UNIVERSITY OF ILLINOIS
DIVISION OF UNIVERSITY EXTENSION

6th

TURFGRASS CONFERENCE

PROCEEDINGS

College of Law
Auditorium

December 2-3,1965

arranged and conducted by the

COLLEGE OF AGRICULTURE

with the cooperation of the

ILLINOIS TURFGRASS FOUNDATION

University of Illinois
Division of University Extension

SIXTH ILLINOIS TURFGRASS CONFERENCE

December 2 and 3, 1965
Auditorium, Law Building
Urbana, Illinois

You are cordially invited to attend the sixth educational program which is sponsored by the Illinois Turfgrass Foundation and the College of Agriculture of the University of Illinois. The purpose of this program is to provide up-to-date information for those in the turfgrass field.

Program committee

M. P. Britton
J. D. Butler
F. W. Slife

PROGRAM

Thursday, December 2

10:30 a.m. - 1:15 p.m. Registration

Thursday, December 2--First Session
Moderator - Walter Fuchs, Jr., Lemont, Illinois

1:15 - 1:20 p.m. Welcome - Assistant Dean, Warren Wessels

1:20 - 1:40 p.m. Fungicide Work

M. P. Britton
University of Illinois

1:40 - 2:15 p.m. Tree Damage: Prevention and Correction

J. B. Gartner
University of Illinois

2:15 - 2:35 p.m. Weed Control in Turf

F. W. Slife
University of Illinois

2:35 - 3:00 p.m. Plant Nutrition

T. K. Hodges
University of Illinois

Thursday, December 2--First Session (Continued)

3:00 - 3:15 p.m.	Break

Moderator - Vernon Verstraete, Kewanee, Illinois

3:15 - 3:35 p.m.	Thatch: A Problem in Turf J. D. Butler University of Illinois
3:35 - 4:20 p.m.	Greens Construction J. L. Holmes Chicago, Illinois
4:20 - 4:40 p.m.	Turf Disease Research M. J. Healy University of Illinois
6:30 p.m.	Banquet--314 Illini Union

Friday, December 3--Second Session

Moderator - James R. Burdett, Lombard, Illinois

8:30 - 8:45 a.m.	Announcements Ted Woehrle, President I.T.F. Chicago, Illinois
8:45 - 9:05 a.m.	What Makes a Fungicide M. C. Shurtleff University of Illinois
9:05 - 9:25 a.m.	Arsenic and Low Phosphorous Soils C. W. Lobenstein Southern Illinois University
9:25 - 10:10 a.m.	Shrubs for Recreational Areas M. C. Carbonneau University of Illinois
10:10 - 10:20 a.m.	Break

Friday, December 3--Third Session
Moderator - Ben Warren

10:20 - 10:40 a.m.	Lawn Insect Control R. Randall University of Illinois
10:40 - 11:00 a.m.	The Sod Industry Today Eugene Johanningsmeier Detroit, Michigan
11:00 - 11:45 a.m.	Bluegrass Varieties F. V. Juska Beltsville, Maryland
11:45 a.m.	Adjourn

THE SELECTION AND USE OF FUNGICIDES FOR DISEASE CONTROL ON BENTGRASS

M. P. Britton[1]

The title of this paper indicates that there are a number of fungicides that can be used to control turfgrass diseases. Fortunately, we are in the happy position of having to pick and choose among several tried and true fungicides that have served us well for quite a few years, plus some excellent new ones. During the last five years, fifty chemicals having fungicidal activity have been tested at Illinois to determine their effectiveness against fungi that cause common diseases of bentgrass. Some of the experimental chemicals were discarded after the first or second application because they caused excessive damage to the grass plants. Many more seemed to be harmless to the grass plants and nearly so to the fungi! These, of course, did not give the amount of control that you want on your turf areas, and they were discarded also.

Two new materials have been tested that are superior to the older standard fungicide mixtures that were also included in the tests for comparison. The new materials are DYRENE (50% 2,4-Dichloro-6-O-chloroanilino-S-triazine) and DACONIL (DAC 2787) (75% Tetrachloroisophthalonitrile). They are superior because they provide a high degree of control of brown patch (*Rhizoctonia solani*), dollar spot (*Sclerotinia homeocarpa*) and leaf spot (*Helminthosporium sorokinianum*). The good, standard fungicides utilizing some form of mercury, cychloheximide, thiram (Tetramethylthiuram disulfide) or heavy metals such as Cadmium--or combinations of these and in some cases other materials--gave as good control on one or two of these diseases, but not on all three!

Two other new materials that are worthy of being brought to your attention are DITHANE M45 (80% combination product of zinc and manganese ethylene bis

[1] Associate Professor of Plant Pathology, Department of Plant Pathology, University of Illinois, Urbana.

dithiocarbamate) and DIFOLITAN (80% N-(1,1,2,2-Tetrachloroethylsulfenyl)-cis-4-cyclohexene-1,2-dicarboximide). These fungicides gave excellent control of brown patch and leaf spot, but were not effective against dollar spot. The one thing that all four of these new fungicides possessed, to a greater degree than the other fungicides, was an ability to give almost complete control of leaf spot when they were applied on a preventive schedule.

Unfortunately, we have not been able to obtain data on the control of Pythium blight in any of our tests. The reason for this is that it has developed only once in our testing program, and the amount of development was so sparse that no evaluations could be made. Data on the control of snow mold was collected during one winter and spring, and these confirmed reports by other investigators that maximum control was obtained with fungicides containing mercury as an active ingredient. We have obtained no data on the effectiveness of Dyrene, Daconil, Difolitan or Dithane M45 against fungi causing snow molds.

It is quite obvious that there are many good fungicides for use against diseases of bentgrass. It is also obvious that you probably won't need all of them in your spray program. How then should you go about selecting the fungicides that you need?

