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*In cooperation with*

ILLINOIS TURFGRASS FOUNDATION

I am pleased to welcome the members of the Illinois Turfgrass Foundation to their 11th annual meeting, and to thank the Foundation for the continued interest and fine support that it gives to the research and educational efforts of the College in the broad area of turfgrass management and production. The interest and support of the Foundation mean a great deal to us, and we look forward to working with it in the spirit of cooperation and constructive planning that has meant so much in the past.

The conference is presented specifically for persons interested in turf management. The following abstracts present up-to-date information required by those who wish to maintain a high-quality turfgrass area but do not constitute positive recommendations unless so stated. Statements made herein are the responsibility of either the speaker or the institution he represents. Reproduction and publication are permitted only with the approval of each author.

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# GOLF COURSE CONSTRUCTION AND RELATED PROBLEMS

***A.R. Mazur***

Because of high real estate values or the lack of desirable land, golf courses are usually constructed on marginal land. The land most often available is low and poorly drained, hilly with a poor soil type, or for some other reason undesirable for either cropping or urbanization.

If a choice of land is available, consider existing natural drainage, soil type, beneficial topographic features, accessibility, and so forth. Check a potential site during the rainy season to determine if any appreciable drainage problems exist. Rushes, sedges, and *Poa trivialis* are usually indicators of poorly drained land. If you have questions about a particular tract of land, consult the county Soil Conservation Service (SCS).

Poorly drained soils are bad irrigation risks. When irrigation is installed, the drainage problems are magnified many fold. The cost of installing a drainage system and maintaining poorly drained land often more than offsets the initial cost of a more suitable piece of well-drained land.

When you have a choice, avoid heavy clay and silty clay soils, which are generally more difficult to manage than lighter sandy soils. When golf courses are irrigated and have heavy traffic, clay soils are particularly troublesome. Large acreages, moreover, preclude soil amending except for limited areas such as greens and tees.

## Design

Design is the key to a good golf course. A good design combines golfing challenge, aesthetic appeal, and maintainability on the existing terrain. Large sand traps with capes and bays are beautiful to look at but require a great deal of maintenance. Restricted cup placements, trapping, and tee orientation can dictate traffic patterns that permit no relief from turf wear; in such areas frequent sodding or the installation of permanent cart paths may be necessary to maintain a desirable turf cover.

Good surface drainage is an essential design feature, particularly on such intensively maintained areas as greens and tees. Greens should drain in at least three directions. Having all the surface drainage go into the approach, for example, is particularly undesirable. If excess moisture from irrigation and rain is not handled by improved subsurface drainage, the approach will quickly become infested with annual bluegrass, and wear from traffic will leave footprints and ruts in the extremely critical playing surface.

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That the green should not be perfectly level is well understood; however, adequate cupping area should be provided to distribute traffic uniformly over the green. The size of a green is no indication of serviceability: 8,000-square foot greens may provide less cupping area than some 5,000-square foot greens.

## Construction

Do the job right the first time and there will be no financial catastrophe from reconstruction: On a golf course mistakes can be buried but they will have to be dug up again. Include cart paths and service roads in the original plans; adding them later can be expensive in terms of time, money, and aesthetic balance.

There are many ways to construct putting surfaces. The method outlined in the USGA-Greens Section is especially valuable because it can be easily duplicated regardless of a location's soil types. This method uses a soil analysis that prescribes the proportions of sand, soil, and organic matter to use.

The physical properties of a soil should also be considered. The relative proportion of large (noncapillary) pores to small (capillary) pores in the soil is a good measure of the balance between the soil water and soil air that is essential for healthy turf. After five years of traffic, a desirable green should have about 35 percent total pore space, of which 15 percent should be noncapillary and 20 percent capillary. Few natural soils meet the ideal, and the "guess and feel" method of soil mixing often leads to a fine-quality adobe brick.

A green must be provided with adequate subsurface drainage to handle the moisture percolating through the soil profile. A 4- to 6-inch pea gravel and tile base will handle percolating moisture quite adequately. A minimum of 10 to 12 inches of screened soil mixture should be placed over the gravel and tile base. It is preferable to screen the mixture "off site" to insure complete blending of amendments.

Tees should be constructed with at least 4 to 6 inches of screened top soil. They should be large enough to allow frequent changing of markers so that excessive turf wear in any one area is avoided. A rule of thumb is to allow 100 square feet of teeing surface per 1,000 rounds of golf on par 4 and 5 holes and 200 square feet per 1,000 rounds of golf on par 3 holes where irons are used. Multi-level tees have lost popularity in the last few years because valuable teeing area is lost between levels and because mowing is a problem.

When constructing tees, allow a 1 to 1-1/2 percent grade from front to rear to promote quick surface drainage. On multi-level tees the areas farthest from the greens should be sloped slightly to the side to avoid ponding between levels. Where economically feasible, subsurface drainage should be installed in the same manner as for greens. Elevating tees and greens can also improve drainage. Well-drained tees and greens permit play after saturating rains much sooner than poorly drained ones.

The easiest and best time to make drainage improvements is during initial construction. Once the grasses are established, it is natural to be reluctant about tearing things up again to make the necessary improvements.

Grading and leveling fairways are not easy, since some 30 or more acres are involved. Because of the large acreages, little if any soil amending is possible on fairways--hence the importance of the initial land selection. Fairways should have contouring and character, but the final grade should eliminate all ruts and pot holes before seeding. During construction all available topsoil should be conserved and stockpiled until final grading.

It is difficult to drain large areas perfectly. Good surface drainage removes moisture that cannot be handled by percolation through the soil; this helps avoid "scald outs" during the summer and "freeze outs" in the winter. Grading, when done properly with grading stakes and a transit, is the key to good surface drainage. Ideally, there is a 1 to 1-1/2 percent grade from the center out into the rough on each side.

Swales and grass waterways may adequately handle natural surface runoff. More severe situations need tile or slit drains to move the water. The slit or French type drain is widely used because of its quick installation and low cost.

If fairways are to be constructed over swamps or peat bogs, hire a competent drainage engineer. Such areas may require lakes or ponds with relief pumps to lower the water table.

Bunkers and traps, which add to the playing and aesthetic qualities of the course, should be used in proportion to the maintenance budget. The course design should keep hand maintenance to a minimum. Placing traps too close to greens, for example, will result in rapid deterioration of the closely mowed turf; the narrow strip of turf between the trap and the green will be difficult to maintain; sand blasted onto the putting surface will take its toll of mower reels and bed knives. Try to allow at least 10 feet between the actual trap and the outer edge of the green.

Steep flash traps are desirable for visibility but present problems with sand stability. Steep banks around bunkers make mowing operations difficult. Hand labor can be reduced if these slopes are kept within the limits of mechanized mowing.

Surface water should be diverted around traps to avoid washing the sand. Traps must have good subsurface drainage if they are going to play well. The sand in traps that hold water must be replaced frequently; accumulation of soil particles gives this sand a dirty appearance. Poorly drained traps often set up like concrete: select sand with a low percentage of fines and provide good drainage to prevent this.

Irrigation, like drainage, should be installed during construction before the turf is established. Besides being less costly, this greatly reduces the time required for turf establishment, since the newly seeded course can be easily watered.

The design of an irrigation system is no job for an amateur; an experienced irrigation engineer should be employed. The new sophisticated systems with such features as individually controlled heads, syringe cycles, and pumping capacities of more than 1,000 gallons per minute have greatly reduced the man hours required to water the golf course. Operations such as syringing the dew off the whole course before the morning play are no longer out of the question.

Using a mulch or netting material on steep banks and slopes is added protection against washout from sudden downpours. The small extra cost of these materials may save the time and expense of reseeding.

Remember: Forethought and planning can reduce construction and future maintenance costs and provide the best possible golfing conditions in the shortest possible time.

# TURFGRASS SALT PROBLEMS

***T.D. Hughes***

Deicing salts are applied in large amounts to our highways. In Illinois, salt is being used in increasing amounts, because of construction of new roads, but also because of more limited use of snowplows. Public demands for safe travel at high speeds necessitate a more thorough removal of ice than can be accomplished by plowing alone. On roads where traffic loads greatly exceed design specifications, the slowing of traffic movement due to icy conditions can be costly as well as hazardous. Public demands for ice-free roads thus force state highway officials to use large amounts of salt.

## Salt Usage

In Illinois, the amounts of salt used are staggering. A total of almost 2,000,000 tons have been used in the last 13 years. This is enough salt to apply 40,000 pounds per acre on 100,000 acres of land. In other words, it is enough salt to raise the salt levels in the surface 6 inches of soil to 20,000 p.p.m. on 100,000 acres. It appears from the preliminary work that 20,000 p.p.m. of soluble salt is about the maximum that can be tolerated even if the most salt-tolerant plants are used.

The problem of salt on roadside areas is more severe in some areas than in others. The problem is not strictly caused by use of large amounts of salt, but is partly due to the nonuniform distribution. For example, the expressway areas in Chicago receive unusually large amounts of salt. Annual applications on these areas of up to 80 tons per lane-mile are common. Soluble salt concentrations in the soil of 50,000 to 70,000 p.p.m. on medians have been found where grass stands have failed.

