usually involves replacement of the eroded soil followed by either seeding or sodding, depending on the extensiveness of damage. The establishment steps should be the same as those commonly practiced.

SOIL, SALT, AND DEBRIS DEPOSITION

The deposition of soil, salt, and debris is usually associated with shallow, low-velocity or standing water that backs up in the flood plain. Metal, wood, and similar debris should be removed as soon as possible after the water recedes. It is important to take adequate time for the removal of this type of material in order to avoid interference with mowing operations.

A certain amount of soil deposition will always be associated with static water conditions during flooding. Deposits of two inches or more should be removed immediately to save the existing turf. However, if it is anticipated that the underlying turf has already been killed, it may be preferable to deep-plow the area, cultivate, and reestablish.

Thin depositions of soil are difficult to remove and usually cause no immediate damage to the turf. However, an even more significant long-term problem may result, particularly if the thin layer is composed of silt and clay which forms a layer of soil that impairs water movement. The potential effects of interference with water infiltration can be partially corrected through coring.

If a thin layer of silt or salt remains on the turfgrass leaves after the flood waters have subsided, it is important to immediately wash the deposit off in order to minimize direct injury to the leaf tissue by physiological drought.

J.B. Beard is professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan.

SUBMERSION DAMAGE

Direct damage to the turf may occur if the flood waters remain on an area sufficiently long. Causes of submersion injury are quite complex, involving the combination of: (a) soil oxygen depletion; (b) a build-up of certain toxic compounds such as ferrous and sulfide ions under the anaerobic soil conditions; (c) accumulation of toxic organic compounds such as methane and carbon dioxide; and (d) accumulation of toxic by-products, such as ethylene, in the plant tissue. The relative importance of these four conditions is not well delineated.

There are a number of factors affecting the degree of injury that occurs under submersion. Of particular importance is the specific turfgrass species involved. Creeping bentgrass is particularly tolerant to submersion, whereas annual bluegrass, perennial ryegrass, and red fescue are quite intolerant (see table below).

The Relative Submersion Tolerance of Eleven Turfgrasses

Submersion tolerance	Turfgrass species
Excellent	Bermudagrass Creeping bentgrass
Good	Timothy Rough bluegrass
Medium	Meadow fescue Kentucky bluegrass
Fair	Crested wheatgrass Annual bluegrass Perennial ryegrass
Poor	Red fescue Chewings fescue

The actual duration of submersion which causes injury will vary, depending on the number of environmental and plant physiological factors. The likelihood of turfgrass injury from submersion becomes greater with increased duration and depth of submersion, rises in water temperature, and higher light intensity. Water temperature, as affected by the light intensity and time of year, is particularly important in influencing the degree of turfgrass injury. Turfgrass plants that are in a succulent, delicate physiological condition are also more prone to submersion injury.

AERATION — PAST, PRESENT, AND FUTURE

Roger J. Thomas

Aeration is any cultivation of the soil which permits more oxygen in the growing area of turf. Soil porosity has become a very important factor in the development of fine turf. Large pores are important for air and water movement in the soil, while smaller pores are important for retention of water. The respiration of plant roots requires oxygen and produces carbon dioxide; therefore, it is important to have an exchange of air between the soil and the atmosphere. In this presentation, we will speak solely of aeration by mechanical methods.

In the beginning, many terms were presented that caused general confusion. Such expressions as dethatching, aerifying, aerating, spiking, and cultivating were used to basically describe mechanical methods of aerating.

We have drilled holes, sliced in deep cuts, cultivated, spiked, intermittently slotted, brushed, dethatched, dragged with deep pronged objects, and even cultivated at sub-surface levels. Initially, pitch forks or some other homemade devices were rammed into the dry soil areas to permit better moisture and air penetration.

Another theory appeared which said that the lower you mow, the more chance air has to get at the fine cracks in the soil. It was later proven that all grass would not hold up during stress periods mowed at low heights of cut. After the subject of mowing was refuted, the next step that came along was deep-pronged mechanical devices that merely dragged through the soil, drawing up some good and bad turf, generally leaving a mess in the area. Sweepers were developed, or the areas were raked to remove these materials. Play areas were disrupted, and recovery took a long time.

SPIKING

Spiking in some mechanical way was perhaps the first real effort at aeration. Even early tractors had spikes on the wheels to provide aeration, as well as traction, and many simple devices were made to attach to mowers that would break up compaction at the top surface of the soil. Later, special spikers came out for that singular purpose and penetrated the soil anywhere from 1/2-inch to 1-1/2 inches.

CORING

The first real efforts at changing the soil make-up came through the aeration method of plugging or pulling out cores. The size of these cores ranged from 1/4 inch to as large as 1 inch in diameter. The tines were hollow, and merely pulled out a three to four inch plug of soil. While this method disrupts the soil surface and interrupts play, it remains today as the most popular method of aerating. We moved then from the position of removing just a few cores from the soil to removing very

---

R.J. Thomas is marketing director, Jacobsen Manufacturing Company.

many plugs. Some of this was done for the purpose of changing the soil structure by adding sand or soil amendments. Other users found it was one way that they could get water below the soil surface, as compaction really became a problem in heavy traffic areas.

Many different types of tines were then developed, such as hollow closed tines, open tines, "L" shaped blades that merely lifted the turf; four, five, six, and eight inch slicing knives were also developed. Today, a popular method of aerating large areas is to place blades into the soil anywhere from four to six inches, which leaves intermittent slits for water and air to penetrate the soil.

DETHATCHING

Along came the subject of what to do about the accumulation of grasses at the soil surface. The build-up prevents water from getting down to the roots of the soil. The term mat or thatch has been a difficult one to define, but for our purpose here, we refer to it as a surface organic accumulation which limits water and fertilizer, as well as prevents good grass growth. Thatch accumulation builds a spongy rough putting surface on a green, and can contribute to the cause of disease in some grasses.

Dethatching machines were developed to cut the strands of stems and leaf sheaves which failed to decay over a period of years. The purpose of the machine was to slice the runners of vascular strands and accumulate them on the surface so that they could be removed.

Several machines were developed to do this, and from this concept was developed a machine that dethatches and seeds at the same time. Dethatching and seeding has become popular in many areas and the results have been favorable.

Aeration and dethatching by a slitting method disrupts play less because less soil is brought to the surface than in the coring method. It also has a cultivating effect in that the whirling blades cause a cracking action in the soil, permitting water to penetrate it. Cultivation or aeration by this method, however, while growing in favor, has still not achieved the popularity of the hollow-tined cultivator.

Machines for larger areas were developed to both dethatch and sweep, and many of these units have been sold throughout the world. Since the results of dethatching began to appear, some users of equipment felt it would be undesirable to pull plugs or cores of soil from the surface, as this method brought up some of their weed problems. Under the circumstances, these users prefer the blading method of aeration, and realize that thatch can be a real deterrent to fine turf.

Recently, more and more superintendents have reached the conclusion that the severity of the cultivation method to turf does not necessarily insure fine turf growing conditions. Vertical mowing, as it was formerly thought of, involved running the slicing blades through the thatch, into the soil. It was considered desirable to bring up some small amounts of soil. There seems to be a current trend toward considering vertical mowing, where the blades are set merely to "tick the tops." With the advent of the Triplex Greens Mowers, coupled with the concept that the players become upset because the playing conditions are not the same each time they go out, necessitated a device that would reduce thatch, nap, and graining without disrupting the playing surface.

Properly adjusted, vertical mowers that merely "tick the tops" leave the playing surface in good condition; and over a period of time, thatch will be removed in this manner. Deep slicing may not be required, and the playing surface, for all purposes, is equivalent to what it was before the procedure. The trend also might be affected by the fact that the Triplex Greens Mowers are 60 inches wide, and can do the job far quicker because the clippings are collected at the same time the vertical mowing is being done.

Recently, I had the chance to observe vertical mowing being done with 1/2-inch spaces between the blades instead of the normal 3/4-inch spaces. Again, let me stress the point that the vertical mowers are just "ticking the tops" and doing very little slicing of the runners. The fact that the time and effort required to do the job permits golf course operators to do what they now term "vertical mowing" and dethatching more often without severely upsetting the green has to be one of the prime reasons for this trend.

SUB-AIRING

Compaction, as was previously pointed out, presents a real problem to most turf maintenance people. On high-use areas such as football fields, golf courses, and playgrounds, there is a consistent problem of keeping compaction at a minimum. For this reason, the tined Aerators have been used. More recently, an apparent trend to the four- to six-inch blades for loosening the turf has been incorporated. Introduced within the last few years is another new method of relieving compaction which could be termed subsoil aeration. The unit has an oscillating blade which goes fore and aft, and performs at a depth of four to seven inches below the surface. The oscillation of the blades causes tremendous vibration, and shakes the soil from two to three feet around the slits. The process permits heavier and deeper penetration of water and air into the soil, and if calcined clays or other soil amendments are placed on the surface prior to the operation of the machine, penetration of these clays can be found from four to five inches below the level of the turf. If some top dressing and fertilizing is done following sub-airing, recovery is quite quick, but the job must be done at a time during the best growing portion of the season.

SUMMARY

If one can surmise what is taking place today and what will be produced for the future, it would appear that turf maintenance people would rather do the job with wider equipment more often with less physical damage and faster recovery of the turf in the aerating field. Also, operators would prefer to ride instead of walk behind any piece of equipment to do their aerating. Whatever method is used, we know mechanical aerating will continue to be necessary to promote the growth of better turf in our high-use areas.

In the case of schools, institutions, and parks, new aerating methods, while they affect appearance and recovery of the turf, are equally important with relation to the time and cost of doing the work required.

A whole host of new products will be produced in the years to come, basically to reduce efforts, time, and costs. The goal is minimum maintenance, with maximum results to the turf and the least amount of disruption of play or appearance.

THE TORO GREENSMASTER III

Ken Quandt

My goal is to aquaint you with the Toro Greenmaster III triplex greensmower and to explain why I feel that it is the best machine for me under the conditions that exist on my golf course. I do not intend to tell you that it is the best machine for you, because that is a decision that you will have to make after you have had a chance to operate all three machines on your own golf course. However, I am quite enthusiastic about the Toro greensmower so, if the remarks that I make sound like a sales pitch at times, please forgive me, for they are not intended to be.

At the Glencoe Golf Club, we currently have two Toro triplex greensmowers. One was purchased in the spring of 1971, and the other was purchased in the spring of 1972.

In 1971, the one machine that I had was used strictly on the greens. I was skeptical of the quick height of cut change feature on the Greensmaster III and consequently did not use it. I mowed my collars with small walk-behind greensmowers. The Greensmaster III did, however, cut all nineteen of my greens practically every day of the growing season, and did a beautiful job. Where in 1970 it had taken five men 3 hours each to mow all of my greens, in 1971 one man, using a Greensmaster III mowed all of my greens in 4-1/2 to 5 hours. This represents a total savings of ten man-hours per day, sixty man-hours per week, and two-hundred-forty man-hours per month. Needless to say, I fell in love with that first machine.

The only problem that I had was a thinning of the turf in the wheel tracks around the edge of the green where the tires ran day after day in the same location. This forced me to get brave and try out the quick height of cut change feature on the machine. In September of that year, I altered the size of all of my collars to exactly the width of two of the cutting units on the Greensmaster III. From that time forward, we mowed the collars and the outside edge of the greens on a three-day cycle. On the first day, two of the cutting units would be set up to collar height and one would be left at greens height; on the second day, one cutting unit would be set up to collar height and two would be left at greens height; and on the third day, we would not mow the collars at all. On the fourth day, we would start the cycle all over again. In this manner we managed to keep moving the wheel tracks around on the edge of the greens and, within a month or so, the thinning of the turf that we had experienced in the wheel tracks disappeared.

I was now even more in love with the Greensmaster III than I had ever been. In fact, I was so much in love with it that in the spring of 1972 I purchased a second machine, four extra cutting units, and three verticut reels. Three of the reels I set at 5/8-inch, which is the height of cut I use on my Bluegrass-*Poa annua* tees. The three cutting units that came with the new machine were set at greens height (13/64 inch) and the fourth extra cutting unit was neatly packed away in the corner to be used as a spare.

During the weekdays, we now use one machine to mow tees and the other to mow greens and collars. We have found that on weekdays when our play is lighter, we can get

---

Ken Quandt is superintendent, Glencoe Golf Club, Glencoe, Illinois.

by quite well with one mower, but when the thundering herd comes out on the weekends, we need two machines. Therefore, when we are finished mowing tees on Friday afternoon, the tee cutting units are removed and replaced with the green cutting units. For the weekend, we start one machine on No. 1 green and the other on No. 10 green and, in most instances, we can keep ahead of the golfers.

It takes about thirty minutes to change all three cutting units, and requires the removal of only two bolts from each cutting unit. This makes it easier on the mechanic, because he can quickly snap the greenscutting units off the machine that is being used on the weekdays and replace them with the units from the machine that is used on the weekends. He can then lap in the one set of mowers at his leisure while the other set is being used.

When I first started using the Greensmaster III on my tees, I was worried that it would not do a good job the mixture of Bluegrass and *Poa annua* turf, but those worries proved to be groundless. Providing the Bluegrass was not allowed to get too long, the Greensmaster III mowed it beautifully.

I was also worried that the wooden tees and other debris on the tees would cause damage to the reels. This worry also proved to be groundless. None of the tee cutting reels was ever damaged. This past season we ruined two reels, both of them while mowing greens.

The problem of thinning turf in the wheel tracks on the edge of the greens that we had experienced the previous year did not bother us again. We continued to use the three-day rotation in mowing our collars that I described earlier. Our greens were mowed six times a week for the entire season with the Greensmaster III's, and at the end of the season no thinning of the turf had occurred around the edges of the greens.

We also made use of the thatching reels this season, although the wet year that we experienced managed to keep us from using them very much. Even when we did use them, we were not actually trying to dethatch the greens. We average between 40,000 and 50,000 rounds of golf per year on our course, and with traffic like that, the thatch never seems to get a chance to form. The thing that we were going after is the grain that develops in the greens. We set the cutting blades at 1/2-inch spacings and adjusted the unit to cut 1/16-inch into the turf. We found that going over the greens every two to three weeks helped to keep the grain down to a minimum.

I have now explained how we use our two Greensmaster III triplex greensmowers. I would now like to point out some of the features that I think make it such an outstanding machine.

One of the features that I have liked the best is the simplified operator controls. The reels are controlled with two pedals--one pedal engages them and lowers them to the cutting position, and the other pedal disengages them and raises them to the transport position. The gear shift is conveniently located and well marked. The throttle is also very conveniently located.

The seat is large, comfortable, and adjustable for operators of varying leg lengths.

Another feature that I like is the maneuverability of the machine. It can turn in a radius that will leave only 15 inches of uncut grass. We do not turn on the greens, but we have found this maneuverability to be an asset when trying to make turns between closely spaced sand traps and greens.

The polyurethane combs are set down tight for most of the season (even in the hot weather), and really do a great job of combing the turf and keeping the grain from forming. Their effectiveness is due to the fact that they are located immediately in front of the reels. On machines that use brushes, the brushes are located in front of the machines. This means that the front roller goes over the turf before the reel does and rolls down the runners that the brush has pulled up.

Another important feature is the method of carrying the grass catcher baskets. On the Greensmaster III, the baskets are carried on a separate roller, leaving the cutting units to float freely. The weight of the heavy wet grass clippings is never put on the reels. The baskets are also attached quite firmly so that they will not shake loose during transport.

The roller that supports the grass catcher is also the point where the rods that pull the cutting units are attached. This makes for a very low pulling point and insures smooth, even tracking regardless of the direction of cut.

The quick change height of cut feature allows you to quickly and easily set the height of cut up 3/16-inch higher than the height at which the cutting unit is set. For instance, if the cutting unit is set at 1/4 inch and the quick change knobs were moved to the high position, the height of cut would be raised to 7/16 inch. If you have bentgrass tees and are willing to cut them 3/16 inch higher than your greens, you can use one machine and one set of reels to mow both tees and greens.

Obviously, then, the Toro Greensmaster III has a lot going for it, but if I had to pick out one feature that I liked the best, I would have to select the ease of operation. With this machine, you can train almost anyone to mow greens.

WALKING GREENSMOWERS

Robert Williams

While I don't intend to exactly defend the walking greensmowers, we should be aware that the triplex units do have some shortcomings.

Before we go "whole hog" with triplex mowing, keep in mind some of the recent failures of equipment and chemicals that looked great to start with, but never made the grade in the long run. How about artificial turf as a classic example? The floating greensmower unit introduced about 10 years ago is another example of a highly touted advance in greens mowing that didn't prove out.

May I also jog your memories to remind you that the triplex is not at all new. We had triplex and duplex mowers in use about 40 years ago. Perhaps they will prove out the second time around.

Wondering what the current trend is concerning the acceptance of the triplex mower by golf course superintendents, I made a survey of the three distributors in the Chicago area who serve approximately 300 golf courses. Their sales of triplex units to date total up to 265, with an expectation of an additional 85 units sold within the next six months. This totals 350 units by next spring. At the same time, only 54 walking units were sold.

The equipment dealers are concerned about what to do with the eventual trade-ins as well as how to estimate the life expectancy.

Assuming for the moment that we accept all the virtues of the triplex machines, what about their weaknesses?

Potential oil damage.
Wheel tracks, particularly the outer cut.
Tire abrasion, especially on turns.
Back-up insurance, in case of breakdowns.
Neglect for ball bruise repair and trap raking.
Enough turning space off of the green.
Original cost outlay. (about $10,000 for three machines)
Difficulty in getting the height of cut low enough.
Possible grain and thatch development with triplex use.

Generally speaking, my personal philosophy towards new developments in chemicals and equipment is to try to stay about two years behind the researchers and the manufacturers while they work out the "bugs" in their products. It can sometimes be both expensive and embarrassing to use our courses as proving grounds.

I have been using a triplex mower on tees and collars for the past three years with very good results. However, I have been "tongue-in-cheek" about using the triplex on our greens. This past season, we purchased our second triplex so that we could

---

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

get a sampling of its use on greens. We used the machine on our greens every Monday during the spring with seemingly good results. By midsummer, the once-a-week routine had to be discontinued due to scalping around the perimeter of the greens. Last fall, we again tried the triplex, but this time we used it exclusively, seven days a week, with very good results. Our walking units have outside casters which the triplex units do not have, accounting for the scalping when trying to interchange two different types of mowers.

My intentions are to continue to use a moderate, center-of-the-road approach toward greens mowing. We are attempting to work our way into the use of the triplex mowers while at the same time we are keeping 11 single walking units in tip-top shape and ready for use if we should decide to go back to them for any reason.

The reduction of labor costs with the triplex mowers will undoubtedly force their use for mowing in the future. At the same time, the manufacturers seem to be steadily improving the mechanical efficiency of their respective machines. I expect a total transition to take place over the next five years. Let us hope that they are giving us a better tool for management.

SANDTRAP DESIGN AND CONSTRUCTION

Conrad Stynchula

Many maintenance problems of sand traps could be eliminated in the design and construction of a golf course. The difficulty in eliminating these problems is in evaluating the design before the trap is built, and then evaluating the construction while the trap is being built. How can you judge the success of the design and construction before the trap is built? This paper is intended to answer that question and give some guidelines for building a sand trap right the first time.

The four factors used here to judge the success of sand trap design and construction are: suitability of purpose and materials; adaptation to the existing site; relative scale of the trap to the golf course; and integration of aesthetics and function, man and nature.

SUITABILITY OF PURPOSE AND MATERIALS

Purpose

Besides giving an aesthetic quality to a golf course, sand traps indicate the line of play and provide interesting hazards. Often, one trap will be designed for all three purposes, but for easy explanation, the purposes will be explained separately.[1]

Sand traps are placed in strategic areas to indicate or alter the line of play. These traps are planned for the protection of golfers, roads, homes, and anything else which might be damaged as a result of golfers taking a specific line of play to the green.[2] For example, sand traps placed between two parallel fairways influence play toward the outside edge of each fairway or away from the traps. A hooked or sliced shot toward the opposite parallel fairway should be stopped by the traps. The locations and number of traps depends on the length and lay out of the hole. These traps act as safety devices for golfers in each fairway. A high-banked sand trap behind a green would prevent over-shot balls from bouncing into undesirable areas such as the clubhouse.[3]

Like hazards, traps make golf interesting and competitive.[4] They make golf a game of skill, rather than just a game of strength. Traps present a risk, a penalty may result if the risk is taken unwisely.[5] Cutting off the best shot, like the shortest shot to the green, is an example of a sand trap as a risk or hazard.[6] Sand traps should be located so less-skilled golfers have a fairly secure route to the green, and so opportunities are provided for more proficient golfers to obtain lower scores by overcoming directional trap hazards.[7] Fairway traps should be placed far enough from the tee so that the average golfer's tee shot will not reach the sand trap; however, an expert player's shot will have to be carefully placed in order to avoid the trap. Green traps should be situated so they pose a greater or lesser problem in regard to the approach shot. Greens should be trapped closely, depending upon the length of the approach shot.[8] Without traps, players would show less improvement. Good traps make good golfers.[9]

C. Stynchula is Senior, Department of Horticulture, University of Illinois.

Materials

What type of sand should be used in traps? The choice of sand may seem trivial, but the maintenance requirements and the quality of a trap could be determined by the type of sand used. Sand for traps should be as clean as possible from humus, silt, and clay particles. This will reduce the chance of weed growth.[10] Also, the USGA recommends a coarse grade of sand for all traps.[11] A sand having uniform particles of 1 mm in diameter would be best but is economically unfeasible because of the special screening which is required.[12] Brick and plaster sand are good choices except when wind is a problem, in which case concrete sand is recommended. Sand with particles or pebbles exceeding 1 mm can hinder play and cause damage to the reels of greensmowers if the pebbles are left on the green after an explosion shot.[13] Individual grains should be examined. Round grains leave the sand too loose, burying the ball too deeply on a direct shot. Angular grains are recommended because they tend to compact a little more.[14]

Uniform coarse sands settle faster than silica sand, a by-product of the glass industry. Silica sand takes a year or more to settle, while uniform coarse sands takes several months to settle properly.[15]

Synthetic sand has been found effective for both play and maintenance. It has fewer weeds and restricts the growth of bermuda grass, but also costs two- to three-times as much as the recommended sand types.[16]

To allow for sand the final grade for a sand trap should be six inches below the proposed elevation. The base of the trap should be compacted until it is smooth and firm.[17] This will prevent out-croppings of clay or mud clods from mixing with the sand to provide a good medium for weed growth. Sand depth of four to six inches provides enough sand for a good explosion shot, and allows a direct shot into the trap to bury half of the ball.[18] Finally, a ribbon of sod should be placed around the trap. Without the sod surrounding the trap, trap edges wander and the original edge may be lost.[19]

ADAPTATION TO THE EXISTING SITE

How high should a trap bank be? Does a trap need subsurface drainage? Where should a trap be located? Any approach to answering these questions and others related to the site will rely heavily on two factors of the site--diruial climate and soil structure.

When diurial climate is related to trap design, emphasis should be placed on wind and water, from either precipitation or irrigation. Windy conditions require an increase in sand particle size. Concrete sand is recommended. Water drainage in and around the trap plus surface and subsurface drainage influence sand trap design. Traps adjacent to the greens must be built in conjunction with the green construction, properly drained by surface methods or tile.[20] Water can be diverted from flowing into the trap by proper grades, swales, and grass hollows.[21] Also, flat capes will reduce run-off into the traps.[22] Traps built up should not impede or restrict flow of water especially from the green.[23]

Drainage within the bunker is of prime importance from the standpoint of both play and maintenance. Poorly drained bunkers hold water for days after heavy rainfall or irrigation; and after the water disappears, the sand is heavy and difficult to play from. Poorly drained bunkers promote washing or movement of sand from higher to lower areas, and always appear dirty because of the seepage of soil particles up to the sand surface.[24] These problems are particularly evident in pit bunkers, which are unfilled holes in the ground. Modern traps are made by excavating into a natural mound, or by filling.[25] Having the entire trap above the grade is often advisable.[26] Because the trap is raised, it offers few drainage problems. In large traps where proper grade is impossible, terracing should be utilized.[27] With a porous soil, the banks of a sand trap may be higher; however, if an impervious soil is present, tile drainage will likely be needed.

To carry off water quickly:

1. No more than one-third of the trap should be tiled, and that which is, should be in the lowest section of the trap.
2. The tile should be laid eight inches below the base of the trap, with a 1-inch drop for every 5 feet of tile.
3. Add a layer of coarse stone.
4. Add a layer of gravel on top of the coarse stone.
5. Add a 1-inch to 2-inch layer of cinder on top of this gravel.
6. Finally, add 5 or 6 inches of sand.[28]

RELATIVE SCALE OF THE TRAP TO THE GOLF COURSE

Proper scale and mass relationship of the bunker to other golf course features is of critical importance in trap design.[29] When designing a trap, the emphasis should be on the trap but it should not be forgotten that the trap is only one part of the golf course. The fairway, tee, and green must blend with the traps. For example, a small trap placed next to a vast green or a massive trap stretching past a green would give a "sore thumb" appearance. These traps would distort the appearance of the hole, since traps act as visual outlines of the green.[30] Trap size should be related to the size of the green and length of the hole.[31] The greens should be trapped closely, depending upon the length and difficulty of the approach shot.[32] A par three hole should be more heavily trapped because the approach shot is stationary, but this does not mean that a par five hole should have fewer traps around the green.