First of all, you should decide whether you need better disease control than you have been getting. If you have not had a disease problem, you have no need to change your spray program. If you have had a disease problem, then you should do three things: 1) identify the cause of the disease problem accurately; 2) determine whether the fungicides you have been using will give the best control of your disease problem; and 3) determine whether some other management practice is creating a condition that makes it impossible to get good disease control with fungicides. You may need help from your USGA Agronomist or University Turf

Specialist to identify your disease problem. Number two you can do yourself. First, study the results of published fungicide tests to determine the best fungicides for the diseases you need to control. Second, experiment with these on a small scale to find out whether they will work under your conditions. During this experimental period, make careful comparisons between the old spray program and the new one you are testing. If the new materials give better results, then you will probably want to make a change to the new materials. If neither program gives adequate control of your disease problem, then you probably have a situation where some management practice is "setting up" your turfgrass for disease attack. Most of these harmful practices involve water and are necessary to maintain the growth of the grass and become troublesome because of poor internal and surface drainage, compaction, layering, too much clay in soil mixtures, etc. The solution to this type of problem lies in rebuilding the greens or tees properly.

The manner in which a fungicide is applied can affect the degree of control of diseases. The application of fungicides on granules generally results in poorer disease control than spray applications. However, granular formulations of fungicides have a place in disease control programs. They can be applied during the winter months to prevent snow molds when it is too cold to apply fungicides in water or when the soil is too soft to support heavy spray equipment. Our data show that spray applications are consistently superior to equivalent rates of the same fungicide applied on granules, so we suggest that spray applications be used when possible.

In the control of diseases of vegetables and fruits, excellent control has been obtained with both high volume sprayers and concentrate (mist) sprayers. We have no data comparing these application methods on diseases of bentgrass turf. Surely, both methods will give uniform coverage of leaves of turf with fungicide. The use of 10 to 15 gallons of water per 1,000 sq. ft. may give considerably more penetration of fungicide into the thatch layer and thus prevent the build-up of fungus pathogens in the thatch. However, regular, frequent irrigation of greens, tees, or fairways may wash enough of the fungicide off the leaves to accomplish the same thing.

Proper timing can be obtained in different ways. One method is to follow a regular schedule of spray applications at intervals of 7 to 10 days throughout the summer months. Another is to make fungicide applications when your experience tells you that conditions of temperature and humidity are right for disease development. The first method requires more expenditure of money for fungicides; the second requires considerable skill and understanding of turf diseases. Regardless of how it is done, timing the spray applications so that good fungicide coverage of leaves and sheaths occurs during conditions favorable for disease development is essential.

The proper rate of application is important, too. Follow the recommendations of the manufacturer to the letter for the best results. And remember to read all of the label, including the precautionary statements.

STORM DAMAGE TO TREES

J. B. Gartner

Each year considerable damage is done to shade trees from ice and wind storms. Damage amounts to millions of dollars a year and yet many of us do very little to prevent this. Possibly the reason very little is done is that few people realize the true value of a shade tree. The National Arborist Association, in conjunction with the National Shade Tree Conference, has established values for different types of shade trees. This value varies with the species, condition of the species, size and location. As an example: a white oak is a Class I tree. A 20-inch tree would have a cross sectional area of 314 sq. in. and a basic value of $5 per sq. in. If this white oak was in perfect condition, the value for this tree in Illinois would be $1,570. A black locust is in Class V and is worth 20% of full value of Class I trees. Therefore, a 20-inch diameter black locust in perfect shape would only be worth $314.

With these facts in mind, you as maintenance superintendents, are going to have to sell your employers on the value of these trees. It is a sound investment to properly care for these trees. Any recreational area without trees would be uninteresting and would have little value. A lot of people take trees for granted and will do nothing for tree care. A sudden storm can cause damage costing more than a good routine maintenance program. Storm damage can be reduced considerably with proper care.

Ways of preventing storm damage come under several categories which will be treated here as separate topics.

<u>Selection of Proper Species</u> - Many species of trees are more susceptible to storm damage than others. Silver maple, linden and elm are very susceptible to storm damage. These trees are brittle and will snap, crack or break relatively easily. In addition, some form weak crotches which are subject to injury. The

elm forms sharp, V-shaped crotches which split easily in wind and ice storms. Species such as the oaks, hard maples, beech, etc., are strong and are not nearly as susceptible to storm damage as those previously mentioned.

It does not pay to put a great deal of money into repairing or protecting the weaker species, as they will always be a source of trouble. These weaker species should be replaced with trees less susceptible to storm damage. A replanting program should be continuous, even if all the trees are of the better species. Regardless of the species, all trees get old and are eventually subject to increased damage and will have to be replaced. A continuous planting program to replace lost trees will prevent the development of large voids in the landscape.

Proper Pruning - If a tree is continually pruned properly, there will be less trouble from storm damage. The reasons for pruning are to eliminate dead, weak and diseased wood that is susceptible to storm damage. Proper pruning will also help to eliminate the formation of weak crotches. If the weak, dead and diseased wood is removed, then the remaining branches will become stronger and will withstand more adverse conditions.

Proper Fertilization - If the tree is healthy, the branches will become much stronger. Proper fertilization will help to produce a healthy tree. Trees should be fed at least every two years. A recommended fertilization rate is 1 lb. of actual nitrogen per inch of trunk diameter on trees 6 inches and above, and half this rate for those below 6 inches.

Cabling and Bracing - In areas of frequent high winds or ice storms, it pays dividends to cable and brace the more valuable trees. Cabling and bracing is a highly specialized field and, for best results, should be left to specialists. Cabling and bracing involves special engineering skills as to stresses and strains. An improperly installed system costs as much as one done properly and is of very little value in protection of the tree.