A particularly alarming aspect of the problem is that the state of Illinois now uses three times as much salt as it did 10 years ago. The serious problem of salt use has only recently been recognized. If trends continue, however, the problem will become more widespread and more severe quite rapidly.

## Alternative Procedures

What are the alternatives? For reasons mentioned previously, relying solely on snowplows is not feasible. Use of electrical heating cables has been suggested, but the power costs are prohibitive. Use of other inorganic salts, other than NaCl and $CaCl_2$ which are now being used, is a remote possibility. Salts other than NaCl and $CaCl_2$, such as $(NH_4)_2SO_4$ and $NH_4NO_3$, are more

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expensive and less effective. Urea is now being used on some airport runways because it is less corrosive to jet engines. Urea may be a possibility, but use of urea as well as inorganic nitrogen-containing salts such as $(NH_4)_2SO_4$ and $NH_4NO_3$ may cause nitrate pollution problems. Some exploratory work on nitrate formation from urea when it is used on highways will be done this winter.

Another possible solution for controlling erosion, as a result of the loss of vegetation due to salt, may be to pave roadside areas. This would necessitate rebuilding drainage and storm-sewer systems to accommodate the increased rate of flow from roadside areas and would contribute to higher temperatures in the summer. Thus paving is not a very satisfactory solution and probably will be employed only after everything else fails.

## Grass Growth in Highly Saline Soil

Even if the use of NaCl and $CaCl_2$ were to be discontinued, many areas are already severely contaminated. However, it should be pointed out that much of the salt applied remains fixed in the soil to help reduce the pollution problem away from the site of application. Leaching and removal of soil by erosion are of some help, but in severely contaminated areas, the soluble salt levels are too high for immediate removal in these ways. Thus soluble salt levels in the soil will probably remain high for several years. A most urgent need is for plants highly tolerant to salt that can be used on these areas.

A grass was found on roadside areas in the Chicago area that appeared to exist under conditions that were inhibitory to other grasses. This has been tentatively identified as *Puccinellia airoides*, Nuttall's alkaligrass. Greenhouse investigations indicated that it will grow in soil containing 20,000 p.p.m. of soluble salt and that it is even more salt tolerant than crested and western wheatgrass. It is also very desirable in appearance and is short enough to be grown on roadside areas without requiring extensive mowing. Many studies are now being conducted to gain more information about the grass. Some of these studies are being conducted to test herbicide tolerance and sod-forming ability. Genetic variability within the species is being checked. If considerable variability is noted, it may be possible to select within the species for increased salt tolerance. Observations to date indicate that it is a good seed producer.

The results definitely indicate that the Nuttall's alkaligrass can be successfully used to provide a vegetative cover on areas that up to now have been void of vegetation. This constitutes a significant step in solving the problem. However, it appears that the soil in some areas contains too much salt for growth of any grass species. The problem is by no means solved.

# TREES--A VERSATILE AND NECESSARY ELEMENT FOR THE GOLF COURSE

***L.T. Whitlock***

Trees, in general, are a very necessary element to the success of a golf course, but they are seldom utilized to their fullest potential. In speaking of trees, it becomes a matter of relationships with respect to function and priorities. Before determining the function, one must determine the actual problems and potentials at hand.

For example, let us assume that we are to improve a course that has already been planted and the plant material is beginning to die out. One must make several decisions about the planting. That is, is it to complement the actual fairway, to enhance the appearance of traps and hazards or to give directional indication of play? Is there enough screening material to allow the players safety? The proper use of tree material hinges to a great degree on the ability of the superintendent or caretaker to discern the highest benefit in the use of plant material.

In light of this hypothesis, then let us direct our attention to the possible problems that may arise. After determining the actual potential of a particular element on the course and why it should be used, we must also determine the best type of material to plant. The tree type must be considered in relationship to the type of terrain, the type of soil, the type of climate, the moisture conditions, and its natural habit of growth. These elements must then be considered in relation to the problem. Which particular tree type most suits the situation at hand? The form and color of a crab apple can act as a distance or bounds marker on a fairway. The form and character of a sugar maple can complement the terrain or enframe a hazard. After selecting the individual plant, one must then consider it in relationship to the other types of trees that are to be used. Are the tree types compatible? A balance and harmony must be achieved between each factor influencing a particular use so that an organized "whole" is achieved from each point of view and the major use functions are satisfied.

As you can see, before you can answer questions of plant selection, color, texture, and maintenance, you have to make the initial determination of what is good and what is bad and how suited a particular plant will be for a certain situation. Problems arise when no definite plan or placement has been formulated in considering the relation of actual plant material to its potential function. One must make the decision as to whether a particular tree, row of trees, or grouping of trees is to act in harmony with some other element. Whether used contrastingly or as a subtle transition, the actual use can heighten the excitement of play.

The tree must thus be considered in its relationship to other things. In considering its relationship, one must ask the questions: what, when, why,

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and how, and as a final test, the question of what will be gained. If one will stay within these simple parameters, the physical design of the course will improve, the excitement of traps and hazards will be enhanced, directional indication of play will aid in the speed of play, the protection of players will be assured, undesirable elements will be screened, and maintenance problems can be prevented. Trees can truly be a versatile element in any golf course, park, or clubhouse area.

# RECENT ADVANCES AND PROBLEMS IN TURF WEED CONTROL

### *J.D. Butler*

A discussion of weed control immediately turns to one of chemicals. Herbicides account for most of the recent work in weed control. It is typical human nature for the majority of those working in a given field to feel that they are as advanced as is possible. However, since the coming of 2,4-D and the many herbicide breakthroughs that followed, those who work in weed control do not have this attitude. Perhaps, along with the possibility of many revolutionary new herbicides, in the not too distant future a central computer system will be available to assist in selecting herbicides. If the computer is supplied with information on the weed, the turf species, the temperature, etc., it could suggest the best chemical for control and the percent chance of success or failure. It could go so far as to suggest better chemical use by recalling small and often forgotten details. As with our present system of making recommendations, the more information and the more accurate it is, the better results the computer would deliver.

## Promising Developments

Much of what holds promise for us today in weed control also presents many problems that must be worked out. Such problems are continuous and exist for the chemist in the laboratory and the user on the golf course or wherever he might be. One of the most promising developments in recent years has been the introduction of herbicides safe enough to use on new seedings or on young seedlings. Annual weed problems in new seedings are usually a problem only in spring and early summer and not in the fall. Siduron at seeding controls crabgrass and certain other annual grasses, and bromoxynil controls certain broadleaf weeds in young stands of Kentucky bluegrass and certain other turf. The use of a herbicide, especially for crabgrass control, has made possible successful spring seedings in southern Illinois where failures were common and expected because of competition from crabgrass.

Several good preemergent and postemergent chemicals are now available for crabgrass control in Kentucky bluegrass. The choice of a chemical for this common problem today may depend a great deal on cost, ease of application, length of residual, etc.

## Weed Control in Bent

Another promising development in recent years has been the introduction of a few selective organic materials for use on bentgrass. These were especially needed for bentgrass greens. When applied with sufficient forethought and

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attention to certain environmental factors, these materials have provided excellent results. Two of the newer materials have received wide acceptance. Bensulide is used for crabgrass and other annual grass control, while MCPP (mecoprop) is used for clover and chickweed control. Other materials are also available that give satisfactory results for weed control on greens. Herbicides for golf greens coupled with acceptable materials for Pythium control on greens have made it possible to have near "perfect" greens most of the time even in the southernmost areas where bentgrass is grown.

## Herbicide Combinations

Combining materials for broadleaf weed control has become a common practice. Many of the major companies which supply herbicides usually market two- or three-way combination materials. Virtually without exception, they use 2,4-D as the major constituent in the combinations. Dicamba, because of its extreme effectiveness as a weedkiller, is often included as a rather small portion. The combinations seem to be synergistic and not additive.

Another major advance in herbicides has been the development of materials with a high level of safety for the desired plant while giving satisfactory control of the problem weed. It is unusual today for a herbicide to be recommended or used if it does not approach the 4X safety factor arbitrarily set by many turf researchers.

## Perennial Weed Control

Little progress has been made in providing satisfactory control of perennial weed grasses and sedges in established turf. Although it has been possible to get a high percentage of control of bermuda and bentgrass in Kentucky bluegrass, the difficulty associated with the control material at the rates required currently prohibits its use on most turf areas. Where atrazine and Kerb can be used--safe for use on only a few grasses--there seems to be hope for controlling some perennial grasses. Perennial grasses are likely to continue as our number-one turf weed problem. However, it seems that we are now on the threshold of some major chemical breakthroughs in this area.

In Illinois, especially in the northern part, annual bluegrass is the major weed problem on golf courses. Although it is tolerated and even desired on some of the finer golf courses, newer and more selective herbicides are needed. On bermudagrass where *Poa annua* is a problem, Kerb has shown promise as a postemergence control. Limited quantities of this chemical are becoming available in the south. However, this material has not shown promise on bentgrass or bluegrass because of acute phytotoxicity.