Proper scale of sand traps in perspective to the golf course may be the most difficult to evaluate because one must visualize a trap in three dimensions from a contour map.

INTEGRATION OF AESTHETICS AND FUNCTION: MAN AND NATURE

Trap mounds should be planned to conform with the natural topography.[33] This eliminates the two extremes of sand traps. One extreme is the flat, nondrainable trap made from gashes or holes in the ground. These small, flat, nearly unseen dabs of sand are very common but unattractive.[34] Because they have poor drainage and are not visible to the golfer from a distance, they are unfair hazards and do not serve the function of a trap. Often a golf ball will roll through these traps. The opposite extreme is a trap which has steep and abrupt angles around and within the trap.[35] A modern trend toward milder convulsions of the traps and gentler rise from the bottom of the trap to the top edge have allowed for more efficient use of larger mowers, and thus, less hand mowing.[36] Steep-flashed banks are good for visibility, but lack the stability of sand on the banks and require more hand mowing. This does not mean that a trap should be lowered if drainage within the trap is good. Back slopes should be gently contoured so scalping does not occur.[37]. The base and shoulder of the trap after compaction should conform to the contours.[38]

The erratic edges of capes and bays which were thought to give a trap a more natural appearance are not applicable today.[39,40] These convulsions or serrations of trap edges should be mild enough so that a mower can follow them without leaving areas which must be mowed by hand.[41] Recently, this has become important for riding trap rakes, so less area would have to be raked by hand.

The location of traps around a green is important for maintenance. Bunkers too close to the green can cause: difficulty in mowing banks, or in mowing greens with a triplex; reel and bedknife damage from sand blast; and a spot accumulation of sand on a green from sand blast, with an eventual drought spot.[42]

The post World War II trend was also ineffective. Traps twenty feet from the green were ineffective as hazards.[43] The present recommendation is that traps be placed ten feet from the green.[44] The location of the trap can also affect traffic flow, especially in the vicinity of the green. When designing a trap, care must be taken to avoid blocking convenient traffic patterns with traps.[45]

Golf would suffer without sand traps, and golf courses would lose some of the beauty and contrast provided by neat, clean bunkers. However, if poorly designed and constructed traps require more maintenance than can be justified, they can easily become an eye-sore as well as an unfair hazard.[46] The solution is to build traps right the first time!

REFERENCES

1. "Bunkers," *USGA Green Section Bulletin*, vol. 6 (August, 1926), p. 11.
2. *Ibid.*, p. 11.
3. Frederic Cain Raymond, *The Landscape Architectual Approach to Flexible Golf Course Design*, (Urbana, 1962), pp. 6-7.
4. "Bunkers" (August, 1926), p. 11.
5. Lawrence Packard, "Golf Course Design Principle," *The Golf Course Superintendent*, vol. 38 (August, 1970), p. 16.
6. H.S. Colt and C.H. Alison, *Some Essays on Golf Course Architecture*, (London, 1920), p. 38.
7. Cain, p. 26.
8. Packard, p. 16.
9. Robert Hunter, *The Links*, (New York, 1926).
10. "Question and Answer," *USGA Green Section*, vol. 8-10, (March, 1928), p. 61.
11. "Turf Twister," *USGA Green Section Record*, September, 1967.
12. Lee Record, "Sand vs. Grass," *USGA Green Section Record*, (March, 1967), p. 21.
13. "Turf Twister," September, 1967.
14. Record, p. 21.
15. *Ibid.*
16. "Turf Twister," January, 1970.
17. William J. Spears, Letter to C. Stynchula, July 13, 1972.

18. "Bunkers," *Building Golf Holes for Good Turf Management*, ed., Marvin H. Ferguson, (New York, 1968), pp. 30-32.

19. "Bunkers," *USGA Green Section*, vol. 7, (November, 1927), p. 220.

20. *Ibid.*

21. Cain, pp. 6-7.

22. *Ibid.*

23. "Bunkers," *Greenskeeper Report*, vol. 21-23, (July, 1954).

24. Ferguson, ed., pp. 30-32.

25. Geoffery S. Cornish, "Course Design for Both Maintenance and Play," *Golf Course Reporter*, Nov.-Dec., 1965, p. 15.

26. Ferguson, ed., pp. 30-32.

27. "Special Problems of Sand Traps," *USGA Green Section*, vol. 8, August, 1928, pp. 174-176.

28. *Ibid.*

29. Ronald W. Fream, "Build It Right The First Time," *Turf Grass Times*, March-April, 1971, p. 10.

30. *Ibid.*

31. "Bunkers," *USGA Green Section Bulletin*, vol. 5, (April, 1925).

32. Packard, p. 16.

33. Ferguson, ed., pp. 30-32.

34. Fream, p. 10.

35. Ferguson, pp. 30-32.

36. Packard, p. 16.

37. *Ibid.*

38. Spear, letter.

39. Cornish, p. 15.

40. *USGA Green Section Record*, March, 1967, p. 23.

41. Packard, p. 16.

42. Ferguson, pp. 30-32.

43. Packard, p. 16.

44. Traps, *The Golf Course Reporter*, vol. 26, (August, 1958), p. 22.

45. Ferguson, pp. 30-32.

46. *Ibid.*

BIBLIOGRAPHY

1. "Bunkers." *Building Golf Holes for Good Turf Management*. Edited by Marvin H. Ferguson. USGA. 1968. P. 30.

2. "Bunkers." *Bulletin of the Green Section of USGA*. Vol. 1, November 10, 1921. P. 240.

3. "Bunkers." *Bulletin of the Green Section of USGA.* Vol. 1, December 16, 1921. P. 258.

4. "Bunkers." *USGA Green Section.* Vol. 7, November, 1927. P. 220.

5. Cain, Raymond Frederick. *The Landscape Architectual Approach to Flexible Golf Course Design.* University of Illinois, Urbana. 1962.

6. Casey, Edward J. "Bunker Renovation." *USGA Green Section Record.* March, 1967. P. 23.

7. Colt, H.S., and C.H. Alison. *Some Essays on Golf Course Architecture.* London: "Country Life." 1920.

8. Cornish, Geoffery S. Course Design for Both Maintenance and Play. *Golf Course Reporter.* November-December, 1965. P. 15.

9. Fream, Ronald W. "Build It Right The First Time." *Golf Course Reporter.* Vol. 26-27. June, 1958. P. 30.

10. Hunter, Robert. *The Links.* New York: Charles Scribner's Sons. 1926.

11. Packard, Lawrence. "Golf Course Design Principle." *The Golf Course Supt.* Vol. 38, August, 1970. P. 16.

12. "Question and Answers." *USGA Green Section Bulletin.* Vol. 8, March, 1928. P. 61.

13. Record, Lee. "Sand vs. Grass." *USGA Green Section Record.* March, 1967. P. 21.

14. "Reflections of Bunkers." *Bulletin of the Green Section of USGA.* Vol. 1, November 10, 1921. P. 196.

15. Ripley, C.R. "Traps and Water Drainage." *Greenskeeper Reporter.* Vol. 21-23, July, 1954. P. 11.

16. Spears, William James. Letter concerning sand trap construction. July 13, 1972.

17. "Special Problems of Sand Traps." *USGA Green Section Bulletin.* Vol. 8, August, 1928. P. 174.

18. "Traps." *The Golf Course Reporter.* Vol. 25, July, 1957. P. 24.

19. Tull, Alfred. "Golf Course Design." *Golf Course Reporter.* Vol. 24-25, July, 1957. P. 24.

20. Turf Twister. "Sand Depth." *USGA Green Section Record.* January, 1969.

21. Turf Twister. "Sanding Bunkers." *USGA Green Section Record.* September, 1967.

22. Turf Twister. "Synthetic Sand for Bunkers." *USGA Green Section Report.* January, 1970.

CHEMICAL CONTROL OF SOME AQUATIC PLANTS

Robert C. Hiltibran

Procedures for chemical control of aquatic plants can be divided into identification of the plant that needs to be controlled, selection of an effective herbicide, and determination of rate and method of application.

Aquatic plants may be divided into six groups based on the leaf attachment and their distribution in bodies of water: (1) emergent plants with roots in the pond bottom but with foliage extending above the water surface; (2) submersed plants with alternate leaf attachment; (3) submersed plants with either whorled or opposite leaf attachment; (4) floating-leaved plants with roots in pond bottom but with leaves floating on the water surface; (5) free-floating plants, which may have roots but float freely on the water surface; and (6) algae.

Many of the herbicides listed are relatively toxic to fish, but when used according to the recommended rate, these herbicides will not kill the fish. Use only those herbicides listed for each aquatic species. Do not increase the rate to obtain better control. *Read the label carefully.*

Most of the herbicides listed are for post-emergence application. Fenac and dichlobenil are for preemergent application. Dichlobenil is effective when applied either to the exposed pond bottom or through the water, but when it is applied through the water, the rate of application must be increased. Fenac must be applied to the exposed pond bottom, as it is not effective as a preemergent herbicide when applied through the water. Applications of preemergent herbicides are recommended in March.

The chemical control of aquatic plants in golf course bodies of water is compounded by the use of the water for watering greens and fairways. Thus, the aquatic herbicide used will have to be selected on the basis of the aquatic herbicide which will be most effective against the aquatic plant, and the herbicide which would be less hazardous to the grass being watered. The application of an aquatic herbicide for the control of an aquatic plant would usually be done while the aquatic plant is growing vigorously, and prior to seed production. This normally would occur in May and June, presumably during a period when watering demands would be less. However, for some aquatic plant problems, herbicide application might be required in July and August which might be during the periods of greater demand for water. To assist in the selection of suitable aquatic herbicides and planning water use, the restrictions on the water use on turf of some aquatic herbicides are summarized below. These are also given on the label, and the labels of any herbicide should be checked carefully before use.

> *Aquathol* (Disodium salt of endothall). The treated water can be used for watering turf immediately.

> *Aquathol-K* (dipotassium salt of endothall). The treated water can be used for sprinkling bent grass immediately.

R.C. Hiltibran is a biochemist, Aquatic Biology Section, Illinois Natural History Survey, Urbana, Illinois.

Diquat. Do not use treated water for irrigation within 10 days after application.

Hydrothol-47. Treated water may be used for watering turf.

Copper Sulfate and formulations containing triethanolamine. Treated water may be used to irrigate turf, fairways, and putting greens immediately.

Dichlobenil, fenac, 2,4-D, and silvex have severe restrictions on their use in water used for irrigation and, therefore, may have limited use in aquatic plant control in golf course lakes.

Following are the suggested rates of various aquatic herbicides for the control of the aquatic plants indicated.

Group and species	Chemical, active ingredient or free acid equivalent	Rate of application	Remarks
EMERGENT PLANTS			
Arrowhead	Use one of following:		
(Sagittaria spp.*)*	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	Silvex		
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (6 lb./gal)	1/4 cup/2 gal.	Wet foliage
	potassium salt (20% G)	1 lb./440 sq. ft.	Spread on water
	Diquat cation	1/4 cup/gal.	Wet foliage
Bulrush	Use one of following:		
(Scirpus acutus)	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Wet stems
	ester (4 lb./gal.)	1/2 cup/2 gal.	Wet stems
	Diquat cation	2 T./3 gal. and 1 tsp. non-ionic wetting agent	Wet foliage to the point of runoff
	Dichlobenil (aquatic granules 4%)	100 lb./A.	Apply in March to exposed bottom soil
Cattails	Use one of following:		
(Typha spp.*)*	Dalapon	4 oz./gal. and 3 caps detergent	Wet foliage
	Amino triazole	2 oz./gal. and 3 caps detergent	Wet foliage
	2,4-D ester (4 lb./gal.)	1/2 cup/gal. and 3 caps detergent	Wet foliage
	Diquat cation	2 T./3 gal. and 1 tsp. non-ionic wetting agent	Wet foliage

Group and species	Chemical, active ingredient or free acid equivalent	Rate of application	Remarks
Creeping water primrose *(Jussiaea repens* var. *glabrescens)*	Use one of following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	Silvex		
	ester (4lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (6 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (20% G)	2 lb./440 sq. ft.	Wet foliage
	Diquat cation	1/4 cup/2 gal.	Wet foliage
EMERGENT			
Spatterdock *Nuphar advena*	dichlobenil	6 lb ai/A 3 lb-4% Granules* per 440 sq. ft.	Spread on the water surface
Waterlilies *Nymphaea* spp.	dichlobenil	5 lb/ai/A	Spread on the water surface
Waterwillow *(Justicia americana)*	Use one of following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	Silvex		
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (6 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (20% G)	1 lb./440 sq. ft.	Wet foliage
SUBMERSED PLANTS WITH ALTERNATE LEAF ATTACHMENT			
Curlyleaf pond-weed *(Potamogeton crispus)*	Use one of following:		
	Endothall		Apply on or below surface
	sodium salt (2 lb./gal.)	1 ppm	
	potassium salt (4 lb./gal. or 10% G)	1 ppm	
	Diquat cation	0.5 ppm or 1 gal./surface A.	Same as above
	Dichlobenil (aquatic granules 4%)	200 lb./A.	Preemergent application
	Fenac	See manufacturer's directions	Must be applied to exposed pond bottom

**The formulation currently available may contain 10% dichlobenil.*

Group and species	Chemical, active ingredient or free acid equivalent	Rate of application	Remarks
SUBMERSED PLANTS WITH ALTERNATE LEAF ATTACHMENT (cont'd)			
Curlyleaf pondweed *(Potamogeton crispus)*	Hydrothol-47 (L) (di-N, N, -dimethylcoco-amine salt of endothall)	0.5 ppm (endothall content)	Apply on or below the water surface
	diquat copper-triethanolamine complex	0.25 ppm diquat equal volume of copper-triethanolamine complex	Apply on or below the water surface
	Hydrothol-47 (10% G)	100 lb./A	Spread on the water surface
Leafy pondweed *(P. foliosus)*	Same as for curly leaf pondweed or use one of following:		
	Dichlobenil (aquatic granules 4%)	400 lb./A	Preemergent application
	Fenac (Sodium salt of 2, 3, 6-trichloro-phenylacetic acid or 10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
Sago pondweed *(P. pectinatus)*	Same as for curlyleaf pondweed or use one of following:		
	Dichlobenil (aquatic granules 4%)	100 lb./A	Preemergent application
	Fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
Small pondweed *(P. pusillus)*	Same as curlyleaf pondweed		
Waterstargrass *(Heteranthera dubia)*	Diquat cation	1 ppm or 1 gal./surface A.	Apply on or below the water surface
	Endothall potassium salt (4 lb./gal. or 10% G).	5 ppm	Same as above
SUBMERSED PLANTS WITH WHORLED OR OPPOSITE LEAF ATTACHMENT			
Buttercup *(Ranunculus* spp.*)*	Diquat cation	0.5 ppm	Apply below water surface

Group and species	Chemical, active ingredient or free acid equivalent	Rate of application	Remarks
Cabomba *(Cabomba Caroliniana)*	Hydrothol-47 [di(N, N dimethylalkylamine) (salt of endothall); L or G]	2 ppm	Same as above
	2,4-D ester (20% G)	2-3 lb/440 ft^2 200-300 lb/ surface A	Apply on or below water surface
Coontail *(Ceratophyllum* spp.*)*	Use one of following:		
	Endothall potassium salt (4 lb./gal. or 10% G)	2 ppm	Spread on water
	2,4-D ester (20% G)	2 ppm	Spread on water
	Silvex ester (4 lb./gal.)	2 ppm	Apply below water surface
	Diquat cation	1 ppm or 2 gal./ surface A.	
Elodea *Elodea canadensis*	Diquat cation	1 ppm or 2 gal surface A	Apply below water surface
Slender naiad *(Najas flexilis)*	Diquat cation	1 ppm or 1.5 gal./surface A.	Same as above
	Dichlobenil (aquatic granules 4%)	400 lb./A.	Preemergent application
	Hydrothol-47 (L)	2 ppm (endothall content)	Apply on or below the water
Southern naiad *(N. guadalupensis)*	Diquat cation	1 ppm or 1.5 gal./surface A.	Apply below water surface
	Dichlobenil (aquatic granules 4%)	400 lb./A.	Preemergent application
	Hydrothol-47 (L)	2 ppm (endothall content)	Apply on or below the water surface
Watermilfoil *(Myriophyllum* spp.*)*	2,4-D ester (20% G)	2 ppm	Spread on water
	Silvex ester (4 lb./gal.)	2 ppm	Apply below water surface
	potassium salt (6 lb./gal.)	2 ppm	Apply below water surface
	potassium salt (20% G)	2 ppm	Spread on water

Group and species	Chemical, active ingredient or free acid equivalent	Rate of application	Remarks
SUBMERSED PLANTS WITH WHORLED OR OPPOSITE LEAF ATTACHMENT (cont'd)			
Watermilfoil (*Myriophyllum* spp.) (continued)	Endothall sodium salt (2 lb./gal.)	3 ppm	Apply below water surface
	potassium salt (4 lb./gal. or 10% G)		Spread on water
	Diquat cation	1 ppm	Apply below water surface
	Dichlobenil (4% aquatic granules)	240-375 lb./A. or 2.5-3.8 lb./440 sq. ft.	Preemergent application only
	Fenac (sodium salt of 2, 3, 6-trichloro-phenylacetic acid or 10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
FLOATING LEAVED AQUATIC PLANTS			
American pondweed (*Potamogeton nodosus*)	Use one of following: Endothall sodium salt (2 lb./gal.)	1/2 cup/gal.	Apply to leaves
	potassium salt (4 lb./gal.)	1/4 cup/gal.	Apply to leaves
	potassium salt (10% G)	1 ppm	Spread on water
	Dichlobenil (aquatic granules 4%)	200 lb./A. or 2 lb./440 sq. ft.	Preemergent application only
FREE-FLOATING AQUATIC PLANTS			
Duckweed (*Lemna minor*)	Use one of following: Endothall sodium salt (2 lb./gal.)	1 cup/gal.	Apply to leaves
	potassium salt (4 lb./gal.)	1/2 cup/gal.	Apply to leaves
	Diquat cation	1 cup/4 gal.	Apply to leaves
ALGAE THAT RESEMBLE TRUE PLANTS			
Chara (*Chara* spp.)	Use one of following: Copper sulfate	1 ppm	Postemergent
	copper-triethanol-amine complex	0.5-1 ppm	
	Dichlobenil (aquatic granules 4%)	100 lb./A.	Preemergent application only

Group and species	Chemical, active ingredient or free acid equivalent	Rate of application	Remarks
ALGAE THAT RESEMBLE TRUE PLANTS (cont'd)			
Chara (*Chara* spp.) (continued)	Hydrothol-47	0.2 ppm	Postemergent
	Hydrothol-47 (10% G)	100 lb./surface A	Spread on the water surface
Filamentous algae	Copper sulfate	1 ppm	Postemergent
	copper-triethanol-amine complex	0.5-1 ppm (copper content)	
	Hydrothol-47	0.2 ppm or 1 qt./surface acre	Postemergent
	Hydrothol-47 (10% G)	100 lb./surface A	Spread on the water surface

CONTINUING EDUCATION FOR GOLF COURSE SUPERINTENDENTS

Paul M. Alexander

Have you ever had one of those days when you were able to sit down and relax for a few minutes without interruption? If so, perhaps you may have silently asked yourself some very penetrating questions like: "Why did I select this profession as my life-long career?"; "Am I a good superintendent?"; "Why am I not as highly respected as my neighboring superintendents, even though my members freely admit that my turf is 100 percent better?"; and "What can I do to improve my situation?"

These are questions that every professional person asks himself sooner or later. Unfortunately, not all of these people will take the step that is so important--making a firm decision to do something positive about the situation. They simply shrug their shoulders and say, "Well, the other fellows just get the lucky breaks," or "My members will never appreciate me regardless of what I do." If this is your attitude, then there is little need for you to read further.

However, for those of you who are genuinely interested in becoming better golf course superintendents, the remainder of this article should prove useful.

The Golf Course Superintendents Association of America has steadily improved on, and added to, its basic precept of providing meaningful educational services to its members, as well as to the turf industry in general. Since the organization of this association on September 13, 1926, every effort has been made to live up to the objectives adopted at that time.

Dedication to better turf and better golf, specifically:

1. To promote research and the interchange of scientific and practical knowledge pertaining to the care of golf courses and turfgrass operations.
2. To emphasize more efficient and economical golf course operations and increase prestige for GCSAA and its individual members as well as the profession of golf course superintendency, which encompasses the production, maintenance, and improvement of turfgrass.
3. To encourage cooperation with other associations and organizations whose interests parallel or complement those of GCSAA, and to stress justice, benevolence, and education to and for its members.

CONFERENCE AND SHOW

The most widely known of GCSAA's programs is undoubtedly its annual International Turfgrass Conference and Show. The 44th such Conference and Show was held January 7-12, 1973, in Boston, Massachusetts.

It is fairly certain that this will be another record-breaker for GCSAA. More than 4,500 persons are expected to attend and the Show will have nearly 150 exhibitors in more than 400 booths. This, in itself, is an educational experience of a practical nature which no progressive superintendent can afford to miss.

P.M. Alexander is director of education, Golf Course Superintendents Association of America.

The educational sessions, spread over 4-1/2 days and utilizing the knowledge and experience of nearly 50 well-known speakers (including more than 30 golf course superintendents), represent a value that cannot be truly measured. How can anyone place a monetary value on knowledge acquired; knowledge which may mean that a superintendent can drastically improve the playing conditions at his course or make more efficient use of available men, equipment or material?

CERTIFICATION PROGRAM

This relatively new program, established on September 1, 1971, is beginning to gain momentum and popularity throughout both the association and other turf-oriented organizations. Perhaps a few figures will corroborate this. At the end of 15 months of operation, the program has:

1. received over 210 prepaid applications, which represents more than 10 percent of the eligible membership;
2. recognized 82 members as Certified Golf Course Superintendents;
3. earned the reputation of offering a comprehensive and difficult, but fair, written examination (approximately 50 percent of all certified members have failed one or more sections of the examination and of these, approximately 50 percent have been successfully re-examined);
4. sold 40 Certification Manuals to non-superintendent GCSAA members who wished to use the manual as a reference source;
5. received over 20 inquiries from both turf and non-turf associations with respect to design, scipe, and operation of the certification program (for consideration of certification within their organizations);
6. generated enough interest that more than 15 articles have been written by other groups about our efforts.

SEMINAR PROGRAM

The most recent GCSAA educational effort, a series of intensive, short-term seminars, became operational in April, 1972. This program, too, is rapidly gaining wide-spread acceptance among the membership because of its direct educational benefits. Before this fiscal year is over, six two-day seminars will have been offered to GCSAA members. The seminars are scheduled for Chicago, Columbus (Ohio), Hartford (Connecticut), Los Angeles, Tampa, and Washington, D.C.

This initial seminar, entitled "GCSAA Management Seminar-I", offers intensive training in basic accounting procedures. It includes simulation exercises in budget analysis, cost analysis, and fixed and variable ratios as related to a hypothetical golf club operation. Based on past, current, and future enrollment figures, nearly 200 members will have attended this first seminar, and the executive committee has instructed the director of education to develop at least two additional seminar topics for implementation in 1973. Priority is to be given to pesticides, the Occupational Safety and Health Act, and "people relations."

The seminar program fulfills the prime objectives of the association by providing for an interchange of practical knowledge, emphasizing more efficient and economical golf course operations, and providing educational benefits to and for members.

Successful completion of a seminar, which is contingent upon passing a nonmandatory written examination, also benefits each participant in that he receives an achievement certificate, transmission of a congratulatory letter from GCSAA's President to a club official (selected by the participant), and accreditation toward certification re-examination requirements if the participant is in the Certification program.

Of course, the greatest benefit of attending a seminar lies in the fact that the participant acquires more knowledge and experience in his profession--*he has done something positive about upgrading his professional status.*

SCHOLARSHIP AND RESEARCH FUND

This agency, founded in 1956 and dedicated to providing financial aid for turfgrass students and research projects and to the dissemination of turfgrass knowledge, has functioned admirably during its years of existence. As of this year, nearly a quarter of a million dollars has been awarded to 469 students and 72 research projects at more than 50 colleges and universities throughout the U.S. and Canada.

A record number of scholarship applications (163) and fourteen research grant applications were received this year. These requests amounted to more than $88,000.00 and created severe selection problems since the fund had only $36,760.07 available for distribution. After very careful consideration, fifty-three students were awarded scholarships totalling $23,450.00, and nine research grant applications were approved totalling $13,170.00.

The GCSAA firmly believes that the Scholarship and Research Fund program is of value to its members and the entire turfgrass industry. Over thirty percent of the scholarship recipients have become superintendents and it is obvious that all members benefit from turfgrass research endeavors. In addition, the very fact that GCSAA makes such awards ensures that our colleges and universities are made aware of the existence of the profession and this, in turn, encourages them to recognize turf management programs.

SLIDE AND FILM LIBRARY PROGRAM

A further indication of the associations's desire to provide up-to-date technical information to its members lies in this area. During the past 2-1/2 years, several hundred color slides and five color and sound films have been obtained. The films are available to any GCSAA member, chapter, or bonafide educational institution on a cost-free loan basis; and as soon as the slides are properly catalogued, they, too, will be available on the same basis.