Cabling and bracing is quite essential in protecting weakened, limber, decayed, split or storm-damaged crotches. With proper treatment, weakened branches can be strengthened to avoid future damage from ice and wind storms.

Crotches split by storms can be drawn together with block and tackle and then bolted with large ridged screw rods or bolts. After bolting, it is essential to reinforce the branches two-thirds of the way up with flexible wire cable. If this is done properly, the tree is structurally stronger than it was prior to the damage.

If cabling is done prior to any damage, there is little need for bolting the crotch. On inherently weak trees, it is best to replant with a stronger species and eventually remove the weak plant that is susceptible to storm damage.

Lightning Damage - Trees on golf courses seem to be more susceptible to lightning damage than trees in other areas. The reason for this is that trees on a golf course are more exposed, and other lightning attracting objects are fewer. Some species such as beech, birch, horse chestnut are rarely struck by lightning; whereas, elm, maple, oak and pine are frequently struck.

When lightning strikes a tree, it can shatter the bark or burn the internal tissue extensively without any external evidence.

The tree should be examined extensively before any major repairs are made. Lightning can kill roots and internal tissue without any external damage. If this is the case, then there is little chance for survival of the tree. It is best first to make minor repairs, and if the tree is going to live, then make the extended repairs. Next, the tree should be trimmed to remove all damaged limbs. Remove all shattered bark and paint all open wounds with a tree paint. The tree should be fertilized and given adequate water during dry spells to encourage rapid growth.

Valuable trees can be protected from lightning. The same principles employed in protecting structures are used in safeguarding trees. Again, this should be left to an expert, as there are principles involved that the average layman does not understand.

Care of Trees Injured from Ice and Winds - After injury has occurred, there is very little that can be done except to remove all broken and torn branches. If possible, remove broken or torn branches at the junction of another limb. Sometimes it is essential to leave stubs on severely damaged trees. In this case, after new growth starts, a leader should be selected and other new branches should be eliminated to permit the new leader to develop into a strong branch.

All wounds should be painted with a good tree paint to prevent decay. In addition, the tree should be fertilized and watered during dry periods to encourage vigorous growth.

As previously stated, there is little that can be done after the damage. Proper care prior to the storm will better enable the tree to survive wind and ice storms.

If you would like to better understand some of the basic information, the following references are recommended:

Pirone. Maintenance of Shade and Ornamental Trees. Published by Oxford Press, New York, New York.

The following bulletins are available through the Superintendent of Public Documents, U. S. Government Printing Office, Washington, D. C.:

Thompson, Robert A. Transplanting Trees and Other Woody Plants. Tree Preservation Bulletin No. 1. Price: 25 cents.

Thompson, Robert A. Safety for Tree Workers. Tree Preservation Bulletin No. 2. Price: 20 cents.

Thompson, Robert A. Tree Bracing. Tree Preservation Bulletin No. 3. Price: 15 cents.

Thompson, Robert A. Shade Tree Pruning. Tree Preservation Bulletin No. 4. Price: 15 cents.

Thompson, Robert A. Rope Knots and Climbing. Tree Preservation Bulletin No. 7. Price: 15 cents

WEED CONTROL IN TURF

F. W. Slife and J. D. Butler

With the continuing increase in our urban population, the demand for information on turf has increased proportionally. Weed control seems to concern lawn owners as much as any other turf topic. New developments in chemicals are interesting and helpful, but unfortunately, they are making some of our older problems worse. It would appear that some weed problems that cannot be solved by the present selective chemicals are on the increase. This may be the indirect result of removing some of the competition afforded them previously. Nimblewill, nutsedge, bentgrass, and tall fescue all seem to be increasing problems for which selective chemical controls are lacking. It may be that these are being brough to our attention more because good control programs have been initiated for crab-grass, dandelions, and plantain.

Tall fescue can be controlled and eventually eliminated with the use of dalapon. Spot treatment with this chemical has been effective. When lawns are thoroughly infested, complete renovation or resodding is almost necessary.

Nimblewill and bentgrass are perennial grasses that are somewhat sensitive to several non-selective foliage contact chemicals. Cacodylic acid and paraquat, are examples of these types of chemicals. These chemicals like dalapon severely injure bluegrass so application must be restricted to the weedy grass. Treated areas must be reseeded or resodded. Complete elimination with these materials are not a certainty and regrowth may occur.

Nutsedge has been a serious problem in turf in many areas of the U. S., but in recent years it has increased in the North Central states. Because it produces a chain of nutlets beneath the soil surface, its control has been extremely difficult.

During the past few years more chemicals have been added to our arsenal for both broadleaf and annual grass control in turf.

New Broadleaf Chemicals - Diacamba, sold as Bavuel D, continues to do an outstanding job on broadleaf weeds less sensitive to 2,4-d. Consistently good results have been obtained on knotweed, white clover, ground ivy, red sorrel, chickweed and henbit. None of the above plants are easily controlled with 2,4-D. The most practical program seems to be to mix 2,4-D and dicamba together. Using ½ lb. of active ingredients of each per acre has given good results. Further research may indicate that the ratio of dicamba can be lowered still further. Dicamba still presents a much greater hazard to nearby shrubs and flowers than does 2,4-D and its use must be carefully supervised.

MCPP - Like dicamba, this material controls many broadleaf weeds that 2,4-D does not control well. It is outstanding for the control of white clover, but has been slightly less effective on knotweed and others as compared to dicamba.

Tordon is a new chemical especially effective on most broadleaf plants. Rates of 1 to 3 ounces per acre has given excellent control of many broadleaf annuals. Because of the hazard of drift and root absorption by shrubs and trees, this compound may have to be restricted to large turf areas where sensitive plants, other than weeds, are absent.