## Major Problems

As mentioned above, the major problem in turf weed control continues to be the control of one perennial grass growing in another. Nimblewill, tall fescue, bentgrass, and bermudagrass are major weed problems, and in some situations rough bluegrass, because it was a contaminant in the seed, has become a noticeable problem.

Today it is important to recognize the lack of specific chemicals to do certain jobs. One must also face the prospect of regulations and restricted or prohibited use of certain chemicals. Currently 2,4,5-T has restricted usage requirements. And it seems not unlikely that a license will be required--if for no other reason than forcing the reading of the label--for handling certain materials.

Other problems are associated with the fact that a certain amount of residual action is necessary for some of the materials to work satisfactorily. An example of this would be in preemergent crabgrass control. This opens the possibility for a great amount of research that has been talked about but not worked on very much--the ability to totally inactivate a compound or better yet to turn it on and off at will.

## Herbicide Experience

Another problem associated with the use of a herbicide is the need for experience with the specific material. Virtually any of the products available will have its own little quirks. It is always well to run a small test under as similar conditions as possible. Since some of the recent problems with herbicide injury took so long to show up, it is well to wait four to six weeks or even more if possible after making a test run before applying the material to large areas. Often the decision to use a material comes after consideration that the risk may be worth the potential gain. Of course, borderline decisions have many inherent problems and should be kept to a minimum.

This brings to mind some of the more recent problems with herbicides and "varietal" intolerance. Siduron, for instance, is quite safe to use on certain strains of bentgrass while other strains are quite sensitive. The same problem exists for atrazine on certain zoysia clones, and the problem of using PMA on Merion Kentucky bluegrass should be pointed out. More attention needs to be given to the effects of the common turf herbicides on new grasses before releasing them.

## Equipment Needs

Many of the problems associated with herbicides, whether poor control or turf or tree injury, are not necessarily the fault of the one making the treatment or the material, but of the method of application. Certainly the manufacture of equipment has made tremendous progress, and there is available everything from extremely accurate boom sprayers to helicopters for herbicide application. But the problem for the individual is usually that his limited inventory does not have the "perfect" piece of equipment needed for the particular material. Probably the most common herbicide injury problem this past year was on greens where patches of white clover had been spot-sprayed during the heat of the summer with a knapsack sprayer. The tendency for anyone using a small hand sprayer is to go overboard on the amount applied, causing injury to the turf or even killing it.

The progress in turf weed control has been phenomenal. The problems have been relatively small, and the advances great. Chemical weed control has virtually eliminated most of our common weed problems, and the sophistication of this young science seems to offer great promise for the near future.

# VIEWS OF TURF PROBLEMS IN THE 70'S

## *C.W. Lobenstein*

Forecasting the specific turf problems and developments in the 70's requires unusual wisdom and powers of extrasensory perception. Without such divining powers, however, I foresee our turf problems primarily as a continuation of those we have faced in the recent years. They may appear to change somewhat in intensity, but the basic issues are likely to be pretty much the same.

The principal challenge to the turf and grounds manager or superintendent will be the necessity to face these same problems more squarely than we have in the past. We will need to more thoughtfully utilize existing knowledge and increased research in order to recognize and correct basic causes rather than to merely palliate ("to ease without curing") our basic turf problems.

This can perhaps best be illustrated in the area of disease, weed, and insect control. The rapid developmental research of agricultural chemical products has certainly kept us in operation the last few years. This is good, but perhaps not so good either. Has the ease with which we could bail ourselves out of trouble with these materials too frequently kept us from really getting down to the basic reasons for disease or weed problems? I think we need to give increasing attention to the fact that in our use of chemical pesticides, we do upset biological balances in our turf. When we do, we cause injury to beneficial organisms at the same time we destroy the primary pest. We must recognize that chemical usage is a two-edged knife in our plant environments.

Observations of some old turf experimental areas which previously had received regular fungicide applications have been reported to show much more serious disease outbreaks when they were no longer protected by fungicides than did adjoining check areas which had not been treated in the past. During the severe Pythium season in 1969, bentgrass fields on a sod farm in the Kansas City area were apparently free of the disease, even without fungicide protection, while golf courses all around were faced with a constant battle to salvage their greens of the same varieties. Yes, the sod fields were mowed at greater heights, they were not kept as wet, nor were they pushed as hard. But neither had they been sprayed with any fungicides. It is risky to make assumptions from this, but it raises questions in our minds. Who knows what natural enemies of Pythium or other disease-causing organisms we destroy in our routine (and seemingly essential) preventive spray programs?

How many problems of weak, noncompetitive turf are actually attributed to a herbicide applied last year or the year before for weed control? This question can legitimately be asked of those considered quite safe. Even though we have considered this question vaguely for several years, safety of

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herbicides is still evaluated mostly by effects upon the visible above-ground portions of the turf. Little critical evaluation of root-growth effects or permanent retardation of the turf itself is included as yet.

Have problems associated with thatch accumulation become more serious only as fertility levels and growth rates have been increased? Aren't they also associated with increased use of broad-spectrum fungicides and insecticides? Broad-spectrum fungicides and insecticides have seemingly been a wonderful development because, ideally, when applied to our turf they controlled "everything." Could be that this is part of the problem--*they have* "controlled" all organisms, beneficial as well as detrimental. Thus, if the chemicals we have will become subject to limitations and restrictions as present trends indicate, the broad-spectrum materials will most assuredly be a primary target of restrictive measures.

This might immediately become a pressing problem. It could be possible that chemicals we have come to rely upon might be subject to these limitations and restrictions, forced by agitated public concern. Chemical usage on golf courses and other large-scale turf areas has unquestionably contributed less (if any) than any other facet of agriculture to environmental pollution. This is due to the minimum surface runoff of turf areas and the careful dosage control we have practiced. However, unless we are alert, aggressive, and at the same time reasonable, our industry may well get caught up in generalized hampering restrictions.

We need, then, to be facing the question, "How do I get the job of control of these pests done without the chemical tools?" It could come to that, although I seriously doubt it. However, in asking the question, perhaps we may do a better job than we have in the past of coming face to face with the reasons in mismanagement that will explain why these pests have come to plague us in the first place.

In this connection, the trend by many successful managers toward a more knowledgeable and even reduced nitrogen usage is encouraging. It is a common observation that those who generally are having the fewest troubles with disease, wilt, traffic, and wear stress are those who have kept nitrogen down to moderate levels. They don't object to the grass being a "little hungry" (as contrasted to "lush" standards), especially in stress part of the season. They have recognized that while the grass plant requires more nitrogen than other mineral elements, it is desirable only if supplied at rates which the plants really need rather than at rates they will actually absorb. There is too much evidence already recorded showing that lush, overstimulated turf is more susceptible to the most damaging diseases or stress factors. Of course it is not good sense either to swing too far on the pendulum to the point of starvation. Such plants are just as prone to the above problems also.

Fertilizer promotion for home lawns has become rather overbalanced in this respect. Promotion programs in the bluegrass region predominantly urge heaviest and most widespread home lawn fertilization in early springtime rather than early fall (because that is the time the consumer is most susceptible). This promotes unnecessary heavy growth of top at the expense of maximum root growth for summer survival. At the same time, it tends to predispose the turf to those diseases which usually take the most serious toll of the home lawns, to say nothing of the maximum feeding of competing weeds. High nitrogen levels, much leaf growth, and dark green color are the key "plus" points in such promotion programs.

We need to revise, in the user's mind as well as in our own, the correct standards and criteria of healthy vigorous grass. This requires recognition that the darkest-green turf producing a large amount of mowable growth is not necessarily the healthiest or most durable turf.

The recent increase in number of new varieties of bluegrasses and other cool-season grasses undoubtedly will continue as much attention is devoted to turfgrasses in breeding programs. However, I think that generally it is a false hope to expect new varieties to solve our problems with respect to diseases and insects. With other crops, and to some extent with turf, experiences have shown that almost as rapidly as plant breeders can develop disease-resistant varieties, the pest organisms can readjust and undergo genetic change, enabling them to attack the new resistant varieties. Even if this does not occur immediately, we often find that the new varieties are now susceptible to pests which previously were not serious, if present at all. Resistance of Merion bluegrass to the Helminthosporium leaf spots but susceptibility to rust and then to stripe smut is an excellent example of this.

Thus in biological systems, where the pests are capable of genetic change almost as rapidly as the host plant, it seems a bit futile to expect our disease and insect problems to be permanently solved by new variety development. Certainly new varieties which possess more desirable growth characteristics and climatic adaptations will be extremely helpful in our management efforts, but--the noble efforts of the plant breeders notwithstanding--it is doubtful that new varieties should be relied upon to permanently solve these problems.

The current trend toward increased use of zoysia to replace bermuda in the southern part of our area may alleviate the problem of what grass to grow for fairways and other sports ground turf. This may solve the question of winter survival and provide an ideal turf for summer traffic, but I am confident that increased acreages of zoysia will bring problems not currently recognized. We have already seen instances of serious-looking disease problems, and even cases of apparent winterkill under conditions of fairly high levels of maintenance. Chinch bug and other insect problems will no doubt appear on the scene if the acreage continues to build. Definite programs for thatch control and regular renovation will need to be developed among other things. This causes one to wonder if bermuda survival problems might not have actually resulted from lack of such a program with them in this area.