The five films, with approximate running times, are:

1. "The ABC's of Putting Green Construction" (23 minutes)
2. "Courtesy on the Course" (18 minutes)
3. "Water Movement in Soil" (27 minutes)
4. "Drainage System for a Difficult Green" (15 minutes)
5. "Your Experimental Green" (20 minutes)

SUMMARY

The principal function of GCSAA is membership service, and high on our list of priorities is providing a wide array of educational material and opportunities. With more than 3,400 members in 90 chapters, our obligation is to assist each superintendent in keeping pace with new developments and methods which will make his work more effective, more efficient, and more economical.

SOD PRODUCTION AND LANDSCAPING SESSION

COMPARATIVE SOD STRENGTHS AND TRANSPLANT SOD ROOTING OF KENTUCKY BLUEGRASS CULTIVARS AND BLENDS

James B. Beard

The first three years of a six-year program of sod production investigations have now been completed at Michigan State University. The basic plan for this work was as follows. Individual cultural practices were to be investigated during the initial three years to determine which ones were best when compared on an individual basis. Studies have now been completed concerning (a) fertilization rates and timing; (b) mowing heights and frequencies; (c) establishment techniques in terms of timing, seeding rate, and wind stabilization; and (d) comparisons of the preferred cultivars, blends, and mixtures for rapid sod strength development.

During the next three years the primary objective will be to combine the best of these cultural practices into various cultural systems to determine which results in the most rapid rate of sod formation. The post-harvest cultural studies involving techniques and methods of transplanting are also continuing. Emphasis will be given during the upcoming year to methods of sod transplanting in shaded sites.

Not all of the work completed during the past year will be summarized in this paper since much of it was included in the Sod Production Field Day Program published and distributed in June of 1971. However, the data collection on sod strength and sod rooting was continued through the 1971 growing season and has now been completed. This work is summarized in this paper.

COMPARISONS OF SOD STRENGTH AMONG KENTUCKY BLUEGRASS CULTIVARS

The Michigan Sod Strength Test was first developed at Michigan State University in 1965. The technique has been refined and improved in subsequent years and has now been adapted for use in experimental work at a number of other universities including New Jersey, Rhode Island, Maryland, Minnesota, and Guelph.

Sod strength measurements among cultivars have been taken on three different plantings made in August of 1968, 1969, and 1970 at the MSU Muck Experimental Farm. The measurements were made at two to three intervals throughout the growing season for each of these plantings. Thus, a very representative evaluation of the comparative sod strengths has now been obtained. The 1971 data are presented in Table 1.

Sod strengths ranged form a high of 187 pounds to tear the sod to as low as 30 pounds (Table 1). At least 80 to 85 pounds is generally desirable for harvesting and transplant handling. The poor sod strength of certain cultivars for August 21, 1971, is caused primarily by greater susceptibiltiy to *Helminthosporium* leaf spot.

Based on these results and earlier data taken since 1968, the relative sod strengths of 22 Kentucky bluegrass cultivars are summarized in Table 2.

J.B. Beard is professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing. Reprinted from the 42nd Annual Michigan Turfgrass Conference Proceedings 1:123-127, 1972.

Table 1. Relative Sod Strengths (Pounds to Tear) of 28 Kentucky Bluegrass Cultivars

Cultivar	Date lifted 7-21-71[a]	9-14-71[a]	Average
Baron	187	131	159
Fylking	188	108	148
Sodco	174	111	142
Nugget	186	87	136
Sydsport	154	119	136
Arista	167	102	134
Pennstar	151	110	130
S-21	132	116	124
Adorno	137	109	123
Primo	138	98	118
Belturf	134	88	111
Palouse	99	114	106
Campus	88	123	105
Prato	106	102	104
Windsor	60	148	104
A-34	141	62	101
Merion	99	102	100
Delft	110	87	99
Geary	104	83	93
Park	81	97	88
Delta	100	77	88
Newport	67	95	81
Cougar	91	67	79
Captan	81	77	79
Monopoly	83	64	74
South Dakota Cert.	67	78	72
Kenblue	39	103	71
Atlas	30	80	55

a/Average of three reps.

Table 2. Relative Sod Strengths of 22 Kentucky Bluegrass Cultivars

Excellent	Good	Intermediate	Poor	Very Poor
Nugget	Belturf	Prato	Cougar	Park
Baron	Primo	Palouse	Delta	Kenblue
Pennstar	Merion	Campus	Monopoly	South Dakota Cert.
Sydsport	A-34	Geary		
Fylking	S-21	Windsor		
Sodco				

Kentucky bluegrass cultivars ranking superior in sod strength for harvesting and handling after four individual seasonal experiments include Nugget, Baron, Pennstar, Sydsport, Fylking, and Sodco. Thus, most of the Kentucky bluegrass cultivars that ranked superior in terms of general turfgrass quality and disease resistance also ranked quite well in terms of sod strength. As a group, they are ranked better than Merion Kentucky bluegrass which has been the standard over the years.

COMPARATIVE SOD STRENGTHS RESULTING FROM BLENDING OF KENTUCKY BLUEGRASS

As in the previous study, eleven selected blends of Kentucky bluegrass have been evaluated at three different plantings from 1968 through 1970 (Table 3).

Table 3. Relative Sod Strengths (Pounds) of 11 Kentucky Bluegrass Blends

Percent composition						Pounds to tear[a]
Fylking	Merion	Newport	Park	Prato	Windsor	
33				33	33	116
	50			50		106
		33		33	33	102
33	33		33			100
33		33	33			99
50	50					98
	50				50	98
33	33				33	97
	50	50				88
	33	33	33			87
	50		50			82

a/Average of three reps.

In studying the results over the entire test period, no one blend or group of blends has ranked consistently superior. In general, the blends do not rank as high or as low in sod strength in comparison to any one of its individual components. Apparently, the blending of two or more Kentucky bluegrass cultivars causes a moderation of the extremes in overall sod strength. No great differences have been evident among the blends, providing they contain one or two cultivars characterized by good leaf spot resistance and sod strength.

The basic concept of blending is more important since it ensures a wider genetic base. Thus, the components of the sod, when transplanted onto the consumer site, will have a wider adaptive ability to environmental, soil, and disease conditions.

COMPARISONS OF TRANSPLANT SOD ROOTING ABILTIY AMONG KENTUCKY BLUEGRASS CULTIVARS

The same experimental areas utilized in the Michigan Sod Strength Tests were also used to evaluate the transplant rooting of 20 Kentucky bluegrass cultivars. Three of these tests have been conducted, once from a 1969 seeding and three times from a 1968 seeding. The sod was produced on an organic soil and subsequently transplanted onto a mineral soil on the MSU turf plots and East Lansing. The actual data for four different lifting times are presented in Table 4.

The transplant sod rooting strength in these studies ranged from a high of 80 pounds to sods which did not root at all. The inability of certain cultivars to root prior to the July 2, 1971, lifting date was caused by severe thinning of the stand from

Helminthosporium leaf spot. Substantial differences were observed in the transplant sod rooting abiltiy among the cultivars. The cultivar response varied with the particular time of the year. These effects are summarized in Table 5.

Table 4. Relative Transplant Sod Rooting of 20 Kentucky Bluegrass Cultivars (Pounds to lift[a/])

Cultivar	Date sod was lifted: 11-6-70	7-2-71	9-9-71	11-2-71[b/]	Average
Belturf	65	98	61	80	77.5
Campus	67	71	71	85	73.5
Captan	61	77	68	55	65.2
Galaxy	54	69	65	61	62.2
Monopoly	49	70	56	71	61.5
A-34	45	80	61	55	60.2
Pp-1	55	64	65	54	59.5
Fylking	48	66	42	51	51.7
Nugget	24	81	60	40	51.5
Newport	51	53	38	63	51.2
Kenblue	65	20	51	68	51.0
Pennstar	38	65	47	51	50.4
Delta	67	23	41	59	47.5
Windsor	61	10	49	61	45.2
Arboretum	54	27	53	--	44.5
Prato	53	15	53	51	43.0
Merion	48	37	20	55	40.0
Park	60	--[c/]	22	63	36.2
Cougar	49	21	15	51	34.0
South Dakota Cert.	58	--[c/]	17	61	34.0

a/Average of three reps.
b/Taken from 1969 seeding, all others from the 1968 seeding.
c/Too weak to measure.

Note that some of the leaf spot susceptible cultivars such as Kenblue, Delta, and Park have superior transplant sod rooting in both the fall and spring periods, but rank quite low during midsummer when leaf spot thinning is severe. On the other hand, a number of improved Kentucky bluegrass cultivars in terms of disease resistance, such as Nugget, Pennstar, Fylking, and Merion, rank much lower than desired. Merion falls in the poor category on a seasonal basis.

These data suggest that it would be desirable to include one of the cultivars with superior transplant sod rooting ability, particularly in the spring and fall period, in a Kentucky bluegrass blend. The most obvious choices among this group are Kenblue, Delta, and Park in terms of seed availability on the American market. Thus, even though these cultivars are highly susceptible to leaf spot, they still have certain desirable characteristics that may justify retaining them as a component in a blend of Kentucky bluegrass cultivars.

Table 5. Relative Transplant Sod Rooting (Pounds to Lift[a/]) of 15 Kentucky Bluegrass Cultivars Expressed on a Seasonal Basis

Relative ranking	Autumn and spring[b/]	Summer	Overall
Excellent (over 65 lb.)	Campus Belturf Kenblue	Belturf Nugget A-34	Belturf Campus
Good (58 to 65 lb.)	Delta Park Windsor South Dakota Cert.	Campus Fylking Pennstar	A-34
Intermediate (51 to 57 lb.)	Newport Prato Merion	Newport	Fylking Nugget Newport Kenblue Pennstar
Poor (36 to 50 lb.)	Fylking Cougar A-34 Pennstar	Kenblue Delta Merion Windsor	Delta Windsor Prato Merion
Very Poor (35 lb. and less)	Nugget	Prato Cougar Park South Dakota Cert.	Park Cougar South Dakota Cert.

a/Average of three reps.
b/Non-leaf spot periods.

SOD-HANDLING TECHNIQUES

Tom Thornton

To gain perspective on sod-handling techniques, let's step back to see where we've been, where we are now, and in what direction we might be heading.

In the good 'ole days in the sod industry sod was cut simply by brawn with nothing more than a blade held in the ground on a sled-like arrangement. Many a sore hip and thigh was soothed with linament before the hard-working sod-buster of the 1930's and 1940's decided to put some horsepower in front of the sod-cutting sled. The power came in the form of a draft horse, or for the more modern farmer, a light tractor to pull the sled.

Necessity, being the mother of invention, forced the further automation of the sod-cutting operation. A revolutionary breakthrough was scored in 1946 when Mr. Ryan of Minneapolis developed a self-propelled machine with an oscillating blade to cut soil and roots at a uniform depth--perhaps a crude machine by our standards today, but a God-send for the sod grower in the early 1950's.

A major refinement in the form of an automatic cut-off was added to the machine in the middle 1950's, which incorporated another blade to cut the sod piece to a predetermined length. This development, with several refinements, is still used as the basic sod-cutting machine in the industry today. Its use perhaps signaled the rapid expansion of sod consumption, beginning in the late 1950's and through the 1960's. It became economically feasible to cut large quantities of sod with a certain degree of automation. The thrust of the 1960's then has been pointed toward automating the handling of sod after it is cut, through the steps of rolling or slabbing and palletizing, or loading in some other manner. Sod growers, being the inventive souls they are, have taken many approaches to this problem.

The early and mid-sixties saw many machines geared toward simply rolling the already cut sod. Many of them that were developed by individual growers never saw the commercial market-place, but rather were relegated to gather rust and dust in the back shed. Two that were marketed and achieved some acceptance were the Ryan Roller and the Damon Roller. Both were somewhat successful, but I think rendered obsolete by the advent of the Hadfield-Schuman sulky roller. The sulkey roller is a very ingenious, yet simple means of using the inertia and mechanics of the basic cutting machine to initiate and complete the roll of sod on the ground as the machine passes over. This single development has eliminated the back-breaking hand-rolling of at least four men.

With the acceptance and use of the sulky roller, we now have our sod cut and rolled in a reasonably efficient manner. How can we handle loading, transporting, and unloading in that same efficient manner? For years the standard approach was to drive a truck alongside the sod in the field and load by hand. This, of course, means that sod is unloaded in a like manner. Some growers have refined this approach by using conveyors for loading, which wins part of the battle, but the sod

---

Tom Thornton is manager, Thornton's Turf Nursery.

still must be unloaded by hand. Others began using pallets, which were a terrific benefit to the customer, but not always an advantage to the grower. In most cases the pallets were stacked by hand in the field, which really was no more efficient than to load with a conveyor.

Since the middle 1960's machines have been developed with varying degrees of success to combine the harvesting operation into one machine--some have cut and rolled sod, some slabbed sod, all have the common denominator of the finished product ending up on a pallet.

One of the earliest harvesting machines was the Princeton, which cut, shook off excess soil, elevated, and discharged slabs to be stacked on a pallet.

Next came the Big J which rolls and discharges to the rear where four stackers can stack two pallets simultaneously.

The Brouwer machine, originally developed in Canada and for a time manufactured and sold by Ryan, is now back in the hands of the Brouwer organization. It cuts, rolls, and discharges to two men at the rear for stacking on a pallet.

John Nunes from California has developed a machine similar in concept to the Brouwer, but offering an option of slabbing the sod instead of rolling it.

A different twist has been taken by Beck of Alabama in developing the Big Roll Machine. A tractor-powered cutter cuts three 16-inch widths of sod and rolls them on a spool. The spool is then loaded for delivery and unloaded in a like manner. At the site the sod is unrolled by a tractor, thereby minimizing the labor required for laying the sod.

Another different approach has been taken by Wetzel of Michigan. His machine cuts two rows of 24-inch x 4-foot pieces. They are elevated and discharged flat to the rear of the machine and are loaded on a pallet automatically. The two men on the rear are needed only to turn every fifth layer in the opposite direction so as to stabilize the pallet. This machine is extremely fast but does need refinement.

So much for harvesting--how does this affect the landscaper who could not care less how we harvest, but merely wants his sod delivered as ordered. He is affected in two ways. First, if we can harvest faster and more efficiently, we can deliver quicker and more predictably. Second, by our labor savings we can keep our product more reasonably priced. This is evidenced by the fact that sod prices, aside from minor year-to-year fluctuations, have remained practically constant for the last ten years, in spite of an average of 2-1/2 percent per year inflation.

As more and more sod is harvested on pallets, it follows that it will be delivered and unloaded with a fork lift, thus affording a great labor-saving for the landscaper.

We need further work on the concept of sod that weighs less, either by cutting thinner, or by removing some of the excess soil. If this could be accomplished, we could then consider a larger unit size than a square yard. Even increasing to a ten-square-foot roll would decrease the number of rolls you had to handle by 11 percent. A two-square-yard roll would cut the number of rolls in half.

In conclusion, I hope I have illustrated the path we've travelled and suggested some possibilities of approaches we should and perhaps will take in the future.

SOD-HARVESTING TECHNIQUES FROM 1960 TO NOW

Claude Wiewel

Our farm is located in the west-central part of Illinois in the Mississippi bottomlands, some 12 miles north of Quincy. Our soil is sandy silt-loam and sandy-clay. It is fairly heavy mineral soil, especially when wet. Our season usually starts about the second week in March and lasts up to about the second or third week in December. The climate is mild in fall and spring, but our summer months are generally hot, dry, and very humid. Some bluegrasses are hard to grow through the summer months in this region.

We started in sod production around 1960. For the first five years, we did all our harvesting by hand (rolling and loading) because we installed almost all the sod we grew. At first, we had some 10 acres of sod. We were retailing, so to speak, most of our sod and doing very little wholesaling. But as our wholesale volume increased, we definitely were getting interested in finding a quicker way to harvest than by hand. Of course, our wholesale orders weren't extremely large ones, but it was hard for us to install sod in the building areas while getting out our wholesale orders. When we were getting out wholesale orders, we found that we had to hire more men in order to stay up with our installations.

In 1966 we bought a Ryan all-purpose roller, which seemed to be a good method of rolling. Incidentally, our sod was cut six feet in length and 18 inches wide. But the Ryan roller created problems for us. Our soil was heavy and tacky, this caused the ends to curl too tightly. It took longer to straighten the ends out, than to lay the rest of the roll. Besides this, landscapers were hollering about the ends. Of course, it seemed to be a machine that we were repairing all of the time, too.

1967 and 1968 brought a different type of harvesting method, which I thought was quite an improvement over the all-purpose roller. This was the Ryan with the sulky rider-roller. This cut and rolled the sod in one operation. We were pleased with this method. Of course, the loading was still being done by hand. We made a homemade conveyor, which we pulled alongside the trucks. This just took the ache out of your back, if you were loading all day.

In late 1968 we had been awarded contracts for the first time for sod to be delivered on pallets. This was a new trend for us altogether--something that I really didn't care much about. It was going to be an added cost for a fork-lift and pallets. We found also that it was an added cost in labor.

For us to load some 4,000 yards and install another 600 yards, we had up to 12 men working. Then, most of the day, I was back and forth seeing to the work being done on both ends. With ulcers, I was unsettled quite a bit, believe me!

We had to find a better method for palletizing. Hand work and hiring a dozen people just didn't hit me right, it was too costly. So to try to eliminate some of this, we looked at various sod harvesters. Princeton's machine seemed too bulky for use.

Claude Wiewel is owner, Wiewel's Sod Farm, Quincy, Illinois.

Nunes Sod-Harvester at first did not interest me until I read an advertisement stating that the Nunes machine would harvest 800 to 1,000 yards per hour, rolled or slabbed. This I liked!

In 1969 we bought the Nunes Sod-Harvester. Of course, the bugs had to be worked out for our type of operation. After we got used to it, we went from 12 men to 5 men. In a day we could harvest up to 8,000 yards without working the men too hard. This was a vast improvement. Of course, we had to pre-cut all the sod with a sod cutter first.

We are definitely quite pleased with the Nunes Sod-Harvester, but still it has its ups and downs. We are still looking around for a better harvester. We have been looking at the Wessel Harvester. This machine does it all--it cuts and palletizes by itself, cutting down the labor cost by two men.

But at the present time, we have a cutting attachment on the front of our harvester. This has eliminated one man and the time of transporting a cutter from field to field. Also, it eliminates time trying to start a separate machine. In our type of soil this hasn't been the complete answer. It seems the cutting head doesn't stay in the ground, when the soil is too dry, as the Ryan cutter did. We had to modify this attachment also.

The cost of the Nunes Sod-Harvester, with cutting head, is around $19,000 at Patterson, California. This machine will harvest 800 to 1,000 yards per hour consistently. Of course, the strength of the sod makes the variation. Regardless of what sod harvester you purchase, be it Big J., Princeton, Nunes, Wessel, or any other, you will have to modify it to your type of production. Each harvester will work, but you will want it to work in your production and field arrangement.

GRASS CLIPPING UTILIZATION

Ben Warren

Substantial amounts of clippings are produced in the normal operation of a sod nursery. In most cases these clippings are treated as a necessary nuisance. Some investigation has been done into utilization of this material by individual growers, and Michigan State University has done rather extensive work with pelletizing sun-dried clippings and investigating possible uses of the material.

In 1970, with much help from Wiley Minor of Princeton Turf Nursery, we were able to interest Dr. George Kohler of the USDA Agriculture Research Division in undertaking a study of the nutrient value of dehydrated clippings.

Chemical analysis of both freeze-dried and dehydrated clippings were made to determine the percentage of moisture, protein, fat, fiber, ash, calcium, and phosphorus. Determinations were also made of the milligrams per pound of caroteen and xanthophyll.

This work indicated the most valuable components to be the protein and xanthophyll. Protein was found at a level of 25 percent and xanthophyll at 400 to 500 milligrams per pound. Because of the latter material, we were advised that the poultry feed market would probably be the most rewarding. Xanthophyll is included in a poultry ration to impart the yellow color to the skin and to the yolk of the eggs. Alfalfa meal is a common source of this pigmenter.

Because there is an established market for xanthophyll and the grass clippings analyzed considerably higher than the alfalfa, price estimates were made for grass clippings by computer. The range was from $100 to $200 per ton. This was followed by feeding tests conducted by the Halloran Laboratory, a prominent poultry testing lab in California. The results confirmed the value indicated by the chemical analysis, except that amount of utilizable xanthophyll was somewhat lower than expected.

In 1971 a machine was developed for gathering clippings, and material was processed by a commercial alfalfa dehydrator. The experiment was not so extensive as we had hoped, but enough was learned to build an improved harvesting machine and commence the installation of dehydrating and pelletizing equipment on our nursery.

The small amount of marketing experience obtained in 1971 indicates a price range of $80 to $110 per ton, which is somewhat lower than the computer estimate. The yield per acre will vary with maintenance practices, particularly water and fertility management. We have seen a range from four to eight tons of dried material per acre per eight-month year.

In this sort of use it is necessary to consider the type of chemicals used in production. It appears, from analytical work done so far, that at least with herbicides we can conform to the minimum residuals allowed. Our first installation will be in California. We plan to operate there for at least a year before we consider installations at our other locations.

Ben Warren is president, Warren's Turf Nursery, Palos Park, Illinois.

SODDING AND HOME LANDSCAPING

Clarence Davids

A real challenge is being presented to contractors today in the landscape field. Twenty years ago the selection of sod grasses available to those in the industry could very easily be counted on one hand. But today with progressive and really imaginative growers, we have quite a wide variety of sod grasses available. We also have an excellent selection of turf heights a customer may desire. The cutting tolerances vary from the low of 3/8-inch to well over 2 inches tall.

We have sod available for sunny locations, partially sunny locations and even areas with approximately up to 45 percent shade. This has been accomplished through our excellent uses of red fescues and blue grass varieties. With these shade tolerant sods available, the contractor can give his customers a wide variety of sods for many problem areas where the best recommendation formerly was a ground cover or possibly decorative stone because no turf could survive under those conditions.

I will not discuss the benefits of seeding as compared with sodding. This is up to each individual to decide and depends on how aggressive a salesman he happens to be. For instant results and real customer satisfaction, I am sure sodding will have to rank first. Sod has many uses besides just covering level ground areas. If grading is properly done, sod can be used for terracing, on mounds, and even on berms. If done properly the sod can be easily maintained and mowed.

I would like to make a strong recommendation here that upon completion of any sod installation you instruct the customer as to the proper method of watering until the sods are firmly rooted and also how to accomplish this without literally stomping all over the newly laid sod. Nothing is more aggravating later to a customer as he is mowing his new lawn, than to have the mower jumping in and out of deep footprints put there by himself because you failed to instruct him on the proper method of watering.

Good public relations are a must if you intend for your firm to grow and build up a good reputation within the industry. Along these same lines, stop back a week after the initial installation was made. Check over the job. Replace small areas of sod that have not taken root or have browned out (especially along the ends) because of inadequate watering.

If the customer fails to water according to your instructions, then certainly he should be responsible for the replacement. Also give him full instructions about fertilizing, the type to use, how often to use it, the proper cutting height, etc. These little things can mean an awful lot to him. Most sod growers furnish a pamphlet on these matters to their customers. These are ways of having a satisfied customer. We've made it a practice for years to always set the customer's mower at the proper height. This is as important as the sod itself. You can lay the

---

Clarence Davids is owner, Clarence Davids and Sons, Landscape Maintenance Contractors, Evergreen Park, Illinois.

most beautiful Merrion sod available, and if the customer cuts it down to 1/2-inch on the first cutting, it will result in an unsatisfied customer, believe me. It will take a considerable amount of time for this sod to come back to its initial beautiful condition.

Sodding certainly is of interest to many home-owners. It is economical and can be afforded by almost all, in contrast to years gone by when only a select few could afford it. In landscaping the home today, we have a challenge set before us as never before. Each home we landscape should excite us and give us a challenge. God has placed us here to be creative, to be imaginative with our talents, to help beautify His creation. What a challenge this really is, to design our plan to work the soil, terrace it if needed and grade it, to provide proper drainage, locate plants for effect to compliment the home, give height where needed with shade trees, decorative trees, even using plants that produce fruits and berries which attract the lovely birds, using plants for color, for their blossoms, using hedges to create living fences, for screening and providing solace for privacy, making each home a miniature arboretum, a small park, working with more imagination and creating oriental settings with decorative stone, railroad ties, tanbark, bridges, statuettes, pools, and waterfalls.

To be even more creative we can use outdoor lighting, with different fixtures to create nightscaping, using our plants as background to create shadows and illusions, and then using colored lights for still more dramatic effect. We have products such as the polyethelyne divider which has given us the freedom to make straight lines, curves, scallops, whatever our imagination desires.

We have found another very helpful tool in giving us the flexibility which we need. This is the Easy Marker. It isn't necessary to stand and verbally describe in detail what you have in mind. Just take the marker, lay your scallops on the ground, indicate the location of plants and boulders, literally drawing all your thoughts on the ground so your laborers fully understand where everything should go. This helps eliminate a lot of frustration and the end result is the job gets done. We certainly should be enthused within our trade about the innovations that were created for our industry.

Do you consider your profession as just a way of making a living? Then, I say, get out of it. To be a landscaper you must be creative, sensitive, an artist with so many talents that your mind seems to literally burst at the seams! This is your challenge and mine. When preparing the landscape of a private home, consider it your own home. Do the best job possible using your talents and the customer's suggestions. Then formulate a plan you feel the customer can live with, enjoy, and afford.