Annual Grass Chemicals - The two newest chemicals readily available are Tupersan and Azak. Both are excellent crabgrass killers and appear to give control similar to Dactal, Zytron, and Betasan.

Tupersan - This material is excellent for crabgrass control in established bluegrass lawns. Ten to twelve lbs/acre seems sufficient to give full season control with no carry over. The outstanding attributes of this compound are that it can be applied to the seedbed immediately after seeding and germinating bluegrass, redtop and fescue seedlings are not harmed. Rates for this type of treatment should be restricted to 4 to 6 lbs per acre. These rates will give excellent crabgrass control for 6 to 8 weeks but retreatment will be needed for full season control.

In 1965 some strains of established bent grass were severely injured by Tupersan. Many others were not affected. Since some strains are sensitive, it would seem best not to use Tupersan on bentgrass unless you are certain your particular strain is tolerant.

Azak is a relatively new crabgrass killer for established bluegrass turf. At ten lbs per acre full season crabgrass control has been achieved. Less research information is available on this compound than Tupersan, but it appears acceptable for established turf.

NUTRIENT ABSORPTION BY PLANTS

T. K. Hodges

The essentiality of inorganic nutrients for plant growth is well known. The nutrients which turf growers are most concerned with are nitrogen (N), phosphorus (P), and potassium (K). However, in addition to these elements, several others are necessary for plants to grow normally. In all, 16 elements are now considered to be essential for plant growth and these may be classified into either <u>macronutrients</u> or <u>micronutrients</u> as follows:

<u>Macronutrients</u>	<u>Micronutrients</u>
Carbon (C)	Manganese (Mn)
Hydrogen (H)	Boron (B)
Oxygen (O)	Copper (Cu)
Nitrogen (N)	Zinc (Zn)
Phosphorus (P)	Molybdenum (Mo)
Potassium (K)	Chloride (Cl)
Calcium (Ca)	
Magnesium (Mg)	
Iron (Fe)	
Sulfur (S)	

Both macronutrients and micronutrients are equally essential for growth. The micronutrients are simply required in much smaller amounts than the macronutrients. In most cases, the soil solution contains sufficient quantities of the micronutrients, and no supplemental fertilization with these elements is necessary. In fact, plant roots frequently absorb more of these nutrients than are actually needed for normal growth. In addition to the elements which are actually necessary for growth, the plant also absorbs various elements which are not known to be essential to the plant. For example, plant analyses always indicate the presence of sodium (Na), silicon (Si), aluminum (Al), etc.

Elemental analyses of various turfgrasses are shown in Table I. These grasses were field grown and were under comparable fertility regimes. It is apparent that different grasses have different capacities for absorbing elements from the soil solution.

The inorganic nutrition of plants may be divided into two general areas. The first involves the absorption and transport of nutrients through the plant, and the second aspect involves the function of the various elements in the actual growth processes. Here we will restrict the discussion to just the absorption and transport phenomena.

To understand the absorption and transport of elements by the root, it is first essential to know a little about the anatomy or structure of the root. Figures 1A and 1B are a longitudinal and cross section, respectively, of a single root. In viewing the longitudinal section, one can see that it consists of several distinct zones. The growing point of the root is called the apical meristem and is situated immediately behind, and thus protected by, a group of cells collectively called the root cap. Cells in the meristematic zone are those that are most actively dividing and forming new cells. These cells obviously represent the youngest cells in the root. After a cell has divided, the two new cells undergo enlargement or elongation. At this stage, cells begin to specialize to form various kinds of cells such as root hairs and various cells involved in transport of materials up and down the plant. This root zone is commonly referred to as the root hair zone, and it is in this region that nutrient absorption occurs at the most rapid rate.

The internal structure of the root can be most readily seen by viewing a cross section of the root taken through the root hair zone (Figure 1B). A root hair is a single cell that is nothing more than a specialized epidermal cell. The epidermis simply refers to the outmost layer of cells. Just inside the epidermis is a rather homogeneous group of cells which are collectively called the cortex. The cortex extends from the epidermis to a single layer of cells called the endodermis. The endodermis and all the remaining internal cells are collectively referred to as the stele. The stele consists of several different types of cells. Two of these groups of cells are the xylem and phloem. The xylem cells are a series of long cells connected together end to end and may be thought of as a tube extending through the root and on up into the shoot. These cells are the ones involved in water and nutrient movement up the plant. The other major group of conducting cells are called the phloem. These cells are responsible for the movement of food materials, i.e., organic materials formed by photosynthesis, down the plant from the leaves to the roots. Thus, the stele consists of two specialized groups of cells--the xylem and phloem--and they are responsible for the transport of materials up and down the plant.

Now what about the nature of nutrient absorption by the root? Do the nutrients simply diffuse into the root much as a drop of dye spreads through water? Perhaps the roots act like a sponge or maybe like a paper wick that absorbs water. To appreciate that this is, in fact, not the case, we need to look in a little more detail at the structure or composition of a single cell (Figure 1C). Immediately beneath the cell wall is the outer cell membrane which is called the plasmalemma. This membrane is approximately 50% lipid or fat and because of this fatty nature, the passive entrance of nutrients into the cell is restricted. The obvious question then is: if free passage of nutrients into the cell is restricted, how then do the nutrients get into the root? The answer to this question is that the plant cells must expend energy in order to pull the elements into the cell. This may be visualized as being similar to using energy to pump water uphill. In the case of the plant, however, the energy must come from within. This type of absorption is called active absorption, as contrasted to passive absorption. Passive nutrient absorption, such as diffusion and exchange, does occur, but it is of minor importance as contrasted to active absorption.