If present forecasts are correct, we probably will continue to see more new golf courses and other outdoor recreational areas developed. In spite of all that has been said and written about anticipating and reducing maintenance problems by careful original construction, we still see a disappointing number of problems in new facilities which arise from carelessness or lack of knowledge of sensible turf construction. Unfortunately, the fault sometimes lies in inadequate or erroneous architectural specifications, prepared by someone who really did not understand what he was doing.

Even more tragic and more numerous, however, are those cases where specifications are adequate and sound, but corner-cutting to reduce expense or carelessness in actual construction destroys the value of good specifications. Certainly this is the prerogative of individual choice, but the fact should be recognized then that decreased quality of turf facilities must be expected and accepted. Such a statement no doubt seems superfluous, but I am amazed at the number of cases encountered where such a choice has been made and then later there is a lot of grumbling about the quality of the turf.

Unfortunately too many turf facilities are still being built in situations where architectural responsibility and actual construction are independent and inadequately coordinated. For example I visited a course, opened this year, in which this situation was demonstrated. A vast amount of money was invested yet we found rocks and "globs" of pure clay scattered throughout the putting surface of the new greens. Drouthy streaks alternated with soggy algae-covered spots in the same greens--specified but not built according to decent standards.

In another case, an economy substitution by the contractor resulted in a greens mix consisting of 40 percent gravel, 40 percent silt and clay, and only 15 percent the desirable-sized sands. The result: drainage and grass-growing problems even before the course was opened for play; in fact, it wasn't. We still see repeated examples of too-small tees and greens because of the "higher than anticipated" costs and the argument that too large areas will increase maintenance costs too much; they usually increase those subsequent maintenance costs. In other cases, impatience or unrealistic time schedules bring second-rate construction or short-cuts. Should the price that must be paid in future maintenance and inferior turf always be subservient to those prescribed "opening dates"? Several of our larger sports stadia faced this problem before the current rage to artificial ground covers became "the thing."

Yes, construction costs are high, and will continue higher, no doubt. Certainly, sensible economy is noteworthy, but with the know-how and successful experience that is available today, it does seem foolish to continue to make the same mistakes as in the past in false economies which will ultimately create even higher costs in rebuilding and correcting as well as in routine maintenance. It certainly should pay well to assure (a) sufficient planning and construction periods to avoid last-minute pressures which force cheapening of construction, (b) proper on-the-spot supervision by persons knowledgeable in maintenance procedures, and (c) willingness to invest sufficient capital to assure adequate construction that will give the grass a chance.

Obviously a major problem of the 70's will still be the people who use the turf (or abuse it). Without aggressive efforts on our part, it probably is too much to expect them to recognize or even be concerned about the effects of their carelessness in compacting, abuse, unrepaired ball marks, etc. In these days when there is so much talk and publicity about the environment, the public apathy and apparent unconcern for those things they do to turf and other areas are discouraging to say the least. Still while "people" may aggravate us, we nevertheless have to "keep our cool" and recognize that they are the reasons for our jobs, that without them we wouldn't be growing turf. We have to do our best to cure the trouble they have caused while we try to increase our skills in the slow painful process of "educating them." We have to somehow diplomatically get the point across of the things they can do to help keep the turf they want; to get them to see that they too have some responsibility in helping to maintain the turf they use.

Certainly the "people problem" in terms of available work crews of acceptable quality will continue to haunt us. Most of us declare that we cannot continue to compete with the high wages being paid elsewhere. Perhaps it is time to take a closer and harder look at the question of whether $$ are really the key issue in many cases. How truthfully have we really looked at the question of our own attitudes and the attitudes we see, and even encourage, in our employees?

In a discussion of this question at the recent Missouri Turf Conference, 40 percent of the group attending rated recognition, responsibility, appreciation, and praise as the factors which determined their satisfaction with their job and motivation toward it. Pride, self-fullfillment, respect were rated as the critical items by 34 percent, while *only 10 percent* of this group associated with the turf industry indicated that they felt cash wages, security, profit-sharing, etc., were really the basic factors which determined their happiness or the happiness of their employees with their jobs. These latter factors are most often attributed to worker dissatisfaction, when in fact they may not be the primary problem. As we view the future problems of employees (and even our own), there is no doubt that we should look well beyond wages and money in trying to achieve employee satisfaction in our profession.

Yes, our principal job is understanding and growing grass. However, what has been said so many times before will no doubt be ever more true in the 70's. Our biggest problem, challenge, and managing responsibility will be to increase our willingness and efforts to study and to understand people problems as well as we do turf-growing problems.

# CHANGING THE ENVIRONMENT TO REDUCE TURF DISEASES

## *M.C. Shurtleff*

Before any disease can develop, a series of events must occur. These include the growing of a susceptible host (cultivated turfgrass), the presence of a virulent pathogen, and a favorable environment for growth, multiplication, and spread of the disease-causing organism. Turfgrasses are susceptible to 100-odd pathogens found in Illinois and other areas of the Midwest as well. We can assume these organisms are present in any given area and attack turfgrasses when the right environmental conditions are present.

Even when the disease-causing organism (pathogen) is present and the air-soil environment is favorable, little or no disease develops if the grass is highly resistant. Similarly, disease is unimportant if a virulent organism is present and the grass is susceptible, but the environment is unfavorable. This is why the severity of a disease (such as Sclerotinia dollar spot, Rhizoctonia brown patch, or Pythium blight) varies widely from year to year and from one locality or geographical area to another.

The fungi that feed on grasses are living entities and therefore respond to temperature, moisture, nutrition, and other factors as do the grass plants they attack.

Cool moist weather is absolutely necessary for the development of snow mold, whereas hot dry weather will completely check its development. Pythium and Rhizoctonia brown patch, as you know, thrive during hot moist weather.

Most fungi that cause diseases of leaves and stems are favored by rather specific combinations of temperature, humidity, and grass host, making their identification and control somewhat easier.

The more important factors that regulate the development of a turfgrass disease include air and soil temperature, air humidity, moisture (frequency and amount of rainfall, irrigations, and heavy dews), soil reaction or pH, soil structure, degree of sun or shade, and turfgrass nutrition.

Each turf pathogen has its optimum temperature for growth. We can divide these into three groups--cold, warm, and hot (Table 1). This allows us to forecast disease attacks so that effective chemical and cultural (or environmental) controls may be applied. Furthermore, different stages of the same fungus (such as spore or sclerotial production or germination, penetration, and growth inside the host plant) may have different optima.

Table 2 lists cultural controls for important turfgrass diseases. This is disease control by changing the environment--where growth of the grass plant is favored over growth of the disease-causing pathogen. Following these basic

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management practices should greatly reduce your fungicide bill. When the "environmental controls" in Table 2 fail to hold diseases in check, then it will be necessary to apply fungicides. But for fungicides to be effective, these cultural practices should be routinely carried out by the turfgrass manager. Fungicides cannot do the job by themselves.

*Table 1. Turf Diseases Favored by Three Temperature Categories: Cold, Warm, and Hot*

| Weather | Disease | Comments |
|---|---|---|
| A. COLD (usually active at 32° to 60°F.) | Helminthosporium leaf spots and blights | All grasses attacked. May develop into Melting-out (see under HOT weather). |
| | Leaf smuts | Patches of plants die in hot weather. Merion Kentucky bluegrass is very susceptible. |
| | Fusarium patch, Typhula blight | Occurs under or at edge of melting snows or during cold, drizzly weather. |
| | Fairy rings, Mushrooms | Rings grow outward at rate of 2 to 24 inches per year. |
| | Spring dead spot of Bermudagrass | Widespread where thatch is heavy. Fungicides give erratic results. |
| B. WARM (usually active at 55° to 75° F.) | Powdery mildew | Common in shade or poorly drained areas. |
| | Rusts | Occur during drouths or when grass is growing slowly. Merion is very susceptible. |
| | Slime molds | Found on all grasses following rains or heavy watering. Easily wiped off. |
| | Sclerotinia dollar spot | Creeping bentgrasses and some Bermudas most susceptible. |
| | Seedling blights, Seed rot | Treat seed with captan or thiram. Avoid overwatering after seeding. |
| C. HOT (active at 70° F. or more) | Melting-out | Attacks crowns and roots of all grasses. Often end result of Helminthosporium leaf spots and blights. |
| | Fusarium blight | Most serious when grass is weak and under stress (e.g., drouth, full sun, heavy thatch). |
| | Rhizoctonia brown patch | Most serious on bentgrasses in overwatered turf. |
| | Pythium disease | Excess water must be removed for fungicide (e.g., Koban, Tersan SP Turf Fungicide, Dexon) to be effective. All grasses are susceptible. |