Also consider seriously the ease of maintenance. Don't make him literally a slave to his home; keep it basic, uncluttered. You should have firm ideas on how it should be done. Don't let the customer design it, you are the professional, he called you to accomplish his Garden of Eden. Don't consider yourself as just a laborer to execute all his ideas. You should know your plants and plant material, show him you are qualified as a contractor and that you are not just another salesman selling inferior work for a cheap price.

Being presentable, neatly dressed, and clean shaven will also show him you are a businessman. He should be able to distinguish you from your laborers. If you made an appointment with your client, by all means keep it. Be prompt because promptness shows interest and interest gets the job.

Today's homes are a real challenge to work on. The stereotyped Georgian home and the bungalow are gone, builders also have become imaginative. Homes are almost being built as individually as ourselves, almost no two alike.

In our planning, we should use a variety of plants. Select nurserymen who are progressive and who have new and interesting plants, improved strains of old plants, and patented plants. Select a variety of evergreens, not just one species. This will give you colors, contrasts, and textures. Use ground covers for effect. There are too many varieties to take time to mention, but they have their place in the landscaped home. Use annuals and perennials, create rose beds, use pots of all shapes, forms, and textures from fiberglass to clay to concrete. Pots set in strategic locations, such as on patios, in garden areas, even on front stoops, give one a feeling of warmth. Plant your pots with a variety of cascade petunias that droop over the end of the pot, creating a beautiful effect.

Today's challenges in landscaping must be met by young firms and old firms. We can be professionals by attending seminars, short courses, and conferences presented by our universities and junior colleges. Certainly, we should belong to associations within our industry; not just belong, but take an active part, exchange ideas, gain new ideas. Elect legislators who are sensitive to our industry, those who realize the important part we play in the total ecology of man and his being.

TREE SELECTION AND CARE

J.B. Gartner and Floyd Giles

TREE SELECTION

The proper selection and care of trees is probably the most neglected aspect of the golf course. Very often we try to get by with the existing trees and many times these are not the species best adapted to golf course use. We do not recommend the removal of these trees since it takes a long time to grow a tree. We do recommend planning to replace these trees with better adapted species over a period of time as the native trees begin to decline. In addition, the existing trees may be of the wrong species; they may be in the wrong location. A golf course would be barren and unattractive, as well as unchallenging, if we did not have trees on the course.

A tree should be used for more than its beauty; it can be very useful in the landscape and should be the right tree for the right place. You can save on maintenance and avoid future problems.

Framing the Green

It is always nice to have a green framed with trees to define which green belongs to which fairway. In this situation you want to select trees that are open in growing habit for good air drainage. You want a tree that is deep-rooted, small-leaved, and not brittle. These trees should be fairly large so lower branches can be trimmed up to avoid interfering with the golfers' approach shot. Trees adapted for this use are red maple, yellow birch, river birch, ash, honey locust, hackberry, little leaf linden, European alder, pines, and cedar. Avoid willows, poplar, sugar maple, Norway maple, beech, buckeye, oaks, catalpa, sycamore, etc.

Screening Between Tee and Green

Here you want small dense trees that will not grow too large. This is needed to protect the golfer making his approach shot or putting while the wild golfer is teeing off on the next tee.

There are numerous trees that can be used for this purpose. Here we want to add a little beauty and color. Use small trees such as the flowering crabs, hawthornes, (except the crusgalli), dogwoods (except Florida), flowering plums, red bud, sumac, carolina silver bell (Helesia), acer palmatum, acer ginnala, amelanchier, yellowwood, goldenrain tree, sourwood, and buckthorn.

Yard Markers

Most golfers like a distance marker either from the tee or green. In this instance, you have the opportunity to select something unusual in character so that it is easily identifiable by the golfer. The tree or shrub selected for this purpose

---

J.B. Gartner is professor and Floyd Giles is assistant professor of ornamental horticulture, Department of Horticulture, University of Illinois, Urbana.

should not be used elsewhere next to the fairway as it would confuse the golfer as to the distance. Some excellent choices here are blue spruce, Japanese red leaf maple, red leafed plum, bald cyprus, contorted hazel, unusual evergreens, etc.

Trees for the Rough

Trees in the rough separate fairways and are a hazard to prevent the golfer from cutting the corner of a dog leg. In this situation the only thing to avoid is large-leaved trees, because nothing aggravates the golfer more than to lose the ball in the fairway because the ball is under a large leaf. Select trees that are relatively maintenance free. Trees that are good for this situation are red maples, willow oak, shingle oak, hackberry, ash, honey locust, Kentucky coffee tree, European alder, yellow birch, river birch, little leaf linden, black gum, and gingko.

Trees to avoid are sycamore, sweet gum, tulip tree, silver maple, Norway maple, sugar maple, red oak, white oak, American linden, elms, white birch, beech, willow, and poplar.

Trees for Non-Play Areas

Here we are looking for trees that are easy to maintain and long-lived. We can use any of the oaks, sycamore, sugar maple, Norway maple, and any of the evergreen trees. Avoid elms, black locust, silver maple, and other problem trees.

TREE CARE AND MAINTENANCE

Many people feel after they plant a tree and water it a few times that no other care is needed. Unfortunately, this is not true. A tree needs considerable care for it to perform at its best. After transplanting a tree it needs supplemental watering for at least three years before it overcomes the shock of transplanting.

Transplanting

Small trees under two inches in trunk diameter can be transplanted with bare roots if the roots are protected and not allowed to dry out. Larger trees should be balled and burlaped. As a rule of thumb, for each inch in tree trunk caliber the ball should be 10 inches in diameter. A tree should never be planted any deeper than it was originally growing. Adequate drainage should be provided if the soil is compacted or there is poor drainage.

Most trees should be staked and wrapped until they are well established. The reason for wrapping with Kraft paper or burlap is to avoid sun scald and borer attacks.

Pruning should be practiced when transplanting to reduce the top and bring it into balance with the root system. The amount to be pruned depends on the care the plant will receive afterwards; if it will receive extra care, then from 5 to 10 percent is all that needs to be removed. If minimum care is given, then 25 percent of the top should be removed. This is done by thinning out the branches and not by heading back.

Regular Pruning

This is a task for a skilled individual. It would be difficult to treat this subject in detail in a short paper.

Remember that the best time for pruning is the winter months. By proper pruning, future problems can be avoided. It is always best to retain the natural size and shape of the tree, never top or head back a tree. All broken and diseased branches should be removed. Remove branches that interfere with other branches and the future growth of these branches. Branches that are forming weak v-shaped crotches should be removed. Weak growth should be removed to allow sunlight to reach grass and other vegetation.

Fertilization

Fertilization of a tree is essential for proper growth and development. A tree can be fertilized in late fall after the leaves have fallen and in the spring and early summer, never fertilize after July 15 as feeding at that time will prevent the tree from hardening properly and may cause winter injury. On trees less than eight inches in trunk diameter, 1/2 pound of actual N of a 10-6-4 or 10-10-10 fertilizer is used for each inch of diameter. For trees over eight inches use 1 pound per each inch in trunk diameter. The best method of fertilization is to drill holes with a two-inch soil auger 18 inches deep and three feet apart. On trees under eight inches start the holes two feet away from the tree. On trees over eight inches start the holes four feet away from the trunk. These holes should extend out to or a little beyond the drip line of the tree. The fertilizer should be distributed evenly in each hole. For those equipped with a root feeder and sprayer, a water soluble fertilizer can be used and applied through a root feeder. Trees should be fertilized every two to three years for best results.

Mowing Injury

More trees are injured by mowers than by any other type of injury. It is difficult to avoid this injury if grass is growing up to the trunk. One of the best means of overcoming this type of injury is to use a weed killer around the base of the tree and then mulch with a good organic mulch, paraquat, or a combination of paraquat and simazine prior to mulching. In addition to preventing injury to the tree, it saves on hand trimming. If you use this practice, avoid golfer criticism by making a local rule of a free lift if the ball lands in the mulch.

Insects and Diseases

It is always best to select trees that are relatively free of insects and diseases. Some of the common insects are mimosa webworm, locust plant bug, red spider, tent caterpillar, bagworm, mealybug, scale, and aphids. Malathion and diazinon are the best chemicals for these since the recommendations change from year to year. It is always best to check with your local extension advisor and ask for Extension Circular 900 which is brought up-to-date yearly giving the latest recommendations.

Some of the common disease problems are anthracnose of sycamore, oak, hard maples and ash; verticilliam on maples, Russian olive, plum, and peach; Dutch elm disease; leaf spot on hawthorn and crab apple; and mildew on lilac, maple, crab apple oak, etc. There are no good control measures except for mildew and leaf spot, and this would be the same as on turf. Try to avoid species or varieties that are highly susceptible to disease problems. Disease problems are more of a cultural problem. By proper fertilization, pruning, and watering many of these problems can be avoided.

Compaction Damage

Much of the damage to trees on the golf course is due to compaction from the use of heavy equipment during construction or remodeling of the golf course. Cart paths should be located away from trees and shrubs. They should be located beyond the drip line of the tree. This type of damage does not show up as soon as it occurs, but from three to five years after construction. Never allow heavy equipment under trees. The first symptoms of compaction are: leaf scorch, decline in vigor, verticillium, and die back. By the time these symptoms appear it is too late to correct the problem. See Extension Circular 1061 for information on avoiding construction damage. It is available through your local extension advisor.

GROUND COVERS AND THEIR USES

Floyd Giles

EMBANKMENTS AND STEEP SLOPES

Embankments present a special problem. Steep areas are usually dry and constructed of clay fill. If such areas are sunny, not too extensive, and well maintained, there are several good choices of ground covers. Winter creeper, lilyturf, tall fescue, and snow-in-summer all have a wide range of soil and moisture requirements and will hold up well with minimal maintenance. Creeping juniper may be used if the embarkment is not too steep.

Establishment--the time between planting and growth of cover to prevent erosion--is a problem, no matter what plant is used. A soil net can be useful in stopping erosion over this period. Plant closer than normal for flat areas and plant horizontally, not vertically.

Fertilizer is the best and least expensive aid to establishing ground cover on slopes. It should be applied prior to planting, based on a soil test or plant requirements. Applying a low-analysis fertilizer often throughout the growing season is also desirable since water carries off much of the surface-applied fertility. Mulch can also be useful and well worth the expense of application to hold moisture near the surface while the ground cover becomes established.

Shady embarkments present a different problem. If the area is shady and protected from the wind, periwinkle (heavily mulched), ajuga, hosta, and English ivy are good choices. Japanese spurge could also be considered if the area is in deep shade and has winter wind protection. All other procedures should be the same as described for sunny embarkments.

ENCLOSED AREAS

Enclosed areas, such as between entrance sidewalks and the house, islands in patios, or circle drives, allow use of ground covers that should be used nowhere else. Ground covers such as polygonum, creeping phlox, and goutweed should be trapped so they will not escape into lawn areas. Plants do well in such enclosed areas and can be kept homogeneous, which is good from a design standpoint.

The reverse is true of plants like Longwood's euonymus, St. Johnswort, thyme, wild ginger, bunchberry, and pachistima. These should be enclosed to protect them from encroachment of grass.

HIGH COMPETITION AREAS

Inhospitable areas unsuited to turf, such as under large old trees, may best be handled with one of the ground covers discussed below. If water can be supplied, or if the area is naturally moist, periwinkle, ajuga, English ivy, and hosta make good cover. In areas that will remain dry due to dense root growth and little

---

Floyd Giles is assistant professor and home landscape specialist, Department of Horticulture, University of Illinois.

water, winter creeper, purple leaf winter creeper, goutweed, wineleaf cinquefoil, English ivy, and creeping potentilla are good. Remember, goutweed will escape. These plants will survive and be presentable, but will improve in appearance with some watering and fertilizing. Pachistima does well if drainage is good and very little water is added.

In groves of smaller trees or flowering trees, barren strawberries, daylilies, wild ginger and bunchberry will do well, especially in good soil or soil that has been improved with fertilizer and mulch.

In areas where the soil has a low pH, such as in rhododendron or azalea beds, the wineleaf cinquefoil is a good choice. Periwinkle and English ivy are two ground covers that blend will with broadleaf evergreens and tolerate acid soils.

LARGE,ROUGH AREAS

Areas that will be seldom viewed, road and pond banks for example, can be covered with crownvetch, tall fescue, or lilyturf. All three will resist encroachment by other plants and easily maintain themselves. Occasionally, honeysuckle is used for such an area, but it invites seedlings, such as poison ivy and tree of haven (Ailanthus), especially in rural areas.

More visible rough areas are best covered with a combination of the shrubby and the creeping ground covers. To enable leveling of an area, use plant covers like creeping spirea, St. Johnswort, bigleaf winter creeper, and dwarf forsythia in the low areas. The combination of both types relieves monotony and covers ground more economically.

NATURAL AREAS

Planting these areas takes planning and good execution to develop properly. Rock gardens, wooded paths, Japanese gardens, and streams can be made attractive and useful if done properly, or they can quickly become weedy.

Ground covers used in these areas should not compete too strongly with flowering perennials, ferns, bulbs, and small shrubs. They should preferably be self-renewing each spring and not be too viny, since vines hold leaves and become trashy. Plants, such as ajuga, wild ginger, daylilies, bunchberry, hosta, and barren strawberry are excellent in the natural setting. If a vining-type of plant is desired, the periwinkle would be the best choice since it can be cleaned in the spring and is not too woody. Creeping juniper, creeping potentilla, and wineleaf cinquefoil are excellent choices for the Japanese garden because their growth habit and appearance are oriental.

WATER AREAS

Yellowroot and daylilies are good near streams and ponds and will effectively control weeds. Polygonum is also good in wet areas, but it must be enclosed on an island or between a sidewalk and the water's edge. If it escapes, it can become a problem, Tall fescue is a good cover for pond banks and larger rough areas.

GOOD COMBINATIONS OF GROUND COVERS, SHRUBS, AND OTHER MATERIALS

When combining plants, environmental requirements such as soil pH, moisture, and sunlight should be considered first. Then, consider plant color, flower color, texture, and growth habit.

Some of the best combinations are potentilla fruiticosa as a shrub and potentilla verna as a ground cover; azaleas and wineleaf cinquefoil; rhododendrons and periwinkle; white birch and English ivy; weeping willows and daylilies or yellowroot; Japanese limber pine or contorted pine and pathistima; abelia and purpleleaf winter creeper; magnolia and wild ginger; flowering dogwood and bunchberry; tall hedge buckthorn and winter creeper; large boulders and sedum collection; thyme and flagstone walks; Anthony waters spirea and creeping spirea; English ivy and wrought iron; ivy and oak trees; stonecrop and flagstone retaining walls; bulbs in almost all ground covers that remain under 12 inches tall; and forsythia and dwarf forsythia.

SPECIAL SOIL AND CLIMATE CONDITIONS

1. Shady, wet: yellowroot, daylilies, plantain lily.
2. Shady, dry: English ivy, winter creeper, pachistima.
3. Hot, sandy: dwarf forsythia, creeping potentilla, creeping spirea, creeping juniper.
4. Shady, sandy soil: hosta, English ivy, barren strawberries.
5. Sunny, acid soil: sedum, creeping spirea.
6. Shady, acid soil: polygonum in an enclosure, winter creeper, bunchberry, English ivy, wineleaf cinquefoil.
7. Shady, alkaline soil: daylilies, Japanese spurge, ajuga.

The ground covers listed below are some of the best when used as described. They will flourish when grown in their own hardiness zones and preferred environmental settings. After each of the ground covers described you will find the capital letter D which stands for deciduous, or E which stands for evergreen. The average height range in inches is alos noted. The zone numbers listed refer to areas of the state where these plants are hardy. A zone map is shown at the end of this series.

Aegopodium podagraria "Variegatum"--Goutweed--D, 12-18 inches High, Zones 1-4

This is a good plant in shade, wet or dry. It has a pH range of 4.5 to 7.5. It will escape and must be enclosed. Goutweed will grow in any soil type, but prefers sandy conditions and spreads rapidly. It is used for its brightly variegated white and yellow-green foliage; flowers are white and not very showy. Plant 14 to 18 inches apart. This plant can become a lawn weed and should not be allowed to escape.

Ajuga reptans--Bugleweed--D, 6-8 inches high, Zones 2,3,4

Bugleweed will grow in sun or shade (better in some shade) in soil with a pH range of 4.5 to 7.0, preferably moist. This plant needs winter wind protection. Flowers are deep blue in early spring on 4- to 6-inch spikes. Plants spread rapidly, so plant 14 to 16 inches apart. Ajuga is an excellent ground cover where it is hardy. Always buy nematode-free plants. There are three major foliage colors: solid green, purplish green, and a white and red variegated. The latter is not winter hardy north of zone 3.

Asarum canadense--Wild ginger--D, 7-10 inches high, Zones 1-4

Wild ginger needs deep shade and moist, rich soil with a pH of 4.5 to 5.5. It is excellent for use in wooded areas. Flowers are not showy. Plant it 10 to 15 inches apart. This is an excellent plant for entryways and protected areas to add a very interesting texture. Ginger blends well with earth-tone colored stone or low statuary.

Coronilla varia--Crownvetch--D, 18 inches high, Zones 1, 2, 3

Use this primarily for large areas away from residences. It tolerates a wide range of soil types and has a pH range of 5.0 to 7.5. Plant it on 12- to 14-inch centers. Flowers are pink in early summer. Crownvetch is good for large, rough areas away from residences. In many areas it draws rodents. It also dries very early and is unsightly. Best use is for road cuts that are not too steep. It is not as effective an erosion stopper as once thought.

Cerastium tomentosum--Snow-in-Summer--D, 12-14 inches high, Zones 1-4

This tolerates a hot dry soil and needs good drainage. It does well in soil with a pH of 5.0 to 7.5. It is a good quick cover for hot areas. It spreads rapidly, so plant 18 to 24 inches apart. Snow-in-summer is covered with small white flowers in late spring.

Convallaria majalis--Lily-of-the-Valley--D, 12-14 inches high, Zones 1-4

This grows in any soil type or pH and in full shade or sun. This plant spreads rapidly; plant 14 to 18 inches apart. Lily-of-the-Valley will become a weed in lawns or flower beds, and it is difficult to eradicate. Each root will produce a new plant. This plant has a 12-inch spike of small white flowers in late spring.

Cornus canadensis--Bunchberry--D, 6-8 inches high, Zones 2, 3

A very delicate plant that needs a moist, acid soil (pH 4.5) in 50 percent or greater shade. Use it for special areas. It spreads slowly and should be planted 6 inches apart. This plant has a beautiful white flower identical to the flowering dogwood (*Cornus Florida*). It is beautiful in entryways and wooded settings.

Cotoneaster dammeri--Bearberry Cotoneaster--D, 2-3 feet high, Zones 1-4

This cotoneaster prefers a well-drained, sandy soil that is slightly acid. This plant needs full sun and good growth. It spreads rapidly. Plant 2 feet apart. Flowers and orange fruit are not showy.

Cotoneaster horizontalis--Rock Spray Cotoneaster--D, 10-18 inches high, Zones 1-4

Rock spray prefers a well-drained soil that is slightly acid. This plant will tolerate 25 percent shade. It spreads rapidly. Plant 2 feet apart. Flowers are not showy, but fruit is outstanding.

Euonymus fortunei "Vegetus"--Bigleaf Winter Creeper--E, 18-24 inches high, Zones 1-4

The culture is the same as for winter creeper. This plant will cover larger areas faster and in some cases the coarser texture is desirable. All of the larger euonymus are outstanding ground covers for use in large areas. They are very hardy and dependable.

Euonymus fortunei radicans--Winter Creeper--E, 12-18 inches high, Zones 1-4

This is very versatile as to soil types, pH levels, and growing conditions. Plant 2 feet apart. It will survive sun, shade, or competition. Very hardy and good in Zone 1. Euonymus scale is a major problem. There are no flowers.

Euonymus fortunei radicans "Variegata"--Variegated Winter Creeper--E, 18-24 inches high, Zones 3, 4

The culture and use are the same as winter creeper, except this is not nearly as hardy as winter creeper.

Euonymus fortunei "Coloratus"--Purple Leaf Winter Creeper--E, 12-18 inches high, Zones 1,4

This is versatile as to soil type, pH, and growing conditions. Plant 2 feet apart. It will survive sun, shade, or competition; very hardy and is good in Zone 1. One major problem is euonymus scale. There are no flowers.

Euonymus fortunei "Longwood"--Longwood's Euonymus--E, 4-6 inches high, Zones 1-4

Longwood's will tolerate a soil pH of 5.5 to 7.0. Plant it 12 to 14 inches apart. It requires some protection from grass and other plants. It is a slow grower, but very good for enclosed areas that will be viewed closely. Longwood's tolerates soils of all types, and requires more moisture than winter creeper. Flowers are not showy.

Forsythia "Arnold Dwarf"--Arnold's Dwarf Forsythia--D, 24-36 inches high, Zones 1-4

This has a soil pH requirement of 5.5 to 7.0 and needs full sun. Plant 2 feet on centers. It will tolerate dry conditions after it is established. Arnold's does not flower. Good for covering large areas that are rough and will only be viewed from a distance or infrequently.

Forsythia viridissima "Bronxensis"--Dwarf Flowering Forsythia--D, 18-24 inches high, Zones 1-4

Culture and use are the same as for Arnold's dwarf. The advantage of "Bronxensis" is that it flowers (after 2 or 3 years) and is somewhat smaller.

Festuca arundinacea--Tall Fescue--D, 10-14 inches high, Zones 2, 3, 4

Tolerates a wide range of soil types and pH levels. Grows well in full sun or 50 percent shade. Has been used as turfgrass, but when used as the more conventional ground cover, it excels. Fescue discourages encroachment by other plants, is inexpensive, and easy to establish, especially in large, rough areas. Excellent for erosion control. Seed at a rate of 100 pounds per acre.

Festuca ovina glauca--Sheep's Fescue--E, 10 inches high, Zones 2, 4

Cultural requirements for this fescue are the same as for tall fescue. The use is much different. This plant is used as a design, pattern, or accent plant. The tight, ball-shape habit of growth makes it very interesting. Use it on mounds or in protected areas, such as courtyards.

Hedera helix "Rochester"--Fine Leaf English Ivy--E, 6 inches high, Zones 3, 4

Culture is the same as for the Thorndale ivy, except it is not quite as hardy. Rochester spreads slowly, so plant it on 12- to 14-inch centers. This compact-growing ivy is excellent near a structure or an area where the coarse stems of the Thorndale are objectionable. It is excellent for use where it will be viewed closely.

Hedera helix "Thorndale"--English Ivy--E, 8-10 inches high, Zones 1, 2, 3

Thorndale has the broadest range of uses of all the ground covers. It will tolerate a soil pH of 4.5 to 7.5, sandy to clay, sun or shade, cool and moist, and will survive in hot, dry conditions after it is established. Ivy establishes slowly so plant on 12- to 14-inch centers. It does not flower, and will climb walls of brick, wood, or stone. This is the most frequently used of all the ground covers.

Hemerocallis--Daylily--D, 24inches high, Zones 1, 2, 3

Daylily requires moisture and a soil with a pH range of 5.0 to 7.0. Plant every 18 inches. Daylily thrives in sun or shade and is grown for flowers, which are of numerous colors and shades. This plant is rather unattractive in winter.

Hosta decorata--Plantain Lily or Funkia--D, 6-24 inches high, Zones 1-4

This plant is excellent in shady or wooded areas. It prefers a moist soil with a pH of 5.0 to 6.5. Plant 14 to 18 inches apart. It will survive under dry conditions also if it is shaded and allowed to become established. Flowers are on spikes and are white or purple in July and August--beautiful in large wooded areas.

Hosta undulata--Variegated-Leaved Plantain Lily--D, 2-3 feet high, Zones 1-4

Culture and use are the same as *hosta decorata*. This plant is a little more susceptible to sunburn. It is good for narrow borders.

Heuchera sanguinea--Coral-bells--D, 10-14 inches high, Zones 1-4

This tolerates almost any soil type and a pH of 4.5 to 7.5. It will grow in 50 percent shade, but prefers sun. It spreads slowly, so plant 12 to 14 inches apart. Flowers are coral red, pink, or white on a 2-foot spike in June and July. Coral-bells will hold their leaves quite late in Zones 3 and 4 and until December in Zone 2.

Iberis sempervirens--Evergreen Candy-Tuft--E, 10-14 inches high, Zones 3, 4

This plant prefers an acid soil with a pH range of 4.5 to 6.0, well-drained. Plant it 12 to 14 inches apart. It needs some shade--afternoon is best. Candy-tuft does not compete well with other plants because of its slow growth. The flowers are very showy in early spring, so this plant is very useful for adding color to a large area of some other ground cover.

Juniperus horizontalis "Wiltoni"--Blue Rug--D, 2-6 inches high, Zones 1-4

Blue rug requires full sun, a pH of 5.0 to 7.0, and well-drained soil. Junipers will survive drouth periods in good condition. This variety is resistant to juniper blight. Plant it 4 feet apart on steep slopes of 20 percent and above and 4-1/2 feet apart on slopes below 20 percent. Do not plant blue rug in or near grass. The grass will smother it and cause dieback to occur. Waukegan "Douglasii" is a larger, similarly colored juniper that can be used near grass or in competition with other plants.