An obvious question at this point is: how do we know that active absorption of nutrients actually takes place, i.e., that so-called metabolic energy must be expended for nutrient absorption. To answer this question, all one needs to do is experimentally alter the rate of metabolism (i.e., the rate the internal machinery of the cells is functioning) and see what this does to the capacity of the root for absorbing nutrients. We can alter the rate of metabolism very easily by simply raising or lowering the temperature, varying the oxygen levels in the proximity of the roots, or by actually poisoning the roots with some chemical. When one conducts such experiments, it is found that nutrient absorption is indeed curtailed by low temperatures, low oxygen levels, metabolic inhibitors, etc. Typical results are presented diagrammatically in Figures 2A, B and C. Thus, the actual movement of nutrients into roots is an active process or, in other words, an energy-requiring process. This absorption is essentially irreverisble, i.e., once absorbed into the roots, the nutrients are released to the external media very slowly.

Having been absorbed into the epidermal cells, the elements can be used for the manufacture of various protoplasmic constituents, formation of new cell walls, etc. In addition, the elements can move from cell to cell through the interconnected cytoplasm system until they arrive at the dead xylem cells where they can then move on up to the shoot in the ascending stream of water. Having arrived in the leaves, the nutrients can again be reabsorbed back into living cells and used for the synthesis of new materials. Some of the nutrients that have been absorbed by the leaf may enter the phloem with the organic substances made in the leaf and then move back down the plant. In addition, some of the nutrients may be washed or leached from leaves during rains, and thus return to the soil solution where they are available for reabsorption.

The overall process of nutrient absorption and transport through the plant is illustrated diagrammatically in Figure 3 and is shown to involve the following major steps:

(1) Absorption or transport into the epidermal and cortical cells by an energy-requiring process.

(2) Movement from cell to cell through an interconnected cytoplasmic system until they arrive at the xylem.

(3) Movement up the xylem to the shoot.

(4) Reabsorption from the xylem into cells of the leaf.

(5) Movement back down the plant via the phloem and/or movement back to the soil via leaching from the leaves.

Thus, nutrient absorption and transport in the plant is a cyclic phenomenon involving several distinct and rather complex processes. With some understanding of these various transport processes, it would now be of interest to consider the actual functions of the various essential nutrients. It is anticipated that this will be considered at the 1966 meeting.

Table I. Element Content of Various Grasses

	percent					ppm								
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Mo	Na	Al	Si
Kentucky Bluegrass	5.1	.27	1.80	.27	.16	102	18	19	33.5	<6	1.77	100	<25	<.20
Merion Bluegrass	5.4	.49	3.08	.36	.32	189	48	45	25.5	9	3.35	310	66	1.65
Red Top	3.3	.32	2.03	.57	.37	590	128	37	21.7	10	6.30	232	503	3.15
Perennial Ryegrass	5.1	.50	3.29	.51	.32	934	73	52	37.6	14	8.45	880	922	6.17
Common Red Fescue	3.7	.34	2.62	.39	.24	266	54	30	20.5	6.5	2.72	95	224	1.48
Kentucky 31 Fescue	5.4	.51	3.70	.49	.35	354	71	47	34.0	9.0	4.05	452	193	3.32
Highland Bentgrass	3.9	.46	3.02	.36	.25	179	83	50	18.7	<6	2.25	367	74	1.43
Meyer Zoysia	2.4	.20	1.45	.29	.13	203	29	35	17.5	<6	1.77	200	146	1.33
Bermuda	2.3	.26	1.14	.38	.25	1066	57	34	43.0	9.5	8.20	577	1145	3.59
Crabgrass	3.0	.36	3.34	.26	.49	496	107	38	47.5	9.0	6.35	367	431	3.78