*Table 2. Cultural (or Environmental) Control Measures That Help Keep Turfgrass Diseases in Check*

| Cultural or environmental control measure | Diseases checked |
|---|---|
| 1. When constructing, provide for good surface and subsurface drainage. Fill in low spots. Uniformly mix soil amendments. Have soil reaction (pH) tested and follow directions in the soil test report. | Seedling blights, Seed rot, Leaf spots and blights, Melting-out, Fairy rings, Rhizoctonia brown patch, Sclerotinia dollar spot, Typhula blight and Fusarium patch, Spring dead spot |
| 2. Buy top-quality, disease-free seed, sod, sprigs, or plugs. When possible, plant when cool and dry. Seedbed should be well prepared and fertile. Avoid overwatering after planting. | Seed rot, Seedling blight, Leaf spots and Melting-out, Pythium blight |
| 3. Follow a recommended fertility program for your area and grasses grown. Avoid overstimulation with fertilizer, especially a quickly available high-nitrogen material, in hot weather. Avoid fertilizing after about September 15; after October 15 in southern part. | Leaf spots and Melting-out, Rhizoctonia brown patch, Sclerotinia dollar spot, Typhula blight and Fusarium patch, Pythium blight, Powdery mildew, Rusts, Fairy rings, Fusarium blight, Spring dead spot |
| 4. Cut frequently at the recommended height for grasses grown. Remove no more than 1/4 to 1/3 of the leaf surface at the same time. Keep turf cut in fall until growth stops. Mower should be sharp. | Leaf spots and Melting-out, Typhula blight and Fusarium patch |
| 5. Collect clippings where feasible. Avoid letting clippings (or thatch) accumulate over 1/4 to 1/2 inch deep. | Leaf spots and Melting-out, Rhizoctonia brown patch, Pythium blight, Sclerotinia dollar spot, Slime molds |
| 6. Remove excess thatch in spring and fall when it accumulates over 1/4-1/2 inch deep (often combined with aerification and topdressing). | Leaf spots and Melting-out, Rhizoctonia brown patch, Pythium blight, Sclerotinia dollar spot, Fusarium blight, Spring dead spot, Slime molds |
| 7. During drouth, water established turf thoroughly, deeply, and as infrequently as possible to maintain quality. Avoid excess water and frequent light sprinklings, especially in late afternoon or early evening. | Leaf spots and Melting-out, Rhizoctonia brown patch, Pythium blight, Sclerotinia dollar spot, Fusarium blight, Rusts, Powdery mildew |
| 8. Increase air movement over turf and reduce shade. Properly space planting materials; thin out or remove nearby trees and shrubs. | Leaf spots and Melting-out, Rhizoctonia brown patch, Pythium blight, Sclerotinia dollar spot, Powdery mildew |

# UNUSUAL FERTILITY PROBLEMS AND THEIR CAUSES

**Roger Brown**

I feel that there is a need to refresh our memories on some of the basic principles of soil fertility so that we can better understand some of the reports we have to use today and so that we can appreciate what happens to our soils, our fertilizers, and our crops every day. I want to briefly review some of the "basics" of soil chemistry and soil fertility.

You will recall that all matter on earth--whether it is the cotton fibers in the shirt you are wearing, or the cellulose fibers of a corn stalk, or the ground you walk on--is made up of 104 elements; we may feel more comfortable calling these atoms. Some of the common atoms are oxygen, which we breathe; iron, which we are all familiar with; and aluminum, another familiar metal. All of the plant nutrients, like nitrogen and phosphorus, are also atoms.

These atoms do not simply exist in space as single neutral atoms floating around. Rather, they all have an electrical charge, either a positive charge or a negative charge. This means that they would have an attraction for each other; the positively charged atoms have an attraction for the negatively charged atoms, much as a magnet attracts metal.

When one or more positively charged atoms fit together with one or more negatively charged atoms, we call the new formation a compound. In forming compounds, the charged atoms fit together in such a way that the resulting compound does not have any charge, that is, it is neutral.

Now, let's develop one of these compounds. Let's take two very common atoms: hydrogen, which has one positive charge; and oxygen, which has two negative charges. If we make a compound from these two charged atoms and we want the compound to be neutral, it would take two hydrogen atoms, since hydrogen has one positive charge, to fit with only one oxygen atom because oxygen already has two negative charges. The result is $H_2O$--perhaps the most common of all compounds, water.

How does this tie in with soils? Soil particles are nothing more than simple compounds, although they are a bit more complicated than the water compound.

Let's look at a clay particle because clay is the only soil material important in most chemical and physical properties affecting growth of plants.

A clay particle is made up mainly of four atoms: silicon, aluminum, hydrogen, and oxygen. All of the atoms are put together in a certain way, and held together by the attraction of the positive and negative charges we mentioned earlier. And they always fit together in a certain way, no matter what kind

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of clay it is or whether it is in Wisconsin or Georgia or Oklahoma. They fit together to make this clay particle a flat platelike or sheetlike structure. Clay is always in this form, in thin sheets, and since the atoms fit together to make this compound, the clay is neutral--no charge. However, the sheets are not continuous, being broken on both ends, leaving some of the atoms exposed. The result is that the clay particle does have a charge and much of it results from these broken, ragged edges leaving some of the atoms exposed. The net effect is--and this is the important thing to remember--that *all* clay, no matter where it is, has a *negative* charge. Therefore, it has the ability to attract and hold anything with a positive charge or repel anything with a negative charge.

Why is all this significant? The reason is this: Most plant nutrients have positive charges. Let's take a look at the list of some plant nutrients.

Potassium has one positive charge; calcium, magnesium, manganese, iron, copper, and zinc have two positive charges. Since the clay has a negative charge and these nutrients have positive charges, the clay attracts these nutrients and holds them.

Some nutrients have a negative charge. Nitrogen, for example, combines with oxygen in the soil and forms nitrate. Nitrate has a negative charge, just as the clay does. Therefore it is repelled by the clay and is kept pushed out into the open spaces between soil particles, so when it rains, the nitrogen is simply flushed through the soil. This is why we can never depend on any significant carryover of nitrogen--we have to apply our total requirement every year.

Sulfur forms sulfate in the soil, and since it too has a negative charge, is flushed out of the soil readily. Fortunately, plants do not require nearly as much sulfur as they do nitrogen. Also, decaying organic matter supplies some sulfur, but many researchers warn that if we use fertilizers containing little or no sulfur, like most of our common fertilizers today, we should watch for sulfur deficiencies within three to five years.

The phosphate nutrient exists with a negative charge, but for some reasons not fully understood, soil clay attracts phosphorus very strongly. In fact, the clay holds phosphorus tighter than it does any other nutrient. All the positively charged nutrients are held by the clay and accumulate or build up in the soil, but finally the soil releases them, and they gradually leach out--but phosphorus leaches almost zero. This is why it is necessary to apply phosphorus deep in the soil--plow it down where possible because it is going to stay wherever we place it in the soil.

If we have a soil very low in phosphorus and want to make a high yield, it is necessary to place some of it deep and then perhaps band some near the plant. The clay has such a strong attraction for the phosphorus that it is trying desperately to get it, and once the clay gets it, the phosphorus is of no value to the plant that year. In fact, in any soil it is very unlikely that our plants will ever get over 20 percent of the phosphate we applied that year. The clay gets the rest of it.

This does not mean that phosphorus is lost for good--we have already said that phosphorus never leaches--but what is not used is simply stuck on the clay and goes into a reserve. The phosphorus level in the soil builds higher and higher, and in time it will be released back into the soil for plants to use.

So much for our basic soil chemistry. Now a few words about soil pH.

We know that plants grow best at a certain pH, and for most plants this is in a range of 6.0 to 6.5. If our soil is below this level, we add lime to increase the pH. But just what is pH and what causes a soil to be acid or alkaline?

Soils are made acid either by hydrogen or aluminum. But for our example let's just use hydrogen. Where does all the hydrogen come from? The rainfall, of course. You recall that water is two hydrogens and one oxygen; when it rains, the water often separates as it gets into the soil. You also recall that the hydrogen has a positive charge, which means it can be attracted to the clay particle. Over the years, then, in a humid area, the clay can get pretty well saturated with hydrogen, and the soil becomes quite acid. When we recognize this in our field, we want to replace the hydrogen with something alkaline to bring the pH back up. The cheapest way to do this is with limestone. We could do the same thing with certain kinds of potash or with magnesium, but these are too expensive, so we do it with limestone.

When we apply lime, we are really applying calcium, which makes the soils alkaline. We literally flood the soil with calcium atoms. We surround every hydrogen atom trying to make the soil acid with many calcium atoms, and finally the hydrogen is "bumped" out of the clay and being unable to find another vacancy on the clay particle is finally leached out of the soil.

But finally all of our limestone has dissolved, and it has done all it can. The rainfall continues, and slowly but surely the hydrogen again begins to "gang up" on the calcium. After a few years, we are right back where we started and have to lime again.

Fertilizer and the whole fertility program is just one part of the overall management program. It is often the most important part, but in many cases other factors limit yields more than fertilizers. As we increase fertility, we expect to increase yields. But after we have increased yields up to a point, they seem to level off, so that no matter how much we fertilize, we get no further increase in yield. In these cases the answer is obviously something besides fertilizers, perhaps a poor stand, a weed problem, or insects. Maybe we have no varieties adapted to higher yields. We know that other management factors are as important as fertilizers, and certainly all practices must be tops.