Juniper chinensis "Sargenti"--Sargents Juniper--E, 18-30 inches high, Zones 1-4

Culture requirements are the same as blue rug. This is the juniper that is used for ground cover in large open areas. It covers rapidly, but should not be used to control erosion. Junipers will not tie down the soil under their wide limb spread, so the area is left subject to undercutting. The entire planting can be washed away on steep areas.

Juniperus procumbens--Japanese Garden Juniper--E, 18-24 inches high, Zones 1-4

Cultural requirements are the same as for the blue rug. The best use of this plant is in rock gardens.

Liriope spicata--Lilyturf--D, 1-12 inches high, Zones 1-4

Lilyturf does well in a wide range of soil types and has a pH range of 5.0 to 7.5. Plant 12 inches apart. Full sun is best, but lilyturf will grow in 50 percent shade. It does well in moist soil, but will tolerate dry conditions for long periods. It will resist encroachment by other plants, yet will not escape or spread too rapidly. Flowers are lilac on spikes that just show through the foliage. Lilyturf is good used in combination with other ground covers. It makes an excellent contrast to sheep's fescue. Interesting patterns can be worked with these two plants.

Lonicera japonica "Halliana"--Hall's Honeysuckle--D, 18-24 inches high, Zones 1-4

This tolerates and does well in all soil types and has a pH range of 4.0 to 7.5. Plant it 2 feet apart. It climbs and should be used in open areas without trees or other objects to climb. Hall's will grow rapidly in sun or up to 75 percent shade. Flowers are yellow or white. It is good cover for a large steep area. This plant blends well in wooded areas or near water. Caution: this plant will climb and smother young trees.

Lysimachia nummularia--Moneywort--D, 1 inch high, Zones 1-4

Moneywort prefers sun, but will tolerate shade. Grows in any type of soil as long as moisture levels are high. Plant 18 inches apart. It will become a lawn weed if it escapes. It spreads rapidly. Flowers are deep yellow in spring and bloom for a long period. It is good in rock gardens or enclosed areas such as entryways. Moneywort is an excellent hanging plant.

Phlox subulata--Creeping Phlox--D, 4-6 inches high, Zones 1-4

This has a soil pH range of 5.0 to 7.0. It needs full sun and should be enclosed to prevent escape into the lawn. Phlox is a rampant grower and should be planted 12 to 14 inches apart. The plant is used primarily for its spring flowers, which come in many colors. In some areas it becomes a lawn weed. It does best where it can be controlled, such as in a planter box or between a sidewalk and buildings.

Potentilla verna--Creeping Potentilla--D, 4 inches high, Zones 1-4

This plant is one of the best low-matting types of ground cover and requires a soil pH from 4.5 to 6.5. It thrives in full sun. Plant it 12 inches apart. The flowers are deep yellow and good for mass flower effect in spring. This is a very neat, compact plant.

Potentilla tridentata--Wineleaf Cinquefoil--E, 4-6 inches high, Zones 1-4

Potentilla will grow in any soil type, but the pH should be slightly acid, 4.0 to 6.0. It will tolerate dry conditions after establishment. It spreads slowly and must be planted 6 to 8 inches apart. White flowers bloom in May. It grows best in sun, but will do well in 50 percent shade. Excellent in combination with azaleas and other plants that require a low pH.

Pachysandra terminalis--Japanese Spurge--E, 12-18 inches high, Zones 2, 3, 4

This needs complete winter shade and moist, rich soil with a pH of 6.5 to 7.0 for best results. Plant 12 inches apart. It will not do well in exposed, dry areas. Japanese spurge has inconspicuous flowers. This plant is best managed in smaller beds unless it is used in deep wooded areas.

Pachysandra terminalis "Variegata"--Variegated Japanese Spurge--E, 12-14 inches high, Zones 3, 4

Culture and use the same as the green Japanese Spurge. The only difference is winter hardiness. It is only good in Zones 3 and 4.

Pachistima canbyi--Pachistima--E, 10-18 inches high, Zones 1-4

This does not tolerate over-watering, especially in periods of slow growth such as fall and winter. The soil should be sandy and well-drained above and below the surface. A soil pH of 5.0 to 6.0 is best; but this plant will grow in higher pH, although this causes discoloration and slower growth. Pachistima spreads slowly so plant 12 to 14 inches apart. This plant will not control erosion. Flowers are not showy. It does well in areas of root competition with large old trees.

Polygonum affine--Fleece-flower--D, 4-6 inches high, Zones 1-4

Soil pH is not important (pH 4.0 to 7.5). Plant 2 feet apart. It grows best with plenty of moisture. This plant must be enclosed or it will escape and become a problem due to its rapid growth. It grows in a wide range of soil types, and tolerates sun or shade. Fleece-flower will compete with any plant for growing space, so it is best used alone in an enclosed area. Flowers are pink.

Spiraea Japonica "Alpina"--Creeping Spirea--D, 10-18 inches high, Zones 1-4

Creeping spirea is excellent on dry or sandy soils with a pH range of 5.5 to 7.5. It needs 50 percent sun for best flowering. Plant 18 to 24 inches apart. Flowers are pink in late spring. This plant combines well with the larger spirea, such as Anthony Waters, which is itself used as a ground cover in large, rough areas.

Sedum acre--Goldmoss Stonecrop--D, 6-8 inches high, Zones 1-4

This is good in a wide range of soil and pH types. It grows well in sun and 50 percent shade. Plant 10 to 12 inches apart. It works well in retaining walls and under large trees. Bright yellow flowers are produced in early summer.

Sedum acre serangulare--Large Leaf Stonecrop--D, 6-8 inches high, Zones 1-4

Culture and use are the same as for dragon's blood. This sedum has a beautiful yellow flower in late spring. It is the best yellow-flowered sedum of all.

Sedum pruinatum--Blue Spruce Sedum--D, 6-8 inches high, Zones 1-4

This plant will tolerate a wide range of soil, but prefers well-drained sandy conditions. Soil pH does not seem to be important (pH 4.0 to 7.5). It spreads well, so plant 12 feet apart. It has small yellow flowers on spikes in the fall.

Sedum spurium--Dragon's Blood--D, 6-8 inches high, Zones 1-4

Drabon's blood will tolerate dry, sunny conditions after it is established. The soil should have a pH range of 5.0 to 7.0 and be well-drained. This sedum has a deep red flower in summer. Plant every 12 inches. Sedums do not compete well for space with other plants. In hot dry areas, the sedums all perform well. Dragon's blood under these conditions forms a low, dense mat that is quite attractive. Under shade the plant stretches and becomes soft and open.

Stephanandra incisa--Stephanandra--D, 18-24 inches high, Zones 1-4

This requires a very acid soil pH of 4.0 to 5.0. Plant it 18 to 24 inches apart. In most areas iron should be supplied. It needs sun but will tolerate 50 percent shade. It spreads slowly and produces small, pinkish-white flowers in fall.

Thymus serpyllum--Mother of Thyme--D, 1-2 inches high, Zones 1-4

This will grow in almost any soil as long as there is good drainage. It prefers a pH of 6.5 to 7.5. Plant 6 inches apart. It is used primarily for fill in brick or flagstone walks and retaining walls. Flowers are purple on spikes from June through September.

Thymus vulgaris--Common Thyme--D, 6 inches high, Zones 1-4

This is a sun plant that will tolerate a wide range of pH (5.5 to 7.5) and soil types. It grows slowly, so plant it 12 inches apart. It prefers a dry, well-drained sandy soil. This plant is excellent in rock gardens or dry, hot areas. The flowers are pale lavendar on small 1-1/2-inch spikes.

Vinca minor--Periwinkle--E, 6-10 inches high, Zones 2, 3, 4

Periwinkle should be planted in a protected area, especially away from winter wind. It tolerates a wide range of soil types and a pH of 4.5 to 7.5. Plant it 12 to 14 inches apart. Soil fertility levels should be high in all cases. Where it is planted in open, unprotected areas, it develops disease problems. The flowers are blue in early spring and it blends well with broadleaf evergreens.

Viola papilionacea--Violet--D, 6-8 inches high, Zones 1-4

This is a shade plant, but it will tolerate full sun and will grow in any type soil. Plant it 10 inches apart. It likes moisture and spreads rapidly by seed and crown enlargement. Flowers in spring are outstanding and come in a wide range of colors--violet, deep purple, blue, and white. Yellow violets do not make good ground cover. This plant can become a serious lawn weed in shady areas.

Waldsteinia fragaricides--Barren Strawberry--D, 6-8 inches high, Zones 1-4

Barren strawberries prefer moist, average to rich soils in a pH range of 5.5 to 7.0. It grows at a medium rate. The plant has a small yellow flower in spring and makes a good cover for wooded or partially shaded locations. It is excellent for planting under shrub masses.

Xanthorhiza simplicissima--Yellowroot--D, 24 inches high, Zones 1-4

This plant is good for use in wet areas and near water. It tolerates a wide range of soil types and pH levels and will grow in sun or shade. Plant it 2 feet apart. Flowers are not showy. It is a very good water edge plant to control shore weeds and mud.

Hash marks extend zone farther south in open areas

RESIDENTIAL LANDSCAPES — DESIGNED OR STEREOTYPED?

William R. Nelson, Jr.

Dictionary definitions:

Stereotype--"to repeat without variation; to hackney."

Design--"the arrangement of details which make up a work of art."

When you drive through residential areas in any part of the country it is obvious which of the two definitions apply to the home settings. Nearly all of the developments are of the same type--repeated over and over without variation. A home deserves the best setting you can give it. An attractive setting is the result of careful study of the architecture and its surrounding space. If this space is developed properly, you will have both an attractive and useful landscape. It will be a landscape that will accommodate family living activities and at the same time satisfy the visual requirements of beauty.

Merely planting trees and shrubs is not landscaping. In other words, a landscape does not start with the shovel, the wheelbarrow, and some plants. Such an approach results in an unrelated collection of trees, shrubs, and flowers whose final effect leaves much to be desired both visually and functionally. This disorganized, "shotgun" approach demands as much money and effort as an orderly, well-designed landscape. To achieve maximum results from your planning efforts the following suggestions will aid you in developing an orderly approach to effectively solve the landscape problems of your customer.

Successful home landscape planning involves 5 steps

1. Inventory the family's interests, activities, and needs in order to know how to best use the land available.
2. Consider the natural features of the land and space around the home to decide which plants to use and which elements to remove, screen, or de-emphasize.
3. Draw a plan of the property to scale in order to control the arrangement of trees, shrubs, and structural elements.
4. Design plantings for public areas after locating drives and walks.
5. Develop outdoor living areas according to a family inventory and site analysis.

Conduct a family inventory to determine what will be included in your design

1. Identify members of family by age, special requirements, and interests (play equipment, lawn sports, horticultural interests).
2. What is the frequency and type of family entertaining (patio needs, guest parking space)?
3. Do family members have horticultural interests (vegetable garden, flower garden, maintenance)?

W.R. Nelson is professor and extension landscape architect, Department of Horticulture, University of Illinois.

4. What are the service area requirements (clothes lines, compost pile, garbage, recreational vehicle storage, garden equipment storage)?

Analyze the site to evaluate natural features and space around the home

1. Locate and evaluate existing trees.
2. Note bad views off the property.
3. Indicate areas where screening and privacy are required.
4. Check on drainage, soil type, and erosion areas.
5. Consider noises, prevailing winds, and sun pattern.
6. Locate all utilities, above and below ground (drain tile, septic tanks, power and telephone lines).

Draw an accurate scaled drawing of the property as it exists

1. Use cross-section paper (graph paper).
2. Use a scale of 1/8 inches equals 1 foot. A scale drawing will represent actual ground measurements at a reduced unit of measurement.
3. Locate house, walks, drives, trees, shrubs--all features and objects present on the ground.

Design plantings for the public area

1. Locate walks, drives, and parking areas if needed.
2. Determine the visual balance of the house architecture.
3. Note poorly designed architectural features and awkward areas.
4. Select trees for framing the house, for shade, for background, and for repetition or masking of dominant forms in architecture.
5. Consider fruiting habits, flower or foliage color, utilities, form, and scale.
6. Select corner plantings following the rule of thumb that the mature height should not exceed two-thirds the distance from the ground line to the eave. Always select a rounded form.
7. Determine doorway plantings.
8. Check building foundation height to determine extent of additional plantings.

Develop outdoor living areas according to family inventory and site analysis

1. Consider basic human needs of space definition and enclosure (privacy).
2. Develop the structure of the area by determining the location of use areas and define spaces with vertical elements.
3. Locate patios, screen plantings, trees, play areas, game spaces, flower borders, etc.
4. Indicate where plants are needed.
5. Sketch in locations of structures--fences, overhead devices, and shelters.
6. Evaluate the planting design on the basis of line and form, texture and color.

UTILITY TURF SESSION

PUCCINELLIA DISTANS — A SALT-TOLERANT GRASS

T.D.Hughes

A few years ago, an unusual grass was noticed along expressways in the vicinity of Chicago. Information about the discovery was presented two years ago at this conference.

The grass was originally incorrectly identified as *Puccinellia airoides*, but was later shown to be *Puccinellia distans*. During the last three years, considerable effort has been expended in evaluation of the salt tolerance of this grass and in comparing it to other grasses which are known to be salt-tolerant.

The three members of the genus *Puccinellia*--*Puccinellia distans, Puccinellia airoides, and Puccinellia lemoni*--are perennials which exhibit greater salt tolerance than other grasses which have previously been considered salt-tolerant. All other members of the genus *Puccinellia* are annuals and have not been regarded as being suitable for roadside areas. *Puccinellia sp.* has also been compared to such grasses as the *Agropyron sp.* (wheatgrasses) and some of the bents and tall fescue.

Of the three *Puccinellias, Puccinellia distans* has shown the greatest potential for a variety of reasons, but mainly because of its relatively low growth habit and rapid tiller production. It is a bunch grass, however, and does not produce any rhizomes. If a rhizomatous type could be found, it would be very significant.

Several characteristics of this grass are important. One particularly important characteristic is that it is not very competitive in nonsaline soils. Other grasses, such as Kentucky bluegrass, are much more aggressive. Mixtures of Kentucky bluegrass and *Puccinellia distans* cannot be maintained in nonsaline soils, but *Puccinellia distans* becomes the dominant species in saline or salt-contaminated soils.

It is a cool-season turfgrass that prefers moist to wet growing conditions and will not survive in acid soils. It prefers neutral to slightly alkaline (pH 7 or slightly higher) and is strictly sexual. If isolated, it will self-pollinate, but if not isolated, some cross pollination also occurs.

Plans for release of this seed are nearly complete.

T.D. Hughes is assistant professor, Department of Horticulture, University of Illinois.

CONCEPTS OF HIGHWAY TURF MAINTENANCE

Paul R. Craig

Like most states, Illinois has for many years moved her people and commerce on wheels. This created a great need for a network of hard, flat surfaces and rails for these wheel vehicles to move on. With the construction of these types of transportation facilities, land acquisitions began and are increasing today. The amount of land required today for a modern interstate highway is substantially greater than was required for the majority of Illinois' highways, which were constructed over forty years ago. Consequently, with the construction of modern highways, our roadside acreage today is increasing disproportionately to our increase in total miles of highway.

The volume of land presently owned by the Department of Transportation delimits the application of maintenance programs. Perhaps we should now suggest replacement of the word maintenance with management, as here lies the challenge for those of us charged with the responsibility for highway right-of-way. To understand the value and function of highway right-of-way is basic to our future ability to intelligently manage this ribbon of landscape. No other unit of land, public or private, offers more potential for multiple environmental impact. Also, few other areas offer the management challenge to produce positive contributions to environmental quality. Highway right-of-way in Illinois now exceeds one-quarter of a million acres. In the future, this vast ribbon of landscape will become a viable contributor or detractor to environmental quality in our state.

The highway right-of-way in Illinois is primarily a grassland. It is estimated that approximately 70 percent of the total right-of-way acreage is covered with grass. Any maintenance approach to this volume of land requires substantial allocations of money and manpower. Both of these commodities have become more limited, while the demand for newer facilities and more services has increased. It is because of these pressure/demand ratios that a more contemporary management approach is being considered for highway right-of-way in Illinois.

Traditional turf management programs have always included mowing and watering. With the advance in plant technology, additional aspects were added including the use of fertilizers, insecticides, fungicides, and herbicides. However, of the many aspects of turf management, only mowing was adopted for roadside turf; and this mowing soon came to be regarded as essential. It has been generally understood among most highway divisions in the United States that grass at any location is acceptable only if it is mowed. If it is allowed to remain unmowed, it then becomes a weed.

Highway maintenance engineers have always been concerned about the existence of weeds along our highways. This was probably the initial problem in highway turf management and the present mowing concept was conceived as a solution. However, after nearly 25 years of mowing to control weeds, the phenoxy herbicides were developed and soon found widespread acceptance in most state roadside programs.

P.R. Craig is horticulturalist, Illinois Department of Transportation.

The use of herbicides in conjunction with roadside mowing continues today, as does the weed problem they are intended to eliminate. Roadside mowers disturb the land, cut off the food-producing portion of our grass cover, allow increased light penetration, and provide invasion courts for unwanted weeds. These unwanted plants are symptoms of the problem, and most of our herbicide programs have been directed at these symptoms. Each effort in the past has constituted a program in itself, rather than a compatible segment within a comprehensive plan to manage the highway right-of-way.

The control of unwanted weedy and woody vegetation on highway right-of-way is a primary responsibility of highway turf management. We cannot ignore the presence of noxious weeds which present a threat to adjacent land use. Certain other plants are also considered to be undesirable and require control efforts. It is relatively simple to read the Illinois Noxious Weed Law and systematically attack those weeds listed whenever and wherever they occur. In these instances, few judgment issues exist. A noxious weed is present and the law requires that it be controlled. However, an evaluation of invaders other than those listed in the Noxious Weed Law requires special knowledge. These evaluations are best made by personnel with some botanical training and an understanding of plant distribution and succession. Perhaps with these understandings incorporated into the planning of roadside management programs, we will begin to recognize that some plants invading our right-of-way are adventive, while many others are native. Some of each may be troublesome, while most do no harm and could be ignored. Although some are permanent and persist in both mowed and unmowed situations, most plants have rather exacting demands.

Should we continue to mow the highway right-of-way, excluding other aspects of turf management, weeds will continue to be a serious problem. Annual disturbance of turf areas by large mowers assures primary succession of unwanted weeds. Available resources will not permit the incorporation of all of the necessary elements of a sound turf management program. Therefore, we urgently need to re-evaluate our purpose, establish realistic objectives, and act decisively to create a land management program for highway right-of-way.

It is estimated that our current per acre costs for mowing are between thirty and forty dollars annually. This cost is less than 10 percent of the per acre cost for turf maintenance on home lawns, parks, and golf courses. It is apparent that our past efforts were incapable of producing or maintaining turf comparable to any of these three areas. In an effort to prevent any misunderstanding, it should be noted that we are not advocating maintenance practices used on golf courses and other areas of fine turf. To the contrary, we feel we do not need this level of maintenance, do not want it, and certainly cannot afford it. It is our intent to develop a turf management program that is highway-oriented and compatible with both the environment through which the highway passes and with our long-term goals.

We must begin to recognize the highway right-of-way as a large complex ribbon of natural landscape, divided and accented by concrete and steel. In Illinois, our highway right-of-way displays many personalities. It is a dynamic landscape which owes its stability to the management practices employed in its behalf. Occasionally, right-of-way stability is disrupted, often by the management practices intended to stabilize it. It is our primary objective to establish and maintain a vegetative cover that will stabilize the landscape and protect our pavement, structures, and drainage systems. In most regions of Illinois, grass is the most adaptable plant for this purpose. The ecological amplitude of grass exceeds all other plant families which may have been considered as roadside cover; therefore, the highway right-of-way has essentially become a grass farm.

The challenge in roadside management is in the development of conceptual programs to fit a wide variety of environmental conditions. The problems to be solved are legion. Within a single mile of highway in Illinois, we encounter a wide range of adjacent land use including agricultural, commercial, and residential. Within each area, the specific land use varies somewhat. Our agricultural neighbors vary considerably from truck farms, to grain farms, to pasture-livestock operations. Each change in adjacent land use frequently requires some adjustment of management practice.

The management of highway right-of-way in Illinois has frequently been compared to a grass farm or rangeland. To gain a better perspective of the potential problems encountered in highway right-of-way management, consider the problems involved in managing a 150,000 acre farm that is 16,000 miles long and 100 feet wide. We need not concern ourselves with challenge, for here it exists in abundance. We must now begin to prepare ourselves to meet these challenges.

Future highway turf management programs will continue to include areas of mowed and unmowed turf. Hopefully, these areas will receive other considerations as the site dictates. In the future, unmowed areas will constitute a major portion of the total unpaved right-of-way acreage. Such areas may be urban as well as rural. They will serve to blend the highway into its environment, enhance the natural character of our prairie topography, increase available cover for wildlife, protect and restore a nearly extinct community of native prairie plants, improve erosion control potential, and add to the aesthetic qualities of the highway. Future programs will also recognize the integrity and beauty of natural plant communities. The conceptual content of future programs will reflect advanced knowledge and understanding of ecological systems. Roadside management programs will be developed with greater understanding of the contribution or impact a particular practice may have on the entire system. Neither aesthetics nor economics alone shall determine the acceptance or rejection of future right-of-way management concepts. If we hope to make positive contributions to future right-of-way management programs, we will need trained turf managers with an appreciation for ecological integrity. We must convince today's student that tomorrow's challenge is as exciting in right-of-way land management as in any other application of his skills. We must now develop the same sensitivity for potential environmental impact in right-of-way management that we presently demand of engineers in the design and construction of new transportation facilities.

CEMETERY TURF MAINTENANCE PROBLEMS

Lee B. Nyhart

Envision a new, well-graded lawn planted with the best grass varieties available, and landscaped with trees and shrubs to give a pleasant, restful feeling to the onlooker. This could be a public park, golf course, school grounds, or your home lawn; but, this is where the problems begin, because it is a cemetery.

The first step in cemetery landscaping is to dig four-inch holes every 24 feet x 20 feet for placement of lot markers. These markers subdivide the area into graves, each grave averaging 3 feet wide by 8 feet long. (Allow an additional 3 feet x 2 feet for placement of the tombstone at the head or foot of each burial.) Once the cemetery has been subdivided and the grave sold, the grave openings are made. A hole 3 feet wide by 8 feet long by 5 feet deep is dug into the turf. Today this work is accomplished by the use of a backhoe. The excess dirt is hauled away by dump truck, and in many cases, all of the dirt is removed from the grave site. When this is done, it requires several trips back and forth across the lawn. We have tried to reduce the turf damage and compaction by putting flotation tires on all equipment used on the lawns.

After the burial, the hole must be refilled and the sod replaced. We have created a continual grade problem in our lawns by this type of use. To reduce the sinking in this area, we require that all caskets be placed in a concrete vault or box. This prevents the soil from collapsing on the casket, and provides a base to support our equipment. One-half-inch stone chips are placed around the vault; and a load of fill or subsoil removed from the grave at digging time is dumped on top of it. This is then tamped with a hydraulic tamper. An area of about 8 inches is left to be filled with black dirt, walked down before the sod is replaced. After the sod is replaced, it is tamped by hand so that the area is level. This is how it is done today, but not long ago wooden boxes were used, graves were sunken because of the use of a water hose, and cemetery plots were sodded in the spring and fall of the year with the cheapest sod available.

Grave markers and monuments add to the maintenance of the turf area because they must be trimmed around and worked around with all types of equipment. Markers range in type and size from a bronze or granite slab which is 2 feet x 1 foot set flush with the lawn, to a monument which measures up to 10 feet high with a base of 2 feet x 3 feet or larger. (The trend is toward using flush markers of either bronze or granite.) A flower vase is usually installed soon after the burial takes place.

Today we average 650 burials per year, with a total of about 23,000 burials since the cemetery opened 50 years ago. At the time of development and seeding of the lawns, what was used for seed? What has been added in the form of sod and seed? The cost of complete renovation would be prohibitive, so we must improve slowly by the process of top-seeding good grass varieties that are suited to our conditions, type of maintenance, and by the use of fertilizer that will not affect the

---

L.B. Nyhart is manager, Cedar Park Cemetery, Chicago, Illinois.

bronze markers. In this way, we are able to build a healthy turf that will hold up our equipment, and be thick and strong enough to be cut and replaced after the burial has taken place.

Crabgrass is the weed that causes us the most problems. It grows over flush markers and on raised markers, and covers vases and lot markers. We have been able to control it by the use of Balan granular, applied in the spring with a cyclone spreader on a Cushman scooter. The cost of material and time required to apply it is more than offset by the savings in trimming and improved public relations.

The other weeds that are important in the cemetery are dandelions, plantain, and ground ivy. So far, we have had good control of dandelions and plantain by the use of the drip sprayer and the chemical 2,4-D. Ground ivy still presents a problem.

Insect pest and disease are of very minor importance in our type of maintenance, although they may be increasingly important as we upgrade our turf areas.

When we talk about watering, we are referring to the use of water to keep our newly laid sod on our new burials alive and in good color. We do not irrigate as the sod farm does, but we have to have a grave area looking good for the benefit of the bereaved family.

What the family expects from the cemetery is also important. The average person is very satisfied with a well mowed and trimmed turf. There are a few people who expect a putting green, but we are unable to provide this type of turf.