Figure 1

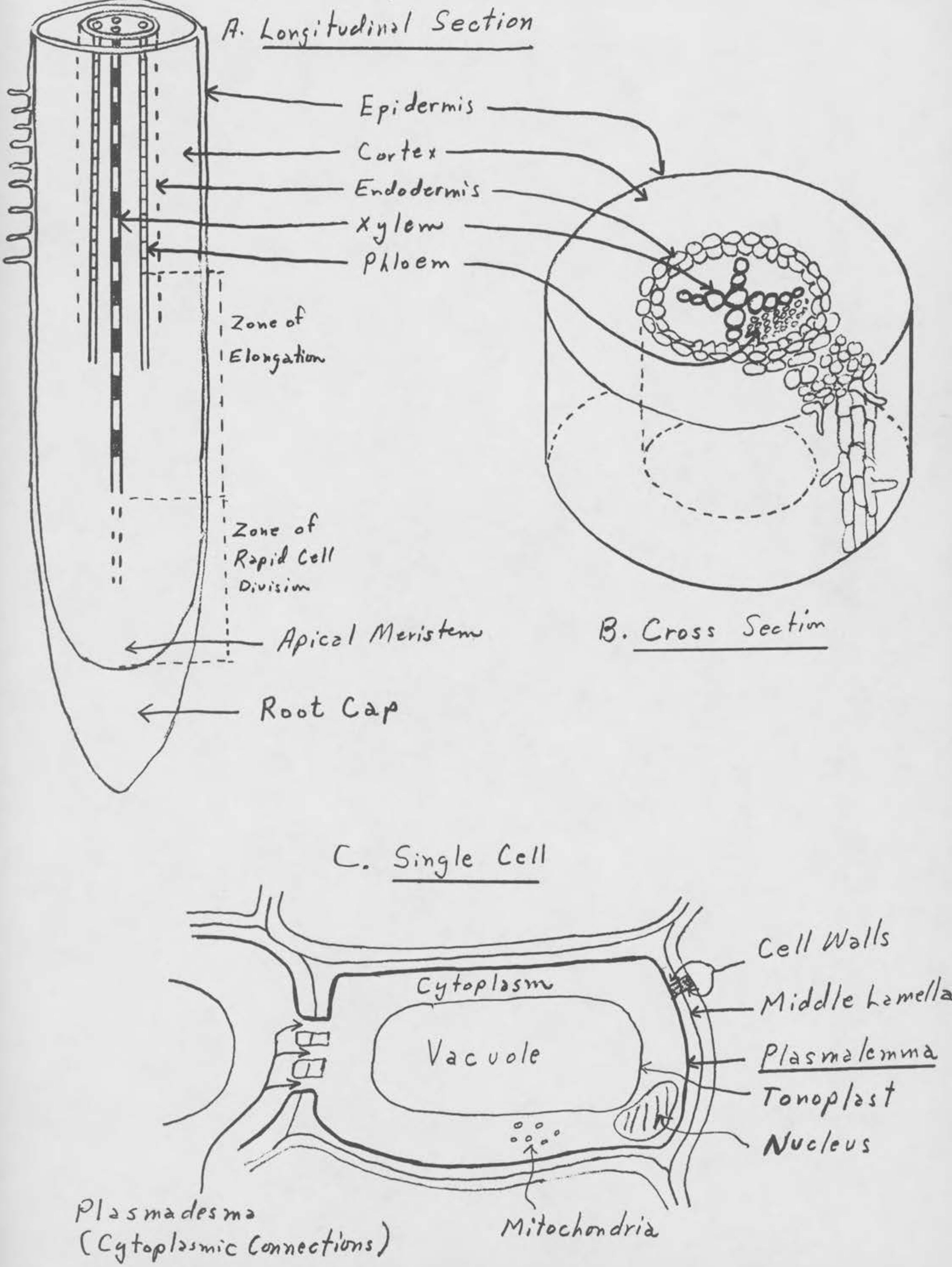
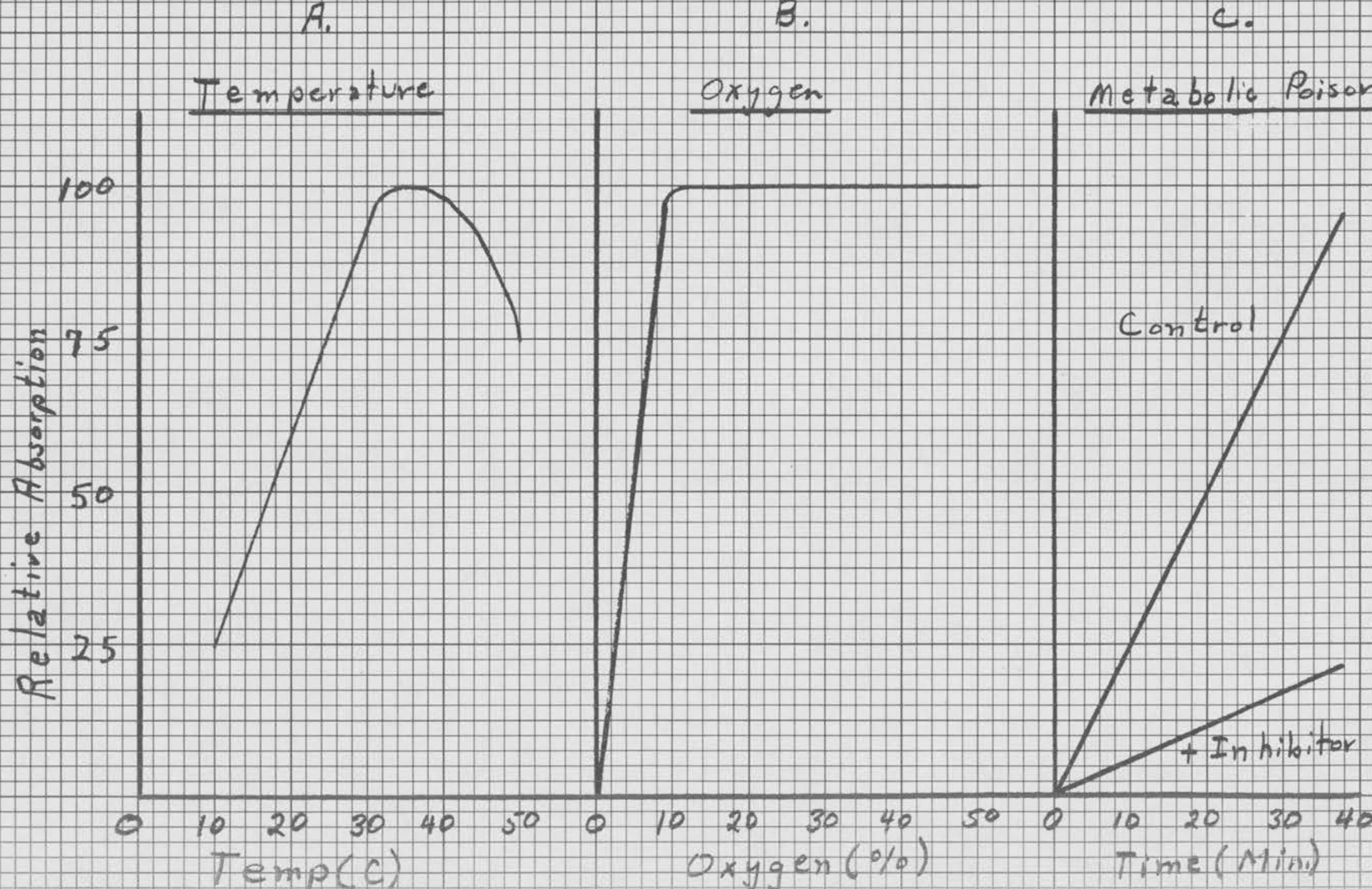
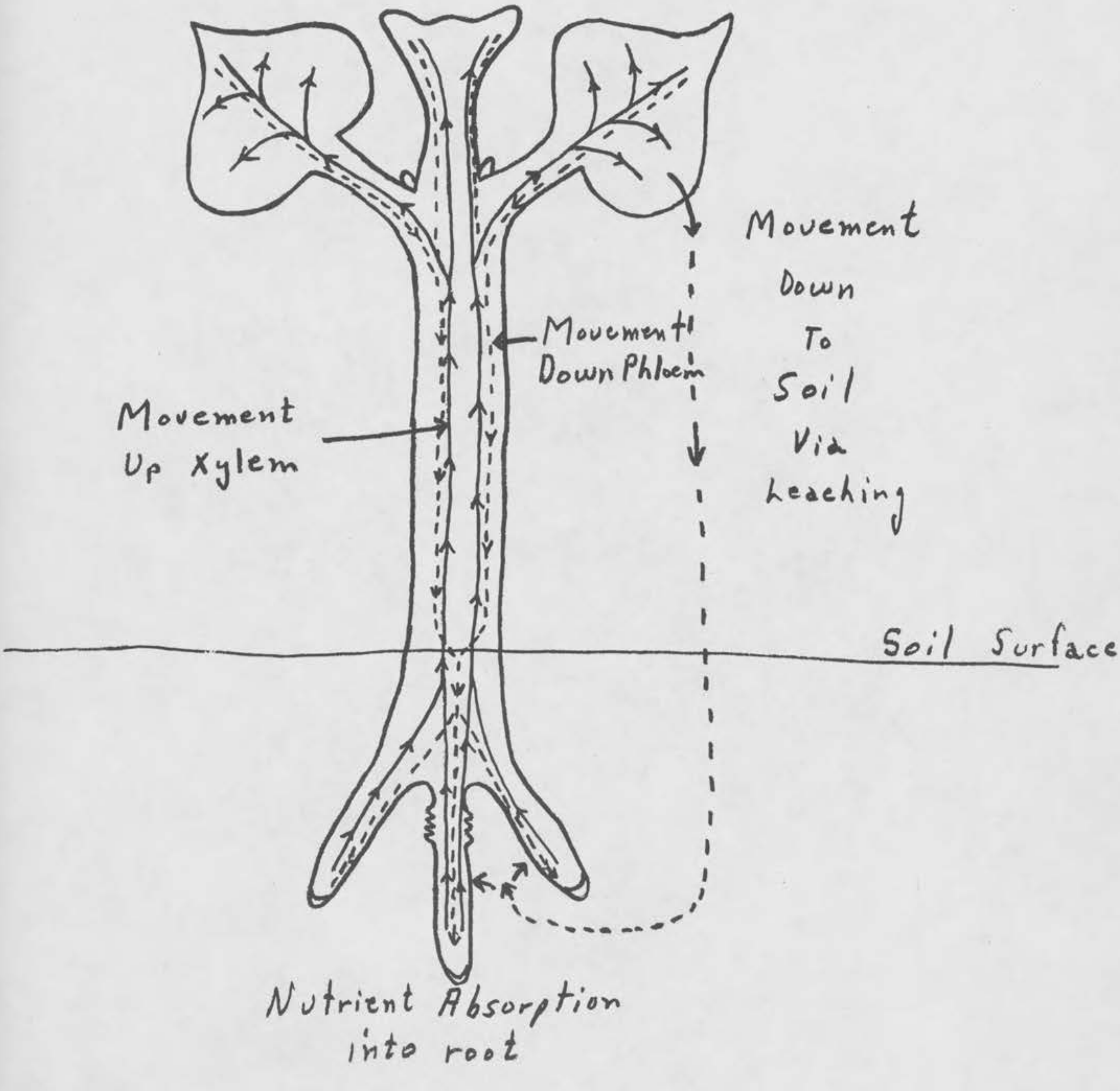