What we want to do in our program is to eliminate fertility as a factor which would limit yields. We feel that if you use our program, you will not have nutrition, or the lack of it, holding yields down.

One major problem is that we have traditionally considered only N, P, and K when we discuss fertility, and in recent years we have learned that in many cases secondary nutrients like Ca, S, and Mg or the micronutrients like B, Cu, Fe, Mn, Mo, Zn, and Cl are the real culprits. Perhaps we had enough N, P, and K, but zinc or perhaps magnesium may have actually been the limiting factor. This situation is particularly common in crops for which yields have increased astoundingly.

Take corn, for example. Fifteen years ago, when farmers got 50 to 100 bushels per acre, perhaps zinc would have never become a problem. The soil weathering--that is, the clay gradually disintegrating and spilling the nutrients it contains, including zinc--may release enough zinc for yields of 50 to 100 bushels for hundreds of years. But with new varieties capable of producing 150 bushels or more per acre, we have found that micronutrients are often not available in sufficient quantity.

In many areas and for many crops, these deficiencies exist even now and are reducing yields, but the deficiencies are not bad enough to show visual symptoms. This is what we call "hidden hunger." In most cases where we have found deficiencies, particularly deficiencies of secondary nutrients and micronutrients, it has been in this range of hidden hunger, limiting yields but just not quite bad enough to see.

This is one reason for the rapid growth of tissue analysis in recent years. We take samples of the actual plants and analyze them. We know exactly how much nitrogen, phosphorus, magnesium, zinc, and the other nutrients these plants are supposed to have at a particular stage of growth.

The first step in our fertility program is to test the soil. What we are really doing in a soil test is finding out how many nutrients are stuck to the clay. Since the clay has a negative charge, it attracts and holds all nutrients except nitrogen and sulfur. The more of these nutrients it is holding, then obviously the less we will have to apply as fertilizer. If the soil test reads "very high" for certain nutrients, the soil is capable of supplying the bulk of those nutrients for any given crop and only a small amount is needed as fertilizer. If the soil is "very low" in any nutrient, the soil is capable of supplying a very small portion of the total requirement and we must depend on fertilizer for the remainder. With a soil test we can predict the additonal requirements.

A soil test can also measure pH. We mentioned that all plants grow best in a certain pH, and we know that for most crops about 6.3 to 6.5 is excellent. If the soil test shows that we need lime, the first thing we want to do is to apply lime because in this area it takes 12 to 18 months for lime to reach its maximum effectiveness. So lime as soon as possible.

Correcting the pH not only makes a better soil for the plant to grow in, but also makes certain nutrients more available. Others are made less available, however.

Let's look at the pH relationship to phosphorus, for example. We have a very low availability of phosphorus even at pH 5 and 5.5. Then it starts becoming more available as pH increases, so that phosphorus finally reaches its maximum availability at somewhere around pH 7.0. This says that if your soil test shows a "high" or "very high" level of phosphorus in your soil but your pH is down to, say, 4.9 or 5.2, very little of that phosphorus will be available to your plants. This is one reason we have to apply such high amounts of phosphorus to a crop like potatoes or tobacco, where we try to keep the pH down low to prevent disease.

What about some of the other nutrients? Surprisingly, the relationship for micronutrients is just the opposite of that for phosphorus. This is, the lower the pH, the more active or available these micronutrients are.

It is obvious that we cannot have both--a pH of 6.5 to keep the phosphorus available and a pH of 5.0 to keep the micronutrients available. So, since plants do best at a higher pH, it has been found that at a pH of about 6.2 to 6.3 we can have some of all of the good things. Obviously, the availability of the micronutrients has been hurt the most. This is the major reason why as we lime to get the pH up where crops grow best we must begin to consider adding back some of these micronutrients. Because even though the soil tests show adequate levels in the soil, the rising pH has literally cut off their availability.

There are also problems with toxicity, that is, poisoning of the plants from too much of a micronutrient. If we keep the pH up, we will probably never see toxicity. But if our soil is high or very high in micronutrients and we let the pH drop to 5 or below, we can expect toxicity, at least from some of these nutrients.

Manganese is a major one giving trouble. We know of manganese toxicity in cotton, for instance, as "crinkle leaf." In apples, we call it "apple measles." It affects soybeans and other crops in a similar way. It can be corrected simply by liming. Manganese toxicities are practically non-existent in soils where the pH is above 5.5. In fact, in some of these soils, if we raised the pH to 7.0, we might have to add manganese for top production.

# PLANT SELECTION AND MAINTENANCE-- KEYS TO DISEASE CONTROL

***Donald F. Schoeneweiss***

As any grounds superintendent will readily admit, maintaining turf is only one of many headaches. The great variety of trees and shrubs that give beauty and distinction to large landscape settings all seem at times to have their own peculiar problems. Injured or declining plant material can mar the beauty of the wealthiest country club as well as the most modest public park. Unfortunately, so much pressure or emphasis is often placed on developing and maintaining perfect turf that maintenance of trees and shrubs is neglected.

To become familiar with control measures for all insects, diseases, and other causes of damage is far beyond the scope of anyone. Even an expert who can devote all of his time to woody-plant problems cannot know all the answers. For the maintenance superintendent, who must of necessity devote most of his time to turf management, the best solution is to become familiar with some of the general principles that apply to certain plant problems. These will, in most cases, provide the proper course of action to take.

The very fact that parks and golf courses are turfed is a contributing factor in many tree and shrub problems. Virtually every tree and shrub requires adequate moisture, drainage, and soil aeration to remain in a vigorous growing condition. As a tree or shrub matures, the root system gradually attains an increasingly delicate balance with the surrounding soil. Any abrupt change such as grading, compaction, altering the drainage pattern through construction or tiling, or the establishment of a heavy turf may upset this balance and place the plant under stress. Even the development of a dense turf on an area that was previously covered by weeds and sparse grass can lead to any number of problems. Although many insects and a few diseases attack vigorous trees or shrubs, many of the destructive insects such as bores and bark beetles and most of the destructive diseases only attack plants that are under stress. The presence of boring insects or stem diseases is a good indication that a plant is under stress.

Unless an intensive program of irrigation and fertilization is followed, the presence of a sod cover may materially restrict the downward movement of water and nutrients to soil layers in which many tree and shrub roots are present. Young trees and shrubs transplanted into sodded areas should survive if they are given the proper care and maintenance. Plants pruned properly and moved with an adequate soil ball into a well-drained planting site should become established rapidly and require minimum maintenance. On the other hand, placing sensitive plants in an exposed location or a poorly drained site or the use of improper planting procedures may cause plants to become stressed. Such situations invite trouble from diseases, insects, drouth, winter injury, or nutritional deficiencies.

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In the case of mature trees or shrubs in a parkway or golf course setting, their sensitivity to soil compaction, grading, flooding, and reduced nutrition is acute. Younger or newly transplanted specimens may not reflect small changes that can cause big problems with more mature plants. Trees such as oak and hickory are very sensitive to changes in soil aeration and are easily damaged.

## Sources of Parkway and Golf Course Tree Trouble

*1. Drainage and soil aeration.*

Although certain trees and shrubs may be found on poorly drained or marginal sites, most woody ornamental plants grow best in a well-drained site that gets adequate moisture periodically. In most cases, poor drainage means poor soil aeration. The ability of most plant roots to absorb water and nutrients is dependent upon a constant exchange of gaseous components in the soil. Thus a reduction or restriction of soil aeration is often more critical than the actual supply of soil moisture. Grading, compaction, installation of lakes, drain tiles, and irrigation all affect soil aeration and drainage. When extensive changes involving one or more of these factors are planned, considerable thought should be given to possible effects on the trees and shrubs in the area. Where large or mature woody plants are involved, intelligent pruning combined with an appropriate increase or decrease in irrigation and fertilization may be of great value. These management practices will help plants survive major environmental changes with a minimum of stress or weakening.

*2. Selection of plant material.*

A golf course or other grounds area should have some type of long-range landscape plan to achieve functional beauty and distinction. Such plans may include various combinations of evergreens, flowering trees and shrubs, shade trees, and ground covers, depending upon the facility and the desired effect. The plans to achieve the desired effect usually include preservation of certain established woody specimens, relocation of other established material, and the purchase and placement of nursery stock. Unfortunately, at times, selection of trees and shrubs is based on such things as size, shape, flowering, fall color, convenience, and of course price. Little regard is paid to susceptibility to disease or insect pests, hardiness, or the ability to withstand other environmental stresses. In the long run, plants which require constant maintenance may prove to be far more expensive than those carefully selected for the site. The tree or shrub that must be sprayed periodically for disease or insect control or that requires special maintenance is undesirable for large plantings.

*3. Irrigation.*

It is surprising how many people, who should be knowledgeable about woody plants, consider trees and shrubs drouth-resistant. The lack of actual wilting and defoliation of woody plants under prolonged drouth does not mean that they are not under considerable drouth stress. Large trees in particular lose tremendous quantities of water, especially on hot, dry, windy days. This water must be replenished if the tree is to remain in a vigorous condition. The presence of a heavy sod cover, through runoff and competition, restricts moisture to tree and shrub roots. Consequently, where a sod cover exists supplemental watering may be essential to keep trees and shrubs vigorous and resistant to disease and insect attack. Deep watering with a root needle can be quite valuable during prolonged drouth periods.