The type of turf found on the fairways of the local golf courses provides a very good guide to quality of turf for a cemetery. This does not mean that we do not want better, but under the conditions that exist in the cemetery and the time and money available for maintenance, this seems to be a realistic goal.

In order to improve our turf, we must secure high-quality sod from the sod grower. We look for grass varieties with the following qualities: good color; low fertility requirements, making a thick sod hold up equipment; slow, low-growing grass, 2 to 4 inches high; drouth resistance; and disease resistance and shade tolerance.

The chemical industry has developed weed controls that are easy to apply and can be applied in our slack season with good controls at a cost that is not prohibitive.

The equipment industry manufactures equipment that will trim markers, cut grass, and reduce maintenance costs.

Some of the things that we have tried with varing degrees of success are as follows:

1. Total kill around the markers. For us, public relations were very poor, although some cemeteries are using it with success.
2. Artificial turf around the marker. This looks good, but the cost is high. We sell it to our lot owners and guarantee it for five years under a five-year care program.
3. Blacktop around lot markers. This worked well for three years, but then grew over with grass. The blacktop started to deteriorate.
4. Electric trimmers. These devices are very time-consuming and dangerous to the operator.

5. Rotary mowers. We use these exclusively for mowing in the cemetery. They range in size from 20 to 88 inches.
6. Hand shears for trimming markers. We hire 20 to 25 high school boys from 5:00 P.M. to 8:00 P.M. Monday through Friday during the month of May. Each boy has a pair of shears and a whiskbroom with which to sweep off the marker after it is trimmed. This method works well.
7. Sod the year around. The sod is purchased in November, and laid out in the field on 2-mil plastic, leaving a space of about 2 inches between the sod pieces. (The sod is cut 18 inches by 3 feet.) This method works well, and we have used it for eight years.

We are providing an old type of service to the community, and doing it in a modern and progressive way. We have adapted to the '70's and are looking forward to the '80's. With new ideas and developments that will be coming from the university and suppliers, we will continue to improve our service to the community.

ATHLETIC FIELD MAINTENANCE
A.R.Mazur

The two main benefits of adequately turfed athletic fields are playing safety and pleasing appearance. Of the two, the functional value of the turf is more important than the aesthetic.

The production and maintenance of high quality athletic turf is dependent on proper design, proper construction, adequate drainage, grass species or varieties, and a maintenance program.

Clear and complete specifications covering methods and materials used during construction not only provide a basis upon which bids can be made, but also provide assurance that the proper techniques and quality of materials will be employed.

Orientation of athletic fields in relation to the sun must be considered during the planning phase. Wherever possible, fields should be oriented with the main axis in a north-south direction.

Surface as well as subsurface drainage cannot be over stressed on any athletic area. Poor drainage is associated directly or indirectly with most of the problems encountered in maintaining athletic turf.

Water-logged conditions are not conductive to optimum turf vigor and may also provide for inadequate footing. Improper drainage will also compound injury to turf from foot printing and compaction.

Underdrainage with washed gravel or crushed stone is particularly effective in improving drainage and should be contoured in the same manner proposed for the finished grade.

Traffic is the major reason for poor turf on athletic fields. In addition to attrition, constant traffic results in soil compaction. Soil mixtures with lower percentage of silt and clay compact less severely, and therefore will be better drained and provide a more deeply rooted vigorous turf. For this reason, sandy mixtures or soils are preferred over heavier soils.

Improvement of surface drainage by crowning is extremely effective. During the final grading operation, the playing area should be crowned as much as possible without interferring with play. On football fields, a 12 to 18-inch (1.25 to 1.87 percent slope) crown is acceptable, while the crown on a soccer field should not exceed 1 percent. The general grading of infield and outfield areas of baseball diamonds is usually 1 percent to allow for movement of surface moisture off the playing area.

Where heavy soils are to be amended, careful choice should be made for desirable conditioning materials. Graded or washed sands (with less than 10 percent passing

---

A.R. Mazur is graduate research assistant, Department of Horticulture, University of Illinois.

through a #60 sieve) and sedge or moss peats are well adapted to this purpose. On heavy soils, such as the local drummer silty clay loam, it is not uncommon to go as high as 70 percent sand, 15 percent peat, and 15 percent soil to get a mixture that has the desired physical properties and will resist compaction when subjected to traffic. Uniform mixing is most readily obtained off-site. Where materials must be mixed on-site, better mixing results when lighter organic materials are laid down first and the heavier soil and sand is put on top. The material must then be tilled several times to obtain sufficient mixing without layering.

A soil test provides the best guide for determining the lime and fertilizer requirements prior to seedbed preparation. Adequate limestone should be applied to adjust the pH to a 6 to 7 range. This range will favor nutrient availability, microorganism activity, and tend to keep pathogenic fungal activity at a minimum.

As turf is not a cultivated crop; the time to adjust the less mobile elements, such as P and K, is during seedbed preparation. Based on soil test, applications of 0 to 20 to 20 or equivalent can be used to bring P and K to the desired levels in root zone to encourage a dense, vigorous, well-rooted sod.

The final seedbed should be a homogenous mixture of parent soil, physical amendments, lime, and fertilizer. Tillage should be sufficiently deep to insure thorough mixing of seedbed materials without undue destruction of soil physical properties. Seedbed depth should be a minimum of 5 to 6 inches. In all cases, working soil that is wet should be avoided because of its detrimental effect on soil structure. Prior to the application of starter fertilizer, the seedbed should be rolled to establish a rough grade. This will indicate the presence of pockets or soft spots that must be eliminated prior to seeding.

A starter fertilizer containing N-P-K is usually raked into the top inch of the seedbed to provide liberal quantities of nutrients to the developing seedlings. Application rate of starter fertilizer should be adjusted to provide 3/4 to 1 pound of nitrogen per 1,000 square feet. The seedbed should then be given its final grading prior to seeding.

Where weeds, insects, or nematodes present a serious threat, soil fumigation is an added measure to ensure success of the operation. Methyl bromide is one of the most commonly used materials, and although it requires a polyethylene cover, there is no residual and the area may be safely seeded within 48 to 72 hours after removal of the cover.

Fall is the most favorable time for seeding operations, as competition from annual weeds is eliminated. When spring seedings are necessary, the use of siduron in the seedbed for preemergence weed control will greatly improve results.

Seedlings of Kentucky 31 tall fescue at 6 to 8 pounds per 1,000 square feet or blends of Kentucky bluegrass 2 to 3 pounds per 1,000 square feet have been widely used. The K-31 is extremely drouth and wear resistant, while the Kentucky bluegrass provides a more quality turf.

The seeding operation should provide uniform distribution, proper covering, and firming of soil around the seed. The best manner of ensuring uniform distribution is to seed at one-half rate and make a second application at right angles to the first. When other than a cultipacker type of seeder is used, the area should be rolled to ensure good soil-seed contact.

Mulches are an added measure for protecting against washing prior to germination and establishment. Straw and salt marsh hay are old standbys, and there are several new emulsion materials that are on the market that can be used very effectively.

Sodding and vegetative planting are alternative nethods to seeding. The seedbed preparation for these is essentially the same as that outlined for seeding. Some of the bluegrasses, as well as the warm season grasses, lend themselves to vegetative establishment. Vegetative establishment is more critical than seeding, as the planting stock is perishable and must be used fairly soon after harvesting. Sodding, on the other hand, is the most expensive method, and where time is available, seeding is usually employed.

New seedings should be kept moist at the surface to ensure germination, and mowing should be started as soon as the seedlings exceed the normal height by 1/4-inch. Thereafter, the area should be clipped at an interval so no more than one fourth of the leaf surface is removed at any one time.

A sound maintenance program should produce turf with maximum wear resistance, high density to provide a uniform playing surface, deep rooting to provide good anchorage, and a turf which will resist damage and provide the desired aesthetic qualities.

Grass should be cut frequently at a height determined by the dominant grass in the mixture. Bluegrass blends with some of the new varieties can be maintained at 1 to 1-1/2 inches, while Kentucky 31 seeding should be kept at around the 2-inch height.

Athletic fields should be kept as dry as possible without the occurrence of wilting injury. One method of determining moisture requirement is to use a soil-sampling probe. When irrigated, the field should be thoroughly moistened to a depth of 4 to 6 inches. Irrigation practices should be coordinated with field use to ensure a maximum time between irrigation and the next use of the field. Periodic aeration will also provide for more efficient water use. As mentioned previously, water management and drainage are very critical in the maintenance of athletic turf.

Compaction is an unavoidable factor that must be confronted in the maintenance of athletic turf. Various types of equipment have been designed to relieve the effects of constant traffic. One of the standard means of relieving compaction is the use of hollow-tined equipment that removes cores 3/4 to 1 inch in diameter. Generally, fields are aerated three times during the year. In the spring, the field should be aerated heavily (6 to 8 times over) prior to fertilization and liming. The field should be aerated a second time in late summer (2 to 3 times over). After the playing season, the field should be aerated again heavily (6 to 8 times over).

Complete soil test should be made every year to determine nutrient and pH status of the field. Lime and fertilizer requirements should be made in compliance with soil tests. Although most athletic fields will require two complete fertilizer applications each year, some may require only one complete fertilizer application and supplemental nitrogen applications. Cool season grasses are benefited most by fall applications. Depending on type of grass, the field will require from 4 to 6 lbs. of N per 1,000 square feet per season.

Weeds, insects, or diseases may dictate the use of pesticides periodically during the season to keep the turf healthy, dense, and vigorous.

Even the best managed turf will withstand only a certain limit of traffic. Injury can be kept to a minimum by: avoiding use when the field is wet; rotating play where possible to allow recovery; and avoiding use of the area for other functions that create concentrated traffic, such as band practice. Also, do not use the area while the turf is in a dormant condition.

THE PAT SYSTEM (PRESCRIPTION ATHLETIC TURF)

W.H.Daniel

Just turn on the suction pumps if it rains during a game! Suck the raindrops down before mud forms! Give the players the firmness for running, resiliency for falling, and traction for turning. Give the coach, the players on the bench, and the spectators a better view by having a flat field. For baseball, help the front office minimize rainchecks by using suction to keep base paths drier. A new concept in athletic turf is now a reality!

Remember when rain meant mud? The extra water at the surface during rain caused surface wetness, creating slippery playing conditions. Crowning the field limited the size of puddles, tile drains helped in springtime dry-out, and sandy soils were more efficient than clay soils; but the surface still remained too wet to use in the case of rain. The Prescription Athletic Turf (PAT) system is not an addition to these methods of turf maintenance, but a replacement for them.

During December, 1970, the idea of putting suction pumps onto drains to pull surface water down into the soil was developed. We first tested an area of 10 square feet in the greenhouse, and later an area of 400 square feet outside. The vacuum developed 4 to 6 inches of mercury, rapidly pulling water and air through sandy subgrade and playing surfaces. In field tests, excessive surface water was removed from a field within 10 minutes.

Based on turf research, a system was developed including eleven items which, when combined, form nine features. The items are: suction pumps, collector drains, plastic sheeting, sand, peat, calcined aggregates, slow-release fertilizers, soil heating cables, vented plastic covers, and power rollers. These items combine to produce the following features: suction pumping, as needed; level fields, to allow the water to move down; water conservation for outflow control; subsurface watering, as needed; nutrient conservation above the plastic; a porous rootzone for ample air supply; heat-adding to keep the soil thawed; heat conservation to reduce frost action; and wear-resistance for increased growth.

The Prescription Athletic Turf system has numerous advantages over other turf maintenance systems. Some of these advantages are listed below.

Gives improved playability. The PAT system provides a firm running surface and the resiliency to absorb the shock of falling. Turf, peat, sand, and proper aerification also increase resiliency. Because standing water may be removed during use, the system minimizes the effect of rain. Crowning the field is no longer necessary, resulting in a more uniform appearance and a better view of the field for spectators.

Counteracts very wet conditions. The PAT system assures rapid infiltration, allows internal storage of water, permits the rapid adjustment of moisture levels, and provides adequate aeration.

Counteracts very cold conditions. The PAT system keeps the soil thawed for safe footing. Because the roots are kept above 40° F., the growing season is extended.

W.H. Daniel is professor, Department of Agronomy, Purdue University.

The system reduces the frost action on leaves, improving color, and reduces frost action on the soil surface. The vented plastic covers conserve soil heat by trapping the sun's energy beneath them. The system adds soil heat by electric cables. These advantages of this system make it possible for warm-season grasses to be used further north.

Counteracts very hot conditions. This system favors evapotranspiration from the soil and turf, cooling the surface. Included under the PAT system is the conservation of nutrients, the minimum watering frequency, and economy of water and labor.

Counteracts very dry conditions. The system conserves rain water as reserve above the barrier, allows subsurface recharge with no wind effect, corrects poor distribution of water, and has "wick" action in three directions--either side and up.

The first PAT field, at Goshen High School, Goshen, Indiana, had one pump (limited to the center 36,000 square feet), and a 14- to 16-inch rootzone above the plastic. Kercher Landscaping contracted the work and was aided by Larry Gadsen, superintendent of facilities, and Rieth and Riley, general contractors. The construction took two months, and sod was laid two months prior to the first home game. The cost was estimated at 75 cents per square foot for that area. The field had 26 uses, including high school and junior high football and band practice. Normal field management included light overseeding before games and light rolling after games. Even with five inches of rain within 48 hours prior to the game, the field was ready for use.

The first full-size field (62,000 square feet with two pumps), was installed by Grand Valley State College, Allendale, Michigan. Including extra excavation and extensive site work, their estimate was $1.10 per square foot. When it was first used during an all-day rain, the field stayed firm and ready for use.

It is estimated that ready-for-use costs for the PAT system will range from 75 cents to $1.50 per square foot, depending on such things as location, delivered sand costs, and overhead. Although the question of cost is always important, the big questions concern quality of construction and development of a level of turf maintenance which will assure good, healthy turf.

Assuming that you are still interested in a PAT system for your field, how do you proceed? First, share information with the architect or designer for your school system. Consider what is possible in scheduling construction and use. Also, see models that are already installed.

Licenses are available to architects and designers on a non-territorial basis (because of wide-ranging activity of firms). Contact: Purdue Research Foundation, Dr. R.L. Davis, Executive Building, Purdue University, West Lafayette, Indiana 47907. Telephone: 317-749-2112.

This is based on patent application No. 263,434, dated June 16, 1972, as filed by the PRF on a "Combination Turf Drainage and Irrigation System."

Additional copies of this report and other turf information are available from: Turf Research, Dr. W.H. Daniel or Dr. R.P. Freeborg, Department of Agronomy, Purdue University, West Lafayette, Indiana. Telephone: 317-749-2891.

Either office can supply lists of licensees and models installed.

A maintenance consultation is strongly recommended to assure programs leading to best performance. Visits, inspections, advising, and program development based on a sliding scale over three years are proposed. A contract is available with the Midwest Regional Turf Foundation, located in the Department of Agronomy, Purdue University. Information will be provided to licensees and owners as PAT systems are installed. Also, turf specialists in local areas may be available.

NEW RYE GRASSES FOR TURF

Howard E. Kaerwer

Quality turf from ryegrass is possible. A new concept in the Midwest, fine-textured perennial ryegrasses have been used for premium and perennial utility turf in the coastal regions of the United States for about ten years.

In England, Scandinavia, and northern Europe, narrow-bladed perennial ryegrass is extensively used on general turf and on sports fields where wear resistance is important. These varieties are adapted to cool, moist, maritime climates.

The first narrow-bladed variety introduced into the United States was Norlea, in about 1958. It was developed in Canada and proved to be quite winter-hardy. However, its turf is rather open and unattractive, and it has not become popular or widely used.

In 1962, Northrup King introduced the first successful fine-textured ryegrass to be marketed within the United States for use along the east coast. Named NK100 Perennial Ryegrass, it proved to be well adapted and readily accepted by park, school, cemetery, and commercial grounds superintendents. Golf course superintendents found it valuable for tees and other areas of hard wear. Many thousands of acres of home lawns and commercial turf have been seeded to mixtures of NK100 and Merion Kentucky Bluegrass. Several million pounds of NK100 seed have been utilized since its introduction.

Experience has shown that NK100 can be successfully used as a compatible companion grass throughout the north-central states. However, because NK100 can be injured some winters, it has not been utilized as extensively in this region as along the east coast.

Pelo Perennial Ryegrass was introduced a year or two later by Northrup King. Originating in Holland, it also lacks complete winter hardiness. This factor has limited the use of Pelo to areas where winters are more moderate. Used alone or in formulas, Pelo has been seeded and interseeded on thousands of turf acres from Pennsylvania into New England. Some Pelo has been incorporated into Midwest formulas where establishment speed and traffic tolerance are primary requisites.

Manhattan Perennial Ryegrass was released in 1967 by the New Jersey Experiment Station located at Rutgers University. Its attractive, moderately dark-green color and turf density provide distinctiveness and turf quality.

Pennfine Perennial Ryegrass, from the research program at Pennsylvania State University, is being introduced this year. Improved mowing quality, disease resistance, and turf texture make it an important advance among the fine-textured ryegrasses.

The newest addition to the list of improved narrow-bladed perennial ryegrass varieties is NK200. Bred in Minnesota by Northrup King, it is winter persistent and adapted to the Midwest.

H.E. Kaerwer is turfgrass specialist, Northrup, King & Co.

A number of additional varieties are presently in tests across the country. Undoubtedly, one or more will become available within the next few years. There has also been a limited amount of seeds of a few European varieties sold in the U.S. However, performance has not been outstanding and supplies are limited.

Each of the six varieties mentioned above has its own virtues and limitations. They also have generic characteristics which make these varieties, as a group, extremely valuable.

Compared to the older "coarse kinds" of annual and perennial ryegrass, these varieties are slower growing, darker green, narrower bladed, leafier, and more prostrate in growth habit. They tend to be more disease resistant and persistent. In addition, they establish almost as fast, tend to be more wear resistant, and are compatible when planted in mixed stands with bluegrasses, fescues, and bentgrasses.

The characteristics of the coarse-textured ryegrasses have limited their use to low-priced seed mixtures and to seedings where permanence and appearance are immaterial. The new fine-textured perennial ryegrass varieties produce quality turf. They are versatile and valuable additions to the fine turfgrasses.

Fast and almost foolproof establishing ability is an important characteristic. These varieties can be expected to germinate 50 to over 100 percent faster than Kentucky Bluegrass. The large seeds develop vigorous seedlings which can emerge from greater depths and through heavier crusts than smaller-seeded species. They can produce satisfactory stands under seedbed and climatic conditions which insure failure with Kentucky Bluegrass and other less vigorous species. While interseeding into thatch is not recommended, these ryegrasses do establish more readily than other species under these conditions. Vigorous root growth means speedy penetration below the potentially droughty surface.

The seedling growth characteristics are compatible with the establishment requirements for bluegrass, fescue, and bentgrasses. There is less likelihood of the fine-textured ryegrasses crowding out the less vigorous components of a mixture. Still, their quick germination discourages weed competition.

These ryegrasses have broad adaption. While they prefer fertile soils with good moisture-holding capacity, they do produce satisfactory sod under less ideal conditions. Adaption of pH ranges from slightly below 5.5 to over 8.0. Nitrogen and other nutrient requirements are similar to the less demanding Kentucky Bluegrass varieties. They are better adapted to midcontinent as well as coastal conditions than the older ryegrass strains and varieties.

A substantial advantage inherent in the new varieties is their ability to produce a dense, uniformly textured turf. They produce a compatible blend of species when established in mixtures with bluegrasses, fine fescues, and even under certain conditions with bentgrasses. Given a casual glance, these ryegrasses can easily be mistaken for Kentucky Bluegrass.

In part, this compatibility is due to the relatively prostrate and leafy growth habit. Like bluegrass, they produce leaves below clipping height.

While leaf color does vary, all are within the same range of acceptability as the more popular Kentucky Bluegrass varieties. All can be used in blends with other fine-textured grasses without negative color effects; in fact, the reflectance from the shiny backs of ryegrass leaves produces an attractive, lively appearance in a lawn.

Narrow leaf blades is another common characteristic. While leaf width can vary due to environment, management, and competition, these ryegrass blades generally will be in the same width range as Merion Kentucky Bluegrass. When mown at 1 1/2- to 2-inch heights, the broadest leaves will be somewhere between 1.5 and 3.0 mm wide.

Turf density may be equal to that of Kentucky Bluegrass, but unmanageable thatch is not likely to develop with these ryegrasses.

Ability to withstand wear and tear is an outstanding advantage inherent in these varieties. They are more resistant to wear than Kentucky Bluegrass, bentgrasses, or the fine-leaved fescues. Vigorous regrowth, large fibrous tillers, and low crown set makes these grasses ideal for football fields and other heavy trafficked areas such as on golf tees and along boulevards. Once well established, it is difficult to tear the plants from the ground.

Another generic value of these ryegrasses is their ability to establish in older lawns to renew turf quality where bluegrasses and fine-leaved fescues fail to cover the ground in a satisfactory manner. Evidently, the root systems have the ability to penetrate compacted soils better than those of other turf species.

These varieties of ryegrasses are not excessively competitive. I have been observing mixed species populations for 15 years, and while there are fluctuations between species due to management, climate, and varieties, the ryegrass does not crowd out bluegrass or disappear due to competition.

These grasses should not be considered shade-tolerant perennials. They do have the ability to establish and produce a turf under moderate shade, but they often do not reproduce to the degree necessary to maintain shaded stands for more than a year or two. When routine interseeding is planned, such as on a shaded tee, considerable success in maintaining a grass cover is possible even when other species have proven unsatisfactory.

Ryegrasses are not rhizomatous like Kentucky Bluegrass, and they do not produce stolons for top-of-ground spread. These ryegrasses do have the ability to establish independently rooted tillers with some ability for lateral movement. It is in this manner that density is maintained.

Mowing quality is improving, but still somewhat below that of the better mowing bluegrasses such as Pennstar. However, the better mowing varieties as exemplified by Pennfine and NK200 often are cleaner cutting than some of the less elite bluegrass varieties.

Mowing height can be adjusted to needs. On southern golf courses where cool season grasses are overseeded on Bermudagrass greens for winter play, these fine-textured ryegrasses can be maintained throughout the winter months at 1/4 inch height. Turf density is developed by seeding at rates from 40 to 50 pounds per 1,000 square feet rather than through tiller development. Stands have been maintained for six years at 1/2 inch mowing height in the Midwest. However, because short plants do not tiller profusely, routine interseeding may be desirable if a dense stand is required.

No difficulty in stand maintenance should be experienced at clipping heights of 3/4 inch and above under most conditions.

Vertical growth tends to be a bit more rapid than is characteristic for Kentucky Bluegrass varieties, but far less than occurs with the coarse-leaved types of ryegrass. Clipping weight will be one-fourth to one-third the amount removed from annual ryegrass.

Summer and winter adaption of these ryegrass varieties is still being evaluated. While satisfactory persistence has been demonstrated, additional experience under more midcontinent conditions is still desirable. Manhattan and Pennfine appear to be more tolerant to conditions in the southern part of the bluegrass belt. NK200 has survived -35° F. temperatures and Minnesota winters with and without snow cover.

Off color and slow growth may occur during midsummer when temperatures are intense. Good management practices and the use of blends with other species can reduce these symptoms. In turn, the narrow-bladed ryegrasses tend to hold their color and density longer into the fall than Kentucky Bluegrass.

Fusarium snow mold can be quite damaging. Management to reduce winter matting can be beneficial in controlling this disease. Fungicide treatment may be desirable where top quality spring turf is required.

Seeding rates will depend upon the results desired and the anticipated conditions likely to exist while the grass is establishing. For new turf, four to six pounds per 1,000 square feet should be adequate, and one to two pounds per 1,000 square feet when interseeding to renew old turf. While these grasses can be seeded alone, I prefer the use of formulas with other species for most purposes. As a general recommendation, 20 percent by weight of the formula can be fine-textured ryegrass seed when establishing a new turf area. For interseeding-established but thin turf, the ryegrass component should be increased to about 40 percent of the seed mixture. For seeding football and other heavily trafficked areas, as much as 60 to 70 percent of the formula should be made up of the narrow-bladed turf type ryegrasses.

There are approximately 300,000 seeds in a pound of these perennial ryegrasses, far below the 1.2 million to 2.2 million seeds in a pound of Kentucky Bluegrass. However, because of the ability of the ryegrasses to establish a stand and then rapidly provide ground cover, less ryegrass seed per 1,000 square feet is required.

If mixtures are to be established, remember that the ryegrass will be up first. Watering practices must be maintained until the slower species are well out of the ground.

Fertility can be a factor in maintaining a fine-textured ryegrass or mixed ryegrass turf. While high fertilizer rates are not required, these ryegrasses will not do well on infertile soil. Rapid growth due to excessive amounts of nitrogen applied at the wrong time can cause midsummer or winter injury and stand loss. One to four pounds of nitrogen per 1,000 feet per year should satisfy most turf requirements. Potash levels should be adequate. Irrigation and mowing requirements are basically similar to the management procedures recommended for Kentucky Bluegrass.

The new ryegrass varieties will be especially valuable where aesthetic and economic considerations must be combined. Landscape contractors as well as public and private grounds superintendents will find that these grasses better meet many of their requirements than other species. Reseeding risk is minimized. Erosion potential is reduced. A usable turf can be established weeks faster when these grasses are included in seed mixtures.