A. Longitudinal Section
Epidermis
Cortex
Endodermis
Xylem
Phloem
Zone of Elongation
Zone of Rapid Cell Division
Apical Meristem
Root Cap
B. Cross Section
C. Single Cell
Cell Walls
Cytoplasm
Middle Lamella
Vacuole
Plasmalemma
Tonoplast
Nucleus
Plasmadesma (Cytoplasmic Connections)
Mitochondria

Figure 2



A.
Temperature
B.
Oxygen
C.
Metabolic Poison
Relative Absorption
100
75
50
25
0
10
20
30
40
50
Temp(C)
Oxygen (%)
Time (Min)
Control
+ Inhibitor

Figure 3



Movement Down To Soil Via Leaching
Movement Down Phloem
Movement Up Xylem
Soil Surface
Nutrient Absorption into root

THATCH--As A Problem in Turf Management

J. D. Butler

Thatch, a rather common term in turf management, denotes an undecomposed layer of plant material occurring at the soil surface. Thatch is often a limiting factor in turf management.

With the demands for the production of near perfect turf, we have seen thatch become an increasingly important factor in the maintenance program. For highest quality turf, the use of improved fertilizers is constantly increasing. Irrigation has become common-place, causing increased growth during warm and previously dry periods. Also, varieties have been selected for vigor and density, further increasing the production of leaves and stems that form thatch.