*4. Use of fertilizers and weedkillers.*

Intensive management of turf nearly always includes periodic application of fertilizers and weedkiller materials. Fertilization is usually beneficial to trees and shrubs, but it should be kept in mind that turf will utilize large quantities of surface-applied nutrients. Therefore, woody ornamentals may need additional fertilization to remain vigorous. Surface fertilization with nitrogen at rates up to 6 pounds of N per 1,000 square feet may serve the woody plants' needs, or soluble N-P-K fertilizers can be placed in the soil by several methods. One method is to place dry fertilizer in a series of holes 12 to 15 inches deep at 2-foot intervals in parallel lines 2 feet apart throughout the area to be fertilized. A second method is to inject a solution of fertilizer into the soil, using a hydraulic pump and a soil needle. The injections are made 18 inches deep at intervals of 2-1/2 feet in parallel lines 2-1/2 feet apart throughout the area to be fertilized. Maximum rates to be used are nitrogen at 6 pounds, phosphorus as phosphoric acid ($P_2O_5$) at 3.6 pounds, and potassium as potash ($K_2O$) at 6 pounds per 1,000 square feet. Fertilizers may be applied in the spring or fall, but application in the spring before trees break dormancy is usually most effective.

Weedkiller materials, on the other hand, often cause serious damage to woody plants. Certain trees are very sensitive to small amounts of weedkillers such as 2,4-D and dicamba. Damage may occur from aerial drift, or the compounds may be taken up through the roots. The long-range effects of weedkiller damage on insect and disease susceptibility are not known, but it is strongly recommended that weedkiller materials not be applied in the vicinity of the root systems of woody ornamental plants.

*5. Soil acidity.*

Most woody ornamentals grow best in slightly acid soil ranging in pH from 5 to 6.5. Some species, notably pin oak but also white and bur oak, hackberry, maples, sweet gum, and several other trees and shrubs, are unable to obtain an adequate amount of iron from alkaline soils. The appearance of chlorotic foliage, where interveinal leaf tissue turns yellow with the veins remaining dark green, is usually an indication of alkaline soil. Correction of iron chlorosis by the addition of iron sulfates or chelates to the soil is effective in some cases but not in others. Iron sulfate or a mixture of equal parts iron sulfate and sulfur may be applied dry in holes bored into the soil or as a solution with a soil needle as previously described for fertilizers. Recommended rates are 1 pound per inch of trunk diameter for small trees or 3 pounds per inch of trunk diameter for trees larger than 6 inches in diameter at breast height. Iron chelates may be applied in the same manner at rates recommended by the manufacturer and are usually more effective but more costly than iron sulfate. If the chlorosis has been induced by the application of lime or limestone or is due to the presence of alkaline clay, correction of chlorosis may be difficult and prohibitively costly. For this reason the soil pH should be determined before planting species such as pin oak. The use of lime or limestone around trees and shrubs should be avoided.

## Some Basic Principles of Disease Control

*1. Foliar spraying.*

Many country clubs, golf courses, and park systems attempt to set up annual preventive spray programs for disease and insect pests. What few people realize is that, although insecticide sprays may effectively control most insect problems, few diseases of woody plants can be controlled economically with foliar fungicides. Fungicides can be effective against some of the leaf and needle diseases, mildews, sycamore anthracnose, and bacterial fire blight, but proper fungicide selection and the numbers and timing of sprayings are critical. Applying fungicidal sprays is usually a preventive measure. By the time disease symptoms have appeared, it is usually too late to spray. In addition, many diseases cause damage only in years when weather conditions are optimum for disease development. Thus spraying annually for disease prevention may be a waste of time and effort. Often other control measures such as the use of disease-resistant materials may be more effective and economical.

*2. Selection of disease-resistant plants.*

Avoiding diseases through selection of resistant plants is an extremely effective control measure that is often overlooked. Information is available on relative resistance of many kinds of trees and shrubs to some of the most common diseases such as apple scab, cedar-apple and cedar-hawthorn rust, fire blight, juniper blight, Verticillium wilt, crown gall, and others. This information should be used when selecting nursery stock for plantings. It is also a good practice to consider disease susceptibility as an important factor in deciding which plants should be preserved and which ones replaced with others that require less maintenance. No matter how large or attractive a tree or shrub may be, if it has a history of severe disease damage, it is bound to present a maintenance problem in the not too distant future.

*3. Maintaining plant vigor.*

As previously mentioned, plants low in vigor often become quite susceptible to disease and insect attack. Many of the serious disease problems such as cankers, diebacks and declines, and root rots can be avoided by proper pruning, watering, and fertilizing. Also, plants low in vigor are often more sensitive to drouth damage or winter injury. Such damage may further weaken the plants and increase disease and insect susceptibility. The cost of maintaining vigorous trees and shrubs is usually far less than the cost of repairing or replacing damaged ones.

*4. Pruning and shearing diseased plants.*

One of the most basic disease control principles is to remove and destroy infected plants or plant parts. This practice helps to eliminate disease organisms and reduce the sources of infection. If disease organisms are allowed to remain on infected plant tissues, they may spread to other portions of the plant or to nearby plants. This is especially so when weather conditions are favorable for disease development. Nearly all disease organisms form spores or other reproductive cells which are released during wet weather and are easily spread by wind and rain or on pruning or shearing tools. Consequently, pruning and shearing of trees and shrubs should never be done during rainy periods or when fog or dew is present. In addition, many disease organisms are wound parasites, that is they require an open wound to enter plant tissues. For this reason it is a good practice to sterilize pruning tools between cuts in alcohol or strong bleach solution. Wound dressing should be applied to fresh wounds whenever possible. Since plants showing extensive damage are likely to continue to be maintenance problems, they should be removed and replaced with vigorous or disease-resistant specimens.

5. *Correct diagnosis.*

The number of plant problems that are incorrectly diagnosed as diseases by unqualified "experts" each year is nearly as appalling as the types of treatments prescribed. By far the majority of damage on trees and shrubs is due to causes other than disease organisms. Nearly every state has at least one organization that is qualified to diagnose woody plants' diseases. If a problem appears and there is doubt as to whether it is a disease or not and what procedure to follow, a qualified expert should be consulted. The plant specialist may want to examine a specimen and he will give the necessary instructions for taking and mailing samples as well as the proper place for identification. He will also give control measures for a specific disease.

Keeping in mind some of the basic principles of the cause and prevention or treatment of plant disease should help avoid needless effort and expense which may not, in the long run, produce the desired results. Maintaining trees and shrubs in a vigorous growing condition and selecting hardy, disease-resistant varieties whenever possible will go a long way in reducing some of the headaches of grounds maintenance personnel.

# SYSTEMIC FUNGICIDE ACTIVITY

## W.A. Meyer

In the last 3 or 4 years, the term systemic fungicide has been used to describe some of the new chemicals released for disease control. In our studies we have found that one of these new fungicides, called Tersan 1991, applied at 3 or 6 ounces per 1,000 square feet controlled stripe smut in established creeping bentgrass turf. Since the stripe smut fungus causes a systemic infection in creeping bentgrass, the control of this disease with Tersan 1991 would suggest systemic activity.

Three factors must be considered in proving that a compound is a systemic fungicide: the compound must be absorbed and enter the host plant; the compound must be translocated from the point of entry as far as the locus of infection; and the compound should act directly upon the pathogen by virtue of its fungitoxic properties.

In the Department of Plant Pathology, we are now investigating the systemic activity of Tersan 1991 in Toronto creeping bentgrass plants. When this fungicide was applied to the roots of 3-week-old bentgrass plants in low concentrations (5-25 p.p.m.), it was detected in the leaves in 24 to 48 hours. When this fungicide was applied to leaf tips of bentgrass plants in these same low concentrations, no movement into the leaves was detected. However, Tersan 1991 was found to move into the leaves of bentgrass when higher spray concentrations of 1,000 p.p.m. were used.

Studies were also conducted to determine whether Tersan 1991 would move laterally in stolons of creeping bentgrass. It was found that this compound can move laterally from a mother plant to new growth and vice versa.

The data from these studies show that Tersan 1991 is a systemic fungicide in creeping bentgrass. The roots of creeping bentgrass are able to absorb and translocate this fungicide very efficiently.

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# TOLERANCE OF SCLEROTINIA DOLLAR SPOT FUNGUS TO DYRENE

***J.F. Nicholson***

Studies just completed in the Department of Plant Pathology show that certain isolates of the Sclerotinia dollar spot fungus are tolerant to Dyrene fungicide. This research was prompted by the observation that there was high degree of Sclerotinia dollar spot disease occurring in the Dyrene-sprayed Seaside bentgrass turf plots at Urbana.