The water and fertility requirements of these ryegrasses are not especially critical. Their slower growth rate insures that mowing and other maintenance costs will not be excessive. Resistance to wear and tear cuts costs for turf maintenance on trafficked areas.

Consider one or more of these improved perennial ryegrass varieties in your seeding and interseeding plans. You will probably find their use to be agronomically and economically rewarding.

PROS AND CONS OF SYNTHETIC TURF

Lee Record

Poor management, maintenance of athletic fields by unqualified personnel, and the super salesmanship of synthetic turf distributors have made a substantial dent in the turf-growing profession. Many turf growers try to sell their administration a $250,000 to $500,000, three-year guaranteed, synthetic playing surface, when a $2,500 sod job that may be required every year or two would be sufficient.

Though most artificial athletic turf installations are relatively new, some definite advantages and disadvantages are being observed. The most important advantages include: inexpensive maintenance; flexibility of use--one surface can be used for many events, reduced player uniform cleaning bills; faster surface; and cancellation of fewer games due to rain because of improved water drainage off of the field.

On examination, many of these so-called advantages disappear. Maintenance of synthetic athletic turf is usually more expensive than claimed because the field must be drained rather than irrigated, and mopped and vacuumed instead of mowed. These procedures require costly equipment and labor. Repairs to the surface and undersurface are difficult and expensive. Though uniform cleaning bills are generally less, sandier soil mixtures on turfed athletic fields would appreciably reduce the rainy day muddiness. Playing surfaces may be faster on artificial turf, but the surer footing provided by natural turf counteracts this advantage. As far as drainage is concerned, new methods of athletic field construction offer drainage systems as efficient or superior to those installed in synthetic turf fields. Another supposed advantage to artificial turf is the reduction of player injuries. This has been generally refuted as its use has increased. Knee and ankle injuries have been reduced in some instances, but more impact and serious head injuries have resulted with artificial turf.

Another major disadvantage of synthetic turf is its expensive installation. The costs are usually between $250,000 and $500,000 for a standard playing field. Imagine how many years of resodding, maintenance, equipment, and labor could be purchased for an excellent natural turf stadium for these figures! The artificial turf may need replacement by the time the intitial installation investment (excluding yearly maintenance) could be used for a grass field. Three years seems to be the longest period known for an artificial turf guarantee.

Other disadvantages of synthetic turf include: higher surface temperatures, often 20° to 30° hotter than grass; brush burns; slipperiness when wet; fading of turf color which is very noticeable on many fields; and pile crush. The turf must be repeatedly brushed against the grain; and constant painting of the stripes is required, as they are often stretched out of position or rubbed off when wet.

Natural turf offers many advantages, and those in the turf world must recognize these advantages and act as ambassadors to spread the word that grass is best!

L. Record is director, Mid-Continent Region, USGA Green Section.

It is still the most economical playing surface available, and is relatively easy and inexpensive to repair. Natural turf provides the coolest playing surface with natural air conditioning, and also produces the oxygen essential to improve our atmosphere. Where natural grass has been properly selected and maintained, a great playing surface has resulted with uniform, green turf. In order to combat the artificial stadium turf trend, knowledgeable turf management and adequate budgeting for quality sod, equipment, chemicals, and labor must be provided.

GENERAL SESSION ON PESTICIDES

ILLINOIS PESTICIDE LEGISLATION — THE YEAR IN REVIEW THE ILLINOIS CUSTOM OR PUBLIC APPLICATION OF PESTICIDES ACT

Juett C. Hogancamp

In 1961 a bill was introduced in the Illinois General Assembly providing for a custom spray law, but it did not pass. In 1963 bills were introduced and passed by the General Assembly, but the bills were vetoed by the governor.

In the veto message the governor appointed the directors of the Departments of Agriculture, Public Health, and Conservation, the Chief of the Natural History Survey, and the Dean of the College of Agriculture of the University of Illinois to act as an interagency committee for the following purposes: (1) to review the current status of the use of pesticides within the State of Illinois and by state agencies; (2) to review the federal research and programs in this area with particular emphasis on the federal regulations which should result from the Report of the President's Advisory Committee on Pesticides; and (3) to recommend legislation, if appropriate, which will prohibit the irresponsible use of pesticides, but not unduly interfere with those operations where pesticides are being safely and properly applied.

During the next two years the interagency committee held a number of meetings and proposed the enactment of a custom spray law. The bill was enacted into law in 1965 and became effective on January 1, 1966. No changes were made in the law until 1971 when a number of amendments were enacted that became effective January 1, 1972.

The Illinois custom spray law includes the following pesticides: insecticides, fungicides, nematocides, and herbicides.

Under the Custom or Public Application of Pesticides Act, custom application of pesticides means the application of any pesticide by aircraft or ground equipment for hire. Public application of pesticides means any applicaion of pesticides by federal or state agencies, municipalities, townships, and other political subdivisions. Custom or public application of pesticides does not include:

(1) application of such materials by a canning establishment on land upon which fruits or vegetables are being grown or are to be grown for preservation or processing by the canning establishment under an existing contract between the canning establishment and the owner, tenant, or occupant of the land;

(2) application by a farmer upon property other than his own for no more than 2 other farmers in any one year;

(3) application by a person on his own property or on property rented, leased, or controlled by him for lawn or garden use;

(4) application by a veterinarian in the practice of his profession;

(5) applications to trees by a tree expert properly licensed under the laws of Illinois;

J.C. Hogancamp is Herbicide Control Advisor, Plant Industry Division, Illinois Department of Agriuclture.

(6) applications of pesticides for the control of nuisance pests or disease vectors, or both, in the immediate vicinity of dwellings or similar structures by persons normally engaged in the activities of PCO work.

A license known as a Pesticide Applicator's License is issued to a person who owns or operates a custom application business that applies pesticides to the property of another outside a structure.

A license known as a Pesticide Operator's License is issued to a person who is employed or directly supervised by a pesticide applicator, and who in turn supervises or operates pesticide applicating equipment, including recommending controls, handling, mixing, and applying pesticides outside a structure, and the disposal of waste excess material and containers.

A license known as the Public Applicator's License is issued to a public employee who exercises direct control over the recommending, selecting, use, and application of pesticides by a federal or state agency, municipal corporation, or other governmental agency.

A Public Operator's License is issued to a public employee who operates an engine- or motor-driven applicating equipment or device used by a federal or state agency, municipal corporation, or other governmental agency to apply pesticides.

The annual license fee for a pesticide applicator is $25.00. The annual license fee for a pesticide operator is $10.00. There is no license fee for the Public Pesticide Applicator's license or the Public Pesticide Operator's license. For each Pesticide Applicator's license issued, a $3,000 performance bond with a surety or bonding company is required. A deposit of cash or other collateral security indicating the financial responsibility of the applicant may be deposited in lieu of bond.

All licenses expire annually on December 31.

At least 20 one-day training sessions are held in February and March each year. Written examinations are given at the conclusion of the meeting. Tests are given in the following categories:

Landscape and Turf,
Industrial Weed Control,
Aquatic Weed Control,
Mosquito Control,
Agriculture.

PESTICIDES IN THE ENVIRONMENT

A.J.Turgeon

Society's growing awareness of pesticides as potential contaminants of our environment has resulted in emotional appeals to restrict or even eliminate their use. Pesticides are often depicted as deadly poisons with the capacity to cause serious harm to some environmental component essential to the so-called "balance of nature." This emotionalism frequently arises from a lack of understanding of what pesticides really are and the fate of these materials following their application. This does not imply that genuine concern regarding the use of some pesticides is not warranted.

Several pesticides are, in fact, extremely poisonous and should be used only by competent professionals. Others, however, are sufficiently safe so that even the untrained applicator can handle them with little real danger to himself or his environment. Finally, the persistence of some pesticides in the soil and in some natural food chains suggests the employment of alternative measures, including other pesticides, for controlling unwanted organisms. Certain chemical agents could conceivably cause long-term, disastrous effects; however, the most serious threat to man and his environment is man himself. Improper procedures of pesticide handling, storage, and disposal have caused senseless injury and death to humans, animals, and plants. Rejection of pesticides for controlling malaria-carrying mosquitoes resulted in widespread misery and thousands of deaths in some parts of the world. Public decisions based on inconclusive evidence could lead to the elimination of pesticides important for food production in a world in which mass hunger and starvation are not uncommon.

The quality of life, and even man's survival, depend in large part on a knowledge of pesticides and their proper use. Included in this is an understanding of the fate of pesticide materials following their introduction into the natural environment. The schematic diagram on the next page illustrates what may happen to a herbicide that has been applied to the soil. Other pesticides such as fungicides, insecticides, etc., are generally susceptible to the same processes as these materials eventually contact the soil.

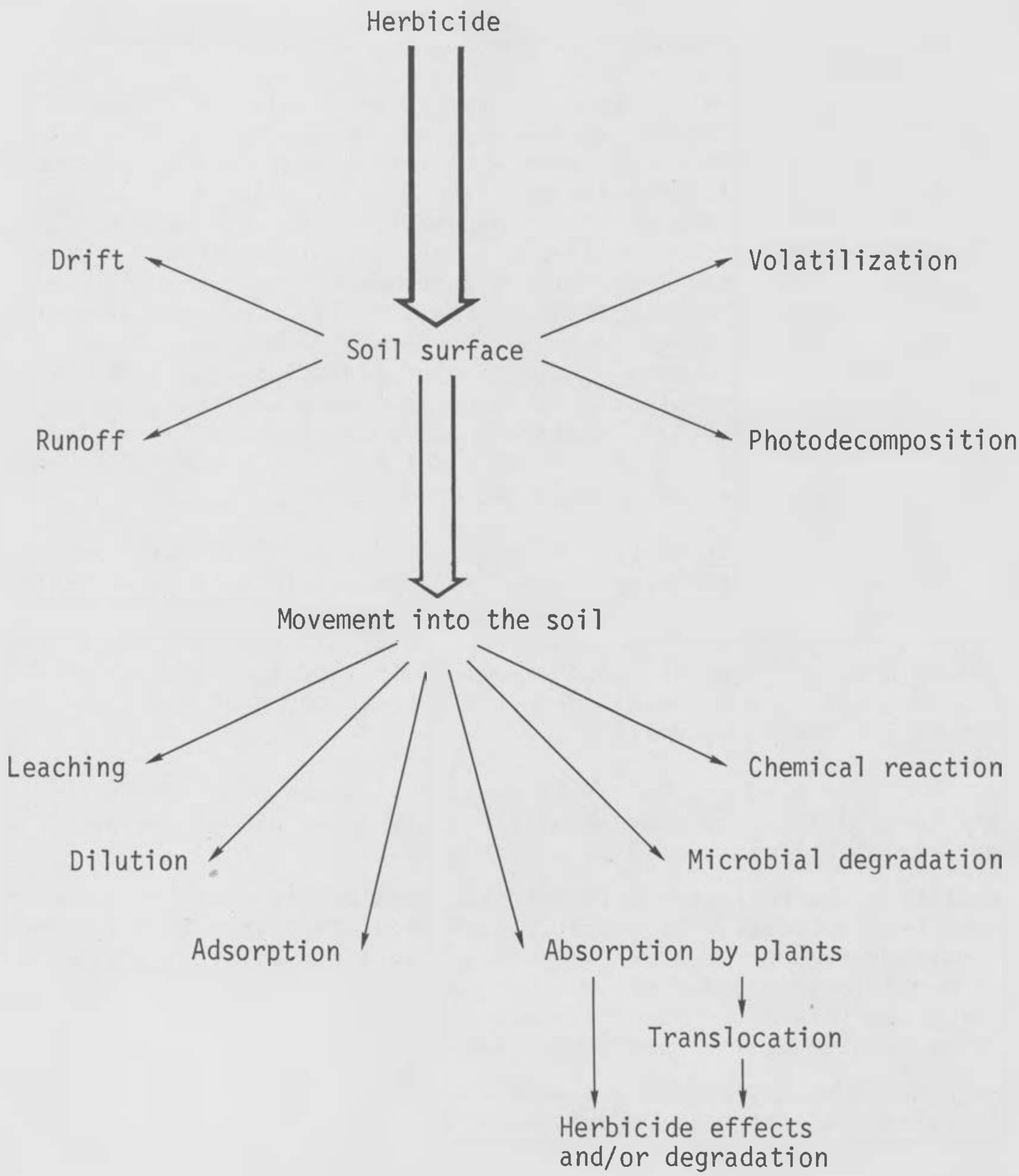
Spray *drift* in wind and *runoff* in water are common phenomena that should be carefully controlled since they result in inefficient use of the pesticide and possible damage to plants or animals in adjacent areas.

A pesticide may be lost due to *volatility* immediately following application. This refers to the property of a specific chemical to change to the gaseous (vapor) state at ordinary temperatures on exposure to the air. This is especially important with such herbicides as 2,4-D ester. The vapors may be carried away from the target site by wind and this could result in extensive injury to desired vegetation and less effective weed control at the target site.

Some pesticides may be changed under the influence of light--*photodecomposition*. This subject is not well understood at present, but it is known that the effectiveness of monuron and simazine may be reduced under high light intensities and low soil moisture.

A.J. Turgeon is assistant professor, Department of Horticulture, University of Illinois.

Movement of pesticides into soil is accomplished by incorporation with suitable equipment or in association with water percolation. Continued water movement through the soil profile may cause *leaching* of the pesticide away from the desired soil level or cause *dilution* across a wide soil depth, thus reducing its effectiveness. Soil texture (sandy vs. clayey) is an important factor associated with leaching and dilution of a pesticide through the soil profile. Pesticides may also be *adsorbed* onto soil particles, making them unavailable to plants and other organisms. Alternatively, they could be degraded by soil microbes such as bacteria and fungi, or the pesticide may undergo some chemical reaction in the soil resulting in a change in its activity. Pesticides are also *absorbed* by plants, causing injury or undergoing processes of *degradation* by enzymes within the plant.

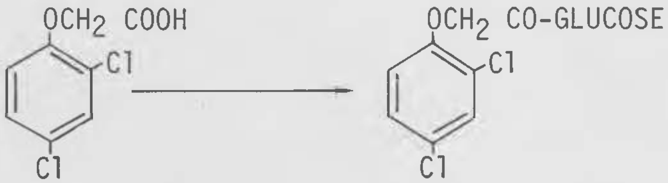


Pesticide degradation may occur as one or many possible biochemical reactions. For example, a halogen such as bromine (Br) might be removed from a compound, rendering it non-toxic:

$$\underset{\text{Methyl bromide}}{CH_3Br} \xrightarrow{\text{Dehalogenation}} Br + \underset{\text{Methane}}{CH_4\uparrow}$$

Dealkylation or removal of an alkyl group is one proposed step in the degradation of 2,4-D followed by hydroxylation of the aromatic ring and, possibly, ring cleavage:

Alternatively, 2,4-D may form a conjugate with a naturally occurring sugar or amino acid so that it is no longer active as a herbicide:



The specific rate and nature of pesticide degradation depend, in part, upon the capacity of living organisms to produce enzymes that can metabolize the foreign substance. Considerable variability exists among pesticides in their susceptibility to enzymatic degradation. Some pesticides are degraded rapidly to carbon dioxide, water, and other simple compounds or elements, while others persist for long periods as the parent compound or as a slight variation of the parent compound. DDT may change rapidly to DDE and then persist in the environment for a long period of time. In contrast, endothall may be completely metabolized in a few days or weeks.

In summation, it is difficult to generalize about pesticides and their potential threat to man's environment. Each pesticide must be considered as a separate entity and it should be studied in terms of its specific physical, chemical, and biological properties. Detailed implementation of safety procedures in handling pesticides and intelligent selection of specific pesticides for specific use situations will generally ensure their safe and effective use.

HERBICIDE SELECTIVITY

J.A.Tweedy

A selective herbicide is a chemical which is more toxic to one plant than to another. When such a herbicide is applied to a mixture of plant species, some may be killed, and others may be affected slightly or not at all. Too often, it is assumed that only the undesirable species will be killed, and that slight injury should not occur to the desirable species. Occasionally, slight injury will be experienced on desirable species, depending on the particular herbicide, the environmental conditions, species, and other factors.

Herbicides may be selective for several reasons. Such factors as the rate of application of the chemical, temperature at time of application, rate of absorption of the chemical through the shoot or root, ability of some plant species to metabolize the chemical, botanical or structural differences between plants, species and cultivars differences, or interactions of these factors may determine if a herbicide is selective.

The basal location of the growing point of turfgrass is importart in herbicide selectivity. Many broadleaf weeds have their growing points at the top of the plant and are more exposed to herbicide sprays. The pubescence on the leaf surface can affect herbicide selectivity. These structures can prevent the chemical from coming into contact with the leaf surface, and reduce herbicidal activity. To overcome this problem, a surfactant can be added to give better wetting and enhance activity if a weed has pubescent leaves. Mouse-ear chickweed is an example of a weed that has a pubescent leaf and stem surface.

The chemical composition of the leaf surface may affect herbicide selectivity. Wild onion, wild garlic, and purslane have waxy leaf surfaces which repel herbicide sprays in water. The addition of a surfactant to the spray solution will generally enhance herbicide activity on these species.

Rooting depth is an important factor in achieving herbicide selectivity with herbicides that are placed on the soil surface. The deep-rooted perennial turfgrasses do not absorb as much herbicide as the shallow-rooted weed seedlings. This is one reason why many pre-emergence herbicides should not be applied to a new seeding of a turfgrass until the plant has become established.

Herbicide selectivity can also be achieved through proper timing of herbicide application in relation to growth of the turfgrass species versus the weed. Maximum absorption of a herbicide and the resulting kill of the weed occurs during periods of rapid respiration and growth. Weeds that have just emerged into a mature turfgrass area are more easily controlled with greater selectivity. For example, the selective control of crabgrass in Kentucky bluegrass with an organic arsenical herbicide is more successful when the crabgrass has just recently emerged. The selective control of winter annual weeds during the dormancy of perennial southern turfgrasses, such as bermudagrass and zoysiagrass, is easily achieved.

J.A. Tweedy is associate professor, Department of Plant Industries, Southern Ilinois University.

Most selective herbicides are only selective at certain rates, or at a relatively narrow range of rates. The rate is extremely important, and for this reason, the label should be followed carefully. If too much phenoxy herbicide is applied, it may be changed from a translocated to a contact herbicide. The result will be poor weed control. If too little phenoxy herbicide is used, no control may be the result. On the other hand, many pre-emergence selective herbicides will control annual grasses without injuring desirable species at specific rates. However, if applied at excessive rates, severe injury or death may result in the turfgrass species.

Another factor to consider with some post-emergence selective herbicides is temperature and rate at the time of application. The organic arsenicals (DSMA and MSMA) are used for selective control of crabgrass and nutsedge in established turf. If the temperature at the time of application is near 90° F., the rate should be reduced in half because the herbicidal activity of the organic arsenicals is temperature and rate dependent. The higher the temperature, the greater the activity, and the herbicides are not effective below temperatures of 70° F.

The herbicide tolerance of turfgrasses varies among species and varieties. Kentucky bluegrass is generally more tolerant than red fescue. On the other hand, bentgrass may be injured by 2,4-D and silvex. Visible herbicide injury on turfgrass species may not be readily observed. The roots of many turfgrass seedlings are quite sensitive to 2,4-D, and while the visible injury symptoms are not obvious, the result may be less drought tolerance and lower vigor. The injured grass plant may be more subject to disease infestation.

The reasons for herbicidal selectivity may be numerous. The objective is to use the chemicals properly to control weeds, with no injury to the desirable turf species. Recommendations on the herbicide label should always be read prior to use, and followed during use to achieve the greatest success. Too often selective herbicides fail to perform properly because an operator failed to follow the label rate or the label precautions.

FUNGICIDES AND HOW THEY WORK TO CONTROL DISEASE

Malcolm C. Shurtleff

Turf diseases and their causes must be considered before discussing how fungicides act to control these diseases. All noninfectious diseases due to extremes in temperature, water, light, soil pH, nutrient imbalances, air and soil pollutants, a wide range of mechanical injuries, or genetic defects will be omitted in this discussion.

Fungi cause all of the over one-hundred infectious turfgrass diseases known in the Midwest. These primitive, filamentous plants lack chlorophyll and cannot manufacture their own food. Disease-causing fungi obtain their food by infecting other living organisms. Fungi that feed on nonliving organic matter are called saprophytes. These fungi are highly beneficial to man as decomposers of the dead leaves, stems, rhizomes, and roots of plants within the turfgrass community, and as antagonists to disease-causing fungi. By breaking down dead debris, fungi keep thatch from building up, and also release nutrients to living grass plants.

There are numerous fungi that have both parasitic and saprophytic stages in their disease cycles. They can feed on dead plant residues in the thatch or upper layers of soil for most of the year. When conditions of temperature, moisture, air humidity, grass nutrition, and other environmental factors are favorable, these fungi attack living grass tissues and cause disease. Examples of disease-causing fungi that can live indefinitely in the thatch or soil include those causing Helminthosporium-type diseases (leaf spots and blights, crown and root rots, or melting-out), Fusarium patch and Fusarium blight, Rhizoctonia brown patch, Sclerotinia dollar spot, Pythium blight, Typhula blight, and Corticium red thread.

Most fungi that attack turfgrasses reproduce by means of spores. These are microscopic propagating units that are often produced in astronomical numbers, and are analagous to the seeds of higher plants. Spores are distributed by such means as air currents, water, mowing and other turf equipment, humans, and insects. Practically all fungus spores except the powdery mildews germinate under conditions of free moisture on the surface of the grass plant, given a favorable temperature for growth and nutrient availability. Most spores are capable of germination soon after they are formed.

The spore first takes up water and swells, initiating a series of enzyme reactions that release stored energy in the spore. The result is a slender germ tube or hypha that commonly branches one or more times while growing over the surface of the grass plant.

Certain disease-causing fungi, such as organisms causing Sclerotina dollar spot, Rhizoctonia brown patch, Corticium red thread, and Typhula blight, rarely produce spores, if at all. They exist in the thatch-soil area as hyphae (thin, transparent tubes bounded by a cell wall) or as compact, brown to black, resting bodies called sclerotia. Sclerotia are distributed by movement of soil, water sprigs, plugs, sod, wind, humans, and turf equipment. A sclerotium is made up of closely packed hyphae

---

M.C. Shurtleff is professor, Department of Plant Pathology, University of Illinois.

rich in stored foods. Because of their organizational structure, sclerotia are ideally suited for surviving extremes of temperature, moisture, and most fungicides. When favorable conditions for growth occur, a sclerotium absorbs water, enzymes are activated, and one or more germ tubes are put forth just like a spore. Sclerotia have the unique ability of germinating more than once, sometimes as many as 30 times, before their food reserves are exhausted.

The germ tubes from spores and sclerotia are capable of indefinite growth at their tips under favorable conditions of temperature, water, and nutrient availability. Germ tubes grow until food is exhausted or until they come into contact with a penetration site.

Penetration occurs: through natural openings called stomates; through wounds made by mowers, cultivation, foot traffic, and feeding injuries of insects and nematodes; or through the plant surface directly. Direct penetration takes place usually by a combination of mechanical pressure on the outer cell wall and the secretion of enzymes that soften or dissolve the cuticle and outer cells walls of the grass leaf, stem, or root.

Following penetration of the outer cell layer, infection is established within the host grass tissues when the invading fungus succeeds in obtaining food from the grass host. The branching, tube-like hyphae may grow between the host cells, inside and through the host cells, or both, depending on the fungus. Hyphae that grow between the cell walls obtain their food by specialized absorbing organs called haustoria. These are balloon- or finger-like projections of the hyphae that are thrust into cells. Examples of haustoria-producing fungi include the rusts, powdery mildews, and *Pythium*. Hyphae of other fungi absorb their food directly from the host cells.

All disease-causing fungi secrete enzymes, toxins, and growth-regulating compounds. Certain fungal enzymes break down complex polysaccharides in the host cell walls, while others destroy the protoplasm within the cells. The result is the formation of simple sugars, amino acids, and other foods which are absorbed by the invading fungus hyphae and used as a source of energy.

Toxins are complex chemicals, sometimes antibiotics or polysaccharides, that destroy the permeability of the host cell walls and kill the protoplasm within the cells or cause it to malfunction. For example, the Rhizoctonia brown patch fungus produces a toxin that kills several cells in advance of the invading hyphae. The Sclerotinia dollar spot fungus secretes a toxin that is injurious to the root tips of bentgrass. Fairy ring fungi also produce potent toxins that injure or kill grass roots.

Growth regulator chemicals secreted by fungi influence the rate of cell division and enlargement, either positively or negatively, resulting in abnormal growth of grass roots, leaves, tillers and rhizomes, or floral parts.

Infection by fungi may result in several mechanisms that interfere with or stop one or more essential functions of the plant. These result in disrupting photosynthesis, respiration, and metabolism of host cells, or blocking transport of foods, mineral elements, and water from leaves to roots or roots to leaves.

Disease development is a series of four events collectively called the disease cycle. The events are as follows:

1. Inoculation involves bringing the fungus, as spores, sclerotia, or hyphal fragments, into contact with the grass plant where penetration can occur.

2. Penetration into the plant occurs via wounds, natural openings, or the plant surface directly.

3. Infection is the process by which the fungus absorbs host nutrients and establishes a more or less stable parasitic relationship with the grass host.