The Sclerotinia dollar spot fungus was isolated from both Dyrene-sprayed plots and nonsprayed control plots. The Dyrene-sprayed plots had a constant application of Dyrene for the past 6 years at 6 ounces per 1,000 square feet each week for 16 weeks during each growing season. The adjacent control plot never received an application of fungicides. Signs or symptoms of dollar spot did not appear on the Dyrene plots until 1970. The Dyrene plots had many times more infection of dollar spot than the control plot without fungicide.

The Sclerotinia dollar spot isolates were grown on synthetic media and transferred to media containing Dyrene. The lateral growth of the fungus was measured and recorded for each isolate.

Isolates varied greatly in the amount of growth on the media with different concentrations of Dyrene. Some isolates would grow only at very low concentrations (10 p.p.m. active ingredients of Dyrene) while others would grow on very high concentrations (1,000 p.p.m. active ingredients of Dyrene). There also were gradations of growth of the fungus between these two concentrations of fungicide. After continuous growth of the fungus for five generations on synthetic media, it did not lose its capacity to grow on media with Dyrene. Toronto bentgrass was inoculated with the Sclerotinia dollar spot isolates and placed in a controlled environment chamber. It was shown that the isolates were still able to infect the bentgrass.

Golf course greens and experimental fungicide plots represent an area of intense use of fungicides. Dosages far exceed levels of application in orchards or field crops. Season-long applications may result in cumulative dosages of 96 ounces per 1,000 square feet or 260 pounds per acre. If fungicide tolerance were to occur because of persistent and repeated usage, the Dyrene plots with six consecutive years of this fungicide would be the most likely place.

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# TRENDS IN TURFGRASS DISEASE CONTROL

## *Houston B. Couch*

During the first two decades of the twentieth century, turfgrass disease-control programs consisted primarily of removal of free water from leaf surfaces by poling or by the application of hydrated lime dusts. In 1917, tests were conducted by the Green Section of the United States Golf Association for the use of bordeaux mixture for control of Rhizoctonia brown patch. By 1919, this material was in general use for control of this disease. Repeated applications of bordeaux mixture to bentgrass greens, however, invariably resulted in extreme phytotoxicity, with complete loss of the treated greens being a rather common occurrence. In 1920, mercuric chloride was used successfully in the Chicago area for control of Rhizoctonia brown patch. After 1920, the inorganic mercury chlorides began to increase in popularity as turfgrass fungicides.

The foundation for modern turfgrass disease-control programming was actually laid in 1915. That was the year in which the Bayer Company developed the organic mercury fungicide, Semesan. Introduced primarily as a seed treatment, Semesan's potential as a turfgrass fungicide was first tested in 1924 in New York for control of Sclerotinia dollar spot on putting greens. In these trials, different rates of Semesan were applied as drenches in 50 gallons of water per 1,000 square feet. While some phytotoxicity was noted at the higher rates, the material did effectively control the disease. When compared with the bordeaux mixture plots, the Semesan-treated areas not only were freer of disease, but showed less discoloration of the grass. This report of the successful use of an organic fungicide in turfgrass disease control ushered in a new era for this phase of turfgrass management. It was to be almost two decades, however, before organic fungicides would become the mainstay of turfgrass disease-control programs.

The 1930's saw the disappearance of bordeaux mixture as a turfgrass fungicide. Attempts to use sulfur and other forms of inorganic mercury (mercury sulfides, cyanides, oxides, nitrates, and sulfates) proved unsatisfactory. As the result, that decade was marked by an almost universal dependence on Semesan and the mercury chlorides for turfgrass disease control.

During the 1930's, however, a major discovery was made that was to be a milestone in turfgrass disease-control programming. In 1931, an organic compound developed as an accelerator in the manufacture of rubber was discovered to have fungicidal properties. Known by the coined chemical name "Thiram," this material was sold to the rubber industry under the trade name, "Tuads." By 1942, Thiram had found its way into general golf course use, and its new trade name, "Tersan," became a part of the working vocabulary of practically every golf course superintendent.

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The impact of Thiram on turfgrass disease-control programming is interesting in that it provided a basis for expanding, rather than replacing, the organic and inorganic mercuries used so extensively in the 1930's. It was discovered that Thiram in combination with either the mercury chlorides or Semesan made an ideal tank mixture. In addition to its own spectrum of fungicidal activity, Thiram reduced the phytotoxicity potential of the mercuries. As the result, the introduction of Thiram to golf course use established a new dimension in disease control--greater efficiency with less possibility of injury to the grass.

During the 1950's, a new pesticide group was introduced into turfgrass disease-control programs. The development of the antibiotic Acti-dione provided the turfgrass management specialist with a type of pesticide previously unknown in plant disease control. In the field of antibiotics, this material was unique in that it was antifungal instead of antibacterial. In the field of turfgrass disease control, it not only covered many of the standard disease problems, but also provided a level of control of rust and powdery mildew never before realized.

Another characteristic of the 1950's that was to have a major impact on turfgrass disease-control programming was that it marked the beginning of the present era of frequent release of newer turfgrass varieties with significant differences in agronomic type. With the Kentucky bluegrasses, in particular, this has meant a change in the relative importance of certain diseases, and consequently a change in concepts of disease-control programming. Diseases such as rust, powdery mildew, stripe smut, and Fusarium blight that were of either minor or transient importance before the 1950's have since become a common part of the diagnostic repertoire of turfgrass management specialists concerned with the growth of bluegrasses.

The 1960's were characterized by more changes in turfgrass disease-control programming than any preceding ten-year period. It was during this decade that a total awareness of the importance of parasitic nematodes as turfgrass pathogens was developed. As the result, with many turfgrass management programs, nematicides are now included in the regular list of pesticides. Also, during this decade, the development of newer organic fungicides such as Dyrene, Daconil, Dexon, Koban, and Fore for turfgrass use greatly broadened the base of selections available to the golf course superintendent.

A significant occurrence during the early part of the 1960's that was to have a strong impact on turfgrass disease-control programming was the identification of fungicide resistance in one of the more common turfgrass pathogens. In 1963, reports of the failure of cadmium-based fungicides to control Sclerotinia dollar spot began to appear. Considered at first to be an isolated phenomenon, by 1966 the problem had been identified in several locations in the eastern part of the United States. A more clear delineation of the nature of the change in the pathogen revealed that many cadmium-resistant strains were also highly resistant to mercury-based fungicides. As a result, Sclerotinia dollar spot, a disease that had been regarded for almost three decades as a problem that was relatively easy to control, could now be curbed in certain localities only by one of two fungicides. Interestingly enough, at this time, these particular formulations had been available to golf course superintendents for less than four years.

Concerning more recent trends in turfgrass disease control, in times past data from Sclerotinia dollar spot tests have generally been interpolated into programs for control of Corticium red thread. This rule of thumb had been established as a workable one following several years of research experience and field observations. Results from our 1970 trials have shown, however, that fungicides which are effective against the cadmium-mercury-resistant strain of the Sclerotinia dollar spot fungus do not necessarily control Corticium red thread, and that materials which are effective against the latter disease may not control dollar spot. This finding further complicates the fungicidal testing and control recommendations for these two diseases.

The snow molds are another group of diseases that have generally been treated as a single unit where control recommendations are concerned. Recent legal restrictions in the use of mercury-based fungicides, however, now make it necessary to prepare individual programs for each disease. Certain of the remaining commercially available fungicides will control both Typhula blight and Fusarium patch. At least one of the widely distributed materials now on the market, however, will control only Typhula blight.

Another point of change in snow mold control programming with fungicides now commercially available is timing and frequency of treatments. A strong feature of the mercury-based fungicides was longevity of control. With this characteristic, if weather did not permit a full program of 3 or 4 applications during the course of the winter, the carryover effect of the earlier treatments usually still prevented total loss. The newer organic fungicides, while providing a very high level of disease control, as a rule do not have long residual activity. Consequently, a full winter program of applications is necessary if proper protection of the grass is to be realized throughout the season.

Most likely to be neglected, and yet of particular importance when the organic fungicides are used for snow mold control, are the late winter and early spring applications. In cool wet weather, the snow molds can be active for 4 to 6 weeks after the winter season ends. When winters have been particularly conducive for snow mold development, preventive spraying for disease control should be continued into early spring.

Looking to the decade ahead, with its continued development of systemic fungicides, the total changes in turfgrass disease-control programming will probably be greater than for the entire period described above. A view of future trends in turfgrass disease control can be seen with the performance pattern of Benomyl, the new systemic fungicide being released for sale in 1971 as Tersan 1991. Because of its systemic properties, it provides for the first time a workable chemical control of stripe smut. In our 1970 trials, it provided 100-percent control of the cadmium-mercury-resistant strain of the Sclerotinia dollar spot fungus. Eight weeks from the time of the last fungicide application, plots treated with Benomyl were still 100-percent free of dollar spot.

With the availability of a large group of systemic fungicides, one can visualize that with future disease-control programs the frequency of treatment for any given disease may be reduced considerably. Also, it is highly possible that such novel techniques for fungicide application as subirrigation may be commonplace. In any event, for the turfgrass management specialist, the next ten years promise to be both exciting and challenging. Also, there can be no doubt that, as in the past, he will continue to occupy a strong leadership role in the development of new trends in turfgrass disease-control programming.