4. The incubation period is the intervals in hours, days, or weeks between establishment of an infectious relationship and the appearance of disease symptoms. During this period, the fungus continues to invade new host cells and tissues, while building up a food reserve. The degree of host invasion depends on the resistance of the grass cells and the disease potential of the fungus. Powdery mildews normally penetrate only the epidermal cells, while blight-producing fungi may invade a high percentage of host cells and tissues within a plant.

After an incubation period of 24 hours to many weeks, the fungus reproduces by forming spores or sclerotia that are disseminated to other turfgrasses where the disease cycle may be repeated.

Turfgrass diseases are controlled by a combination of sanitary and cultural practices, environmental factors, and use of resistant cultivars or grass species, and by the proper use of protective, curative, or systemic fungicides.

This discussion is concerned with how fungicides control diseases. Information on nonchemical control is given in *Lawn Diseases in the Midwest*, available at all county extension offices; and Reports on Plant Diseases Nos. 400 and 402, available from the Department of Plant Pathology, 218 Mumford Hall, University of Illinois at Urbana-Champaign 61801. Even the best fungicides are ineffective without a sound cultural management program.

A fungicide is a chemical that kills or inhibits fungi. We recognize three different types:

1. *Protective fungicides* are applied to seed, foliage, or soil as sprays, dusts, or granules to prevent fungi from penetrating plants and causing infection. These materials provide protection, but do not kill fungi established within a growing plant or seed or most fungi entering through the roots. The great majority of turf fungicides in use today possess protective qualities. Those that are only protective include zineb, thiram, and sulfur. These fungicides must uniformly cover the area of the plant that can be invaded before spores, hyphal fragments, or sclerotia come in contact and infection starts. They require frequent application at 7- to 14-day intervals, depending on weather conditions and watering practices or natural rainfall. Practically all dust and granule formulations function as protective fungicides and should be used accordingly.

2. *Protective-contact fungicides* are used the same as protective fungicides. However, they can destroy established infections. "Contact toxicity" means that the fungicide may either kill or inhibit further growth. The list of protective-contact fungicides includes cycloheximide (Acti-dione), anilazine (Dyrene), benomyl (Tersan 1991), captan, chlorothalonil (Daconil 2787), Karathane, maneb or maneb + zinc ion (Fore, Tersan LSR, Manzate, Dithane M-22), PMA materials, thiabendazole (Mertect), ethazol (Koban), chloroneb (Tersan SP), and the new thiophanates.

3. *Systemic fungicides* are chemicals that are absorbed and distributed within the grass plant, destroying established infections and, hence, controlling certain diseases up to several weeks or more. Examples include Acti-dione, benomyl,

thiabendazole or TBZ, diethyl-thiophanates (Cleary 3336 and Tobaz), dimethyl-thiophanates (Topsin-M, Fungo 50 or 70, Chipco Spot Kleen), chloroneb, and ethazol. To be effective, a systemic fungicide must be absorbed by the seed, leaves, roots or tillers, and rhizomes of the grass plant and be transferred in an active state to where disease infection occurs. There are many potential systemic fungicides that can be taken up by plants but fail because the product soon breaks down to an inactive chemical, accumulates where infection does not occur, is phytotoxic, or for some other reason.

Fungicides kill fungi by breaking the disease cycle in one of several ways. Spores and sclerotia absorb fungicide together with water during the early stages of germination. It has been shown for a number of spores that they selectively absorb certain fungicides up to 500 times the concentration of the chemical in the droplet of water. The spores must thus expend energy to absorb the fungicide which kills it before penetration can occur. Protective-contact fungicides may be taken up by germinating spores or sclerotia to check further growth; the fungicide may be absorbed by fungus hyphae after germination or before penetration occurs, even after the start of infection. This type of fungicide obviously has advantages over the strictly protective type. Systemic fungicides, besides giving fair to excellent protective control when applied as sprays, also inhibit further growth of the fungus once infection has occurred. The fungus is prevented from reproducing and causing additional invasion of the host.

How do turf fungicides kill fungi? We do not know the exact mechanism for every fungicide, and various means may be involved. We do know that the fungicide blocks one or more essential enzyme systems needed by the fungus for its metabolism, growth, and reproduction. The same fungicide may block one metabolic pathway or several, resulting in inhibition or death of the fungus.

When resistance to a fungicide builds up, as it has in some cases to cadmium compounds, Dyrene, and benomyl, the fungus has succeeded in changing its life style metabolism to bypass or shunt the enzyme system that the fungicide is inhibiting. With more specific fungicides, especially systemics, more of this type of resistance to fungicides is expected to occur. The logical solution would be to apply together two chemically different fungicides that block different enzyme systems; or, we could alternate these fungicides. There is evidence that fungi do revert back to their original metabolic pathways after a period of several to many generations.

INSECTICIDES AND THEIR ACTIVITY

Roscoe Randell

For successful insect control, the insecticide and the insect pest population have to at least come in contact with each other. This may appear over-simplified, but it is a basic requirement for effective insect control.

There are factors which influence how well the insecticide reaches the insect population. These factors include location of the insect pest in the turf area, the insect's feeding habits, life cycle of the insect, amount of insecticide applied, amount of water applied with insecticide, and the residual life of the insecticide.

Most insecticides in use today are contact poisons and do not need to be eaten by the insect. If the insect pest to be controlled is in the turf root zone, the insecticide has to at least come in contact with this insect to control it. The same thing holds true for control of leaf-feeding caterpillars. The insecticide should be on the foliage when the insect pest population is present for effective control.

Chlordane is a residual, almost insoluble, contact insecticide with adequate fumigant activity to make it an effective soil insecticide. When incorporated in the soil, it remains effective over a period of years.

Diazinon (Spectracide), carbaryl (Sevin), trichlorfon (Dylox), and chlorpyrifos (Dursban) are all contact insecticides, more soluble than chlordane, effective against leaf-feeding insects and moderate in residual activity.

Malathion, naled (Dibrom), and dichlorvos (Vapona) are contact insecticides which have very short residual lives.

R. Randell is assistant professor and extension entomologist, Agricultural Entomology, Illinois Natural History Survey.

PESTICIDES AND THE MANUFACTURER

J.T. Waddington

This paper includes information on the various requirements that must be met before a pesticide can be registered by the federal government's Environmental Protection Agency. The background material presented here should help you answer some of the many questions thay you may have or that you may have to answer concerning pesticides and the environment.

There are four major areas involved in the labeling and registration of pesticides. The first area is efficacy. This requirement involves the submission of data from various sources on the activity or performance of the product when used in accordance with label directions. This will usually also involve additional data on the use of rates, greater than those on the label, to determine the safety margin of the product for each use for which it is labeled.

Safety to the user is another area of concern in labeling pesticides. This involves the submission of toxicology data on the product to show that the product, when applied, will not expose the user to any undue hazard. These data reveal results of tests done to determine how toxic the compound is, depending on the type of exposure. This includes several types of exposure: Oral (taken in through the mouth); dermal (exposure to skin); inhalation (taken in by breathing); and exposure to the eye. The federal government has four categories in which pesticides are classified depending on their level of toxicity.

The toxicity determines the signal word which must appear on the label. The four categories are as follows:

Category I: highly toxic; signal word--DANGER or POISON and skull and cross-bones; compounds with an LD_{50} of less than 50.

Category II: moderately toxic compounds; signal word--WARNING; compounds with an oral LD_{50} from 50 to 500.

Category III: slightly toxic; signal word--CAUTION; compounds with oral LD_{50} in the range of 500 to 5000.

Category IV: relatively non-toxic; no signal word required; oral LD_{50} in excess of 5000.

LD_{50} refers to the concentration of a chemical in milligrams of chemical per kilogram of body weight of the test animal that kills 50 percent of the animals. Therefore, the lower the LD_{50}, the more toxic the compound because it takes less of the chemical to kill.

If a compound is toxic by another method of exposure, this could affect what signal word appears on the label. Thus, a signal word on the label is just as its name implies--a signal to pay particular attention to the precaution stated on the label.

J.T. Waddington is herbicide coordinator, Agricultural Chemicals Division, Diamond Shamrock Chemical Company.

In addition to determining how toxic a compound is, other effects are measured including birth defects, fertility, growth of newborn, and size of litter. Today, a company attempting to register a new pesticide may spend considerably more time and money in studying these so-called side effects than on any other area of research which may be required to get a product on the market. Terms such as carcinogenicity, mutagenicity, and teratogenicity are seen more frequently in terms of pesticide toxicology studies. Some of these studies may take as long as two years or more to complete.

The third area emphasized in labeling and registering pesticides is the effect of such substances on the environment. Of increasing attention in recent years, this area includes the effect of pesticides on fish and wildlife, particularly when the use pattern of a new product dictates that these species may be exposed to the product. Research on how long a pesticide will persist in the soil environment and what happens to the product must be established. Research in this area would include studies on how a product is broken down in the environment, what other chemicals are formed in these breakdowns, and what is the ultimate fate of these breakdown products. Does this product or its breakdown products get into the underground water supply and ultimately end up in streams and lakes?

Some of these studies, as well as the extent of the research in a particular area, is determined by the results obtained in previous studies. For example, if research shows that a chemical is water soluble, leaches easily in soil, and may ultimately be found in lakes and streams, then toxicity studies on fish become extremely important.

The fourth concern in labeling pesticides includes residue levels of food crops. Although residue studies are not directly involved in pesticides registered for use on turf, it is necessary to review this area in order to fully appreciate the overall area of pesticide registration. When food crops or crops which are fed to animals raised for meat, milk, or eggs are treated with a given pesticide, research must be conducted to determine the fate of that product in the crop or part of the crop which is consumed. Residues are simply the amount of the pesticide or its breakdown products found in the crop. Maximum residue levels or tolerances must be established by EPA on each crop before a product can be registered for use on the crop. The more toxic a compound, the lower the maximum residue that is acceptable. The amount of chemical and its breakdown products (again the residue) will determine the amount of toxicology studies that must be submitted with a petition. Many factors are considered in establishing tolerances of a product on various crops, including how much of a given crop is consumed by humans, and thus, the total residue level that could be consumed by an individual. For example, the average person consumes more potatoes than he does avocados.

In all of the tests previously mentioned, adverse results in any one could spell the death of a product or limitation on how a product could be used. Costs can run as high as several million dollars to develop and obtain registration on a product before one pound is sold. It is possible to spend several million dollars over a period of several years, and then find out that a product cannot be registered because of adverse data in one or more of the areas that have been discussed. Thus, companies are faced with difficult decisions every time a potential product is discovered, and unless there appears to be a sufficiently large market potential, it may be dropped.

The general attitude in this country on Pollution and our environment has had an effect on pesticides and their usage. Many of the regulations discussed above have been extensively expanded as a result of this. It is imperative that pesticides be used properly and strictly in accordance with label directions. However, it is wrong to condemn all pesticides as pollutors and as big factors in killing various species of wild life. Generally, we are faced not with pollution versus no pollution, but rather with which form of pollution is the least desirable. For example, a swarm of mosquitoes or a high pollen count is a serious form of pollution to most of us. Diseased and dead turf or wormy apples are certainly forms of pollution. Should we use pesticides discriminately to control these pollutors of our environment? I believe so.

A perfect example is the tremendous destruction to thousands of acres of forest in the U.S. this year from the gypsy moth. It is estimated that 500,000 acres have been infested with this dreaded insect which a few years ago had been restricted to about 135 acres, primarily through the use of DDT. I think anyone who has seen the remains of a beautiful forest destroyed by the gypsy moth would agree that this moth had profoundly altered the balance of nature in these regions. Pesticides can and do perform an essential function in our environment. As Secretary of Agriculture Butz has stated, "Who is going to decide which 50 million people will starve if pesticides are eliminated in the U.S.?" On the other hand, it is just as wrong for us to indiscriminately use pesticides and not follow label directions in using these materials. Pesticides are tools available to us, whether it be on a food crop or turf, that when used as directed will give the desired results with minimum effect on the environment. The best way to insure that these tools will continue to be available to us is to better understand these products and use them properly.

THE FUTURE OF INORGANIC ARSENICALS

Cecil F. Kerr

In July, 1970, the New York State Department of Environmental Conservation issued a list of 72 restricted chemicals. The original intent of the new regulation was that these restricted chemicals would be applied only by a custom applicator. In the original document, chlordane could be used only for termite control. Arsenicals were restricted to four pounds of active ingredient per acre. Mercury compounds and DDT were banned completely. Golf course superintendents had lost most of their valuable, necessary tools for maintaining beautiful golf courses.

Several superintendents, associations, and researchers wrote letters to the New York Commissioner of Environmental Conservation defending tricalcium arsenate, chlordane, and mercurial compounds. Researchers explained the expertise, knowledge, and responsibility that professional golf course superintendents possess.

New York changed their recommendations to allow usage of calcium arsenate, lead arsenate, and chlordane on turf by permit. The program is sound. Better utilization of chemicals will result from their sensible approach. They are developing uniformity between their requirements and those of the federal government.

Several golf course superintendent associations, leading turf researchers, distributors, over fifty golf course superintendents, and the executive committee of the Golf Course Superintendents Association of America wrote letters to the Director of Pesticides Regulation Division, Environmental Protection Agency, Washington, D. C. These letters were in defense of the usage of tricalcium and lead arsenate to control Poa annua on greens and fairways.

The following information was submitted to the Environmental Protection Agency:

Arsenicals are widely distributed in nature; soils naturally contain from 0.2 to 40 ppm of arsenic. Arsenic is very similar to phosphorus. Factors which affect the behavior of phosphate in the soil will also affect the behavior of arsenate. Phosphates and arsenates are either fixed or absorbed by plants. Fixation is greater in a fine, silty, clay collodial soil. Chelated iron and zinc increase fixation of arsenic. Arsenic and phosphorus are very similar; they exhibit the same valences, and have nearly the same molecular properties.

The addition of iron and zinc to the soil will decrease available arsenic by increased arsenic fixation, and should insure a more gradual removal of Poa annua.

Liming the soil increases the displacement of phosphate by arsenate. The availability of arsenates and P_2O_5 is increased as the pH increases to 7.

Some crops may be injured by concentration of arsenicals, especially on light sandy soils; however, most plants thrive on accumulations of arsenicals. The yields of peas, radishes, wheat, potatoes, turnips, sorghum, soybeans, and cotton are increased on heavy soils, such as Davidson clay loam, even with applications of as much as 1,000 pounds of calcium arsenate per acre.

C.F. Kerr is Chipco Turf Products Manager, Chipman Division, Rhodia Inc.

High levels of phosphate will overcome arsenate by antagonistic action. Increasing phosphate levels cause less arsenic uptake in plants.

Dr. Paul Rieke, soil scientist at Michigan State University, reported at the 42nd Annual Michigan Turfgrass Conference in January that increasing phosphorus will reduce the effectiveness of arsenic. Many golf courses have high phosphorus levels due to the frequent use of complete fertilizers. This necessitates the use of higher arsenic levels to achieve control.

Dr. Rieke further reported that soil reaction may affect the degree of arsenic toxicity. The presence of free Ca Co3 or lime may cause the precipitation of arsenate into insoluble forms. Michigan State University studies are concentrating on the interaction between arsenic phosphorus, soil reaction, and soil texture. Many researchers have reported that arsenic and phosphorus remain in the soil surface. Dr. R.P. Freeborg of Purdue University collected data which demonstrated that arsenicals tend to remain primarily in the upper four inches of the soil. Neither phosphorus nor arsenic leach appreciably in the soil. They do not contribute to pollution of lakes and streams. Dr. Paul Rieke has conducted greenhouse studies demonstrating that arsenates do not present a serious threat to ground water contamination or related pollution problems. He states that the arsenates should remain available to the professional turf manager for the control of Poa annua.

Bent, bluegrass, zoysia, bermuda, and fescue grasses are extremely tolerant to arsenical formulations. Many researchers recommend tricalcium arsenate for Poa annua, crabgrass, and soil insect control.

There is no acceptable substitute for tricalcium arsenate for effectively controlling Poa annua. All other materials seriously injure bent. Overseeding is not possible with most other chemicals.

Professional golf course superintendents have a thorough knowledge of their soil type, pH, phosphate level, and zinc and iron requirements. Purdue University has completed studies with atomic absorption spectrometry analysis that will aid us in computing the approximate amount of arsenic in the soil. Adequate data is available to establish a table of arsenic concentrations which will give a desired percentage of Poa annua control under given conditions.

With repeated applications of tricalcium arsenate, small amounts of arsenicals become available to the plants, gradually removing Poa annua over a period of years. Control is maintained with light annual applications (2 to 3 pounds 48 percent tricalcium arsenate per 1000 square feet).

Arsenicals have nutritional and medical uses. They have been used for treatment of sleeping sickness, malaria, syphillis, and many other diseases. Phenyl arsenic acid is fed to chickens, turkeys, swine, and calves as dietary supplements.

Arsenicals are generally not accumulative beyond the biological amount naturally found in the human body. Most species excrete arsenical dosages in the urine during the first 24 to 48 hours. After continued feeding of arsenicals, many animals can withstand extremely high dosages. The health and vigor of poultry and swine improves with continued feeding of low levels of phenyl arsenic.

The United States Golf Association, Green Section, reported in 1940 that arsenical treatments to turf could be made to kill insects or weeds without introducing any menace to the bird population. Birds are repelled by arsenicals and do not eat either lead or calcium arsenate.

In early October of 1971, the U.S.D.A. Arsenical Committee submitted a report to the Federal Environmental Protection Agency recommending that lead and calcium arsenate not be used on golf courses. On October 29, 1971, several leading turfgrass researchers, technical representatives of industrial firms, and Melvin B. Lucas, Jr., of Garden City Golf Club, met with the U.S.D.A. committee in Beltsville, Maryland, to submit technical data defending arsenicals. The U.S.D.A. reversed their decision. They submitted an amended report recommending tricalcium arsenate for Poa annua control.

Dr. Paul Alexander and the executive committee of the Golf Course Superintendents Association of America wrote to the Director of Pesticides in Washington supporting arsenicals, stating: "Specifically, we wish to support the evidence presented to various state and federal agencies by Mr. Cecil F. Kerr, Dr. William H. Daniel, and myself. This Association represents over 2,400 golf course superintendents from the United States, Canada, Mexico, and other foreign countries. We are firmly convinced that these men, because of their educational backgrounds, actual agronomic experience, and professional integrity, are extremely well-qualified to use the chemical tools which are vital to the growth and management of fine turf."

The Federal Environmental Protection Agency, Office of Science and Technology, and U.S.D.A. Arsenical Review Committees have submitted favorable reports recommending the wise use of arsenicals by professional turf managers.

Calcium and lead arsenate are applied on a prescribed basis. Soil types, pH, phosphorus level, and percentage of Poa annua are analyzed. A ten-point program for gradual removal of Poa annua is recommended.

1. Drain the low areas.
2. Correct soil acidity.
3. Eliminate phosphorus in the fertilizer program.
4. Overseed often, even at the time of application.
5. Aerate.
6. Vary application rates according to existing conditions of soil type, pH, percentage of Poa annua, and phosphorus level.
7. Achieve Poa annua control.
8. Maintain control with light, annual applications.
9. Liquid phosphate may be used as a "check valve" if Poa annua is dying too rapidly.
10. Apply on frost-free ground.

Arsenicals are essential in order to maintain healthy turf. We cannot overlook the value of healthy turfgrass as an anti-pollutant, as a basic oxygen producer, and as a prime erosion control agent. The wise use of arsenicals will maintain a suitable habitat for wildlife while eliminating unsightly weeds and harmful insects on golf courses and recreational parks, providing a beautiful environment.

TURFGRASS: SHADED ADAPTATION AND CULTURE

James B. Beard

Good landscaping calls for utilization of trees and turfgrasses in association. Although no accurate data is available, it is estimated that 20 percent of the existing turfgrass areas in the United States are maintained under some degree of shade. In view of the extensive acreage of shade turf that exists throughout the country, it is surprising how little turfgrass shade ecology research has been conducted. Before we can discuss shade grasses and maintenance, the microclimate typical of shaded conditions must be considered.

Shade adversely alters the turfgrass microenvironment. The most obvious change is the reduction in light intensity. A canopy of trees can screen out as much as 98 percent of the incoming solar radiation. Light quality is also affected in comparison to the normal distribution within the visible spectrum. The light quality under a canopy of trees has a spectrum low in blue and red wavelengths, and a predominance of green and far-red wavelengths. The blue and red wavelengths required for photosynthesis are also the wavelengths screened out to the greatest extent.

Poor turfgrass quality under shade conditions is frequently attributed to a lack of light. However, a number of other important environmental factors must be considered in shade ecology. Included are: moderation of diurnal and seasonal temperatures, both air and soil; increased relative humidity; restricted air movement; increased intensity and duration of dews; a reduction in atmospheric carbon dioxide; and tree root competition for water and nutrients.

Turfgrass adaptation to shade does not involve any single factor, but is the result of a complex microclimatic regime. The increase in relative humidity and dew, plus the reduction in wind movement under shaded conditions, enhances disease activity. The more favorable microclimate for disease and the lack of disease-resistant cultivars have been shown to be key factors in the adaptation of cool-season turfgrasses to shade.

The low light intensities that occur under shaded conditions limit the amount of carbohydrate a plant can synthesize. As a result, carbohydrate deficiencies cause a decrease in shoot, root, rhizome, and stolon growth. In general, the growth reduction of roots under shade is greater than the shoots, and the root to shoot ratio is lowered. This suggests that when carbohydrate supplies are not sufficient to support growth of both the shoots and the roots, the above ground portions of the plant have preference or first priority at the expense of the root system. The root system of shaded turfgrass plants is also reported to be shorter, thinner, wiry, and less branched.

Plants respond morphologically to shade conditions. Typically observed under shade are thinner leaves, larger leaf area, thinner stems, longer internodes, and reduced tillering.

J.B. Beard is professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan.

Turfgrass density in terms of shoot numbers and rhizome numbers is reduced significantly under shade. On the other hand, shading increases plant height and leaf length. Shade stimulates the emergence or upright growth of rhizomes and stolons. A more upright growth habit causes a greater percentage of the plant to be removed during the mowing process, and the development of a more open turf. The establishment of sods by creeping-type turfgrasses is significantly inhibited by shade.

Physiologically shaded plants exhibit the following characteristics: higher chlorophyll content; lower photosynthetic rate; lower respiration rate; lower compensation point; lower carbohydrate to nitrogen ratio; reduced respiration rate; higher tissue moisture content; and lower osmotic pressure.

In general, these morphological and physiological changes cause an overall deterioration in plant vigor resulting in reduced tolerance to heat, cold, drought, disease, and wear.

Based on the limited data available on turfgrass species' tolerance to shade, the fine-leafed fescues are the preferred grasses to be utilized (Table 1). The Kentucky bluegrasses possess poor shade adaptation due to a high susceptibility to powdery mildew. No comparisons between bentgrass and red fescue have been reported. However, assuming that disease control practices are utilized, the bentgrasses should provide adequate turf under shaded conditions, although lower in quality compared to full sunlight. In order for cool-season turfgrass cultivars to perform well under shaded conditions, they must possess improved disease tolerance. Characteristics such as growth habit and ability to capture and convert light energy into chemical energy at various wavelengths are involved in shade adaptation. However, disease resistance is the key limiting factor that must be revealed.

Table 1. Relative shade adaptation of eleven cool-season turfgrasses.

Shade Adaptation	Turfgrass Species
Excellent	Chewings fescue Red fescue Velvet bentgrass
Good	Rough bluegrass Creeping bentgrass Tall fescue
Medium	Colonial bentgrass Redtop Perennial ryegrass Meadow fescue
Poor	Kentucky bluegrass

Culture of turfs under individual trees is no great problem when the limbs below 8 to 10 feet are pruned. Shade turf difficulties are generally encountered with a grouping of trees having an extensive, dense canopy.

The first step in proper culture of shade grasses is to modify the microenvironment as much as possible to favor proper conditions for grass growth. This would include: (a) selective thinning of the tree canopy to improve light penetration to the grass; (b) deep fertilization of tree roots through injection procedures; and (c) some root pruning at intervals, especially with shallow-rooted tree species. The trimming of lower limbs and the thinning of dense barriers of low shrubs or young trees will also improve air movement, reduce the relative humidity, and prevent stratification of air temperatures. The end result is less turfgrass disease problems.

Three basic factors are involved in the culture of turfgrasses under shade. The cutting height should be high, preferably 2 to 2.5 inches for cool-season turfgrasses. The high cutting height provides greater leaf area for the synthesis of carbohydrates that are required to maintain shoot and root growth. Fertilization should be according to the specific needs of the grass. For example, red fescue is impaired when over-fertilized with nitrogen. Excessive nitrogen fertilization will also tend to produce a more succulent tissue that is more prone to disease and wear injury. The third factor involves judicious irrigation. Irrigate infrequently and deeply to minimize disease problems as much as possible. It is preferred that irrigation be practiced in early morning. The microenvironmental conditions favorable for fungal activity will be reduced if water is present on the leaves for the least period of time.

A final factor which should be kept in mind is that turfgrasses growing in the shade are in a succulent condition with a reduced tolerance to wear. Therefore, traffic patterns should be controlled to minimize traffic effects over shaded turfs as much as possible. Shaded turfs are more susceptible to wear injury and have a reduced capability for recovery from traffic.

REFERENCE

1. Beard, J.B. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 658 p. 1973.