Another factor which can contribute to the development of increased amounts of thatch are cool temperatures, which may result in reduced fungal and bacterial decay. The coarse, fiberous grasses, as well as those that grow rapidly, can contribute materially to increasing thatch. Length of the individual blades at the time of clippings and whether or not the clippings are removed can also influence thatch build-up. High and low moisture levels tend to cause a build-up of thatch--this may be due to reduction in oxidation and microbal activity. The chemical environment can affect the build-up. Levels of N, exceedingly acid conditions in the thatch layer and the presence of fungicides could all influence decay organisms and ultimate thatch accumulation. By changing any of the factors affecting thatch development, it would be possible to either reduce or magnify the problem.

Some Possible Benefits of Thatch - Sometimes thatch may be desirable, depending upon where and under what conditions it exists. The following benefits have been credited to mulch (thatch):

Shading and the lowering of soil temperature. With a mulch, soil temperature tends to be lower during the day and higher at night.

Some protection from frost and low temperatures. This can be achieved by the insulation provided by thatch.

Reduction of water loss. Thatch may protect the soil from drying winds.

Reduction of the weed population.

Recycling of nutrients. Some turf areas have looked good for many years without supplemental fertilizer.

Clippings from an acre of bluegrass contain approximately 120 lbs. N, 40 lbs. P_2O_5, and 100 lbs. K_2O.

Cushion for play. There is a rather general agreement that approximately 1/8" of thatch is desired as a cushion on bentgrass greens.

The plant debris could be important in soil improvement. Here, of course, the problem is the incorporation of the thatch into the soil. The organic matter adds to the soil by increasing the soil nutrients, improving drainage and aeration, and ultimately by increasing nutrient fixing capacity.

Adverse Effects of Thatch - The following adverse effects may result from an over-accumulation of thatch:

Reduction of water available to the soil. The thatch can often function as an organic covering, causing runoff.

Limiting air infiltration into the soil.

Shallow root development. Turfgrass roots are predominantly near the surface--either in the soil or thatch. If the roots are in the thatch, drought injury is often severe.

Fertilizer loss. N may be lost to the air. These losses may be more likely with the insoluble forms of N.

Increased disease problems. The thatch and clippings can keep the humidity high around the stems and leaves, thus increasing the disease problem. The thatch may also provide an over-wintering site for the disease-causing fungi.

Aid to insect infestations. The thatch can harbor lawn insects.

Thatch Control - Thatch control on greens is accomplished, in part, with top-dressing. On larger areas, of course, this is not practical and other practices must be used. Layers of thatch at varying depths in greens are often present. Investigation into the cause of the layer will often lead to the discovery that top-dressing had been dropped for a time from the maintenance program.

The present aerifiers allow for the removal of some thatch and soil. This provides a means for vertical improvement of the growing media as well as for a continuous rebuilding program. The use of unsterilized top-dressing may add beneficial micro-organisms for faster breakdown of the organic matter. Some greens have developed such thick layers of thatch that it is necessary to rely upon a rather continuous aerification and top-dressing program. Use of sewage sludge and lime to reduce acidity have also been suggested as ways of increasing decay, thus reducing the thatch accumulation.

At least 15 dethatching machines are available for the removal of surface debris. This equipment is available in a wide range of sizes from those approximately a foot wide to the large tractor-powered equipment. The motorized rake types lift the plant debris relying upon flexible tines. Other commonly used machines work on the vertical mower principle with solid blades removing the thatch. Periodic use of dethatchers has become commonplace in many maintenance programs. Use of these tools, just ahead of top-dressing, is also common practice.

Whether aerifying or dethatching, the best time for the operation would be in spring or fall when grass is growing well and high temperatures are less likely to occur. The "power rakes" and other less severe machines may be able to adjust into the maintenance program at other times.

SPECIFICATIONS FOR A METHOD OF PUTTING GREEN CONSTRUCTION

J. L. Holmes

Golf course construction is presently enjoying its most accelerated pace since the introduction of the game of golf into the United States. Not only are new courses being built, but old ones are being "modernized."

The cost of maintenance has influenced some clubs in their decisions to undertake a rebuilding program. There is a need to do away with features such as sharp contours and abrupt tee slopes which create maintenance problems.

Golf course design and golf course construction have been considered an art rather than a science. The individuality and the character of golf courses in this country have resulted from the artistic talents of some of the great architects in whose minds they were conceived.

Likewise, construction methods have been developed as a result of individual experiences and individual preferences. It is a tribute to those whose efforts have gone into golf course building as well as to those who maintain them that so many courses have stood up well over the years.

The pace of golf activity and the traffic on golf courses are presently at a peak, however, which has never been equaled in our country. Many of the construction methods that were satisfactory in an earlier day will no longer produce greens which will withstand the wear that is now imposed upon them.

Because of these considerations, the Green Section has for the last decade interested itself in construction methods and in a study of the physical problems of soils used in putting greens. Research in these matters has been sponsored by the Green Section at Beltsville; at Oklahoma State University; at UCLA; and during the past six years, an intensive program of study has been supported at Texas A. & M. College.

It has been found that the problems of construction procedures and methods and those of physical behavior of soils cannot be separated. The two matters are related and must be considered together if a desired result is to be produced.

The findings of the Green Section sponsored research are such that a sufficient amount of information is now available to warrant the publication of a suggested method of construction. The procedures which are outlined here may well be used as the basis for specifications which a club may present to the prospective golf course builder.

Such specifications will place no limitations upon the individuality nor the artistry of any architect. They will, however, provide a guide for the builder and for the club which want to be assured that the greens they build will continue to provide good playing conditions for many years.

The basic considerations underlying the specifications and methods presented are those of good drainage and resistance to compaction. These ends cannot be achieved without some compromise. A highly permeable soil which drains readily offers some problems in the establishment of turf. It is loose and sometimes may create difficulty in the changing of cups. These are minor problems, however, when weighed against the advantages of rapid drainage, good aeration, deep rooting, protection against diseases, protection against over-watering, protection against salt problems, a putting surface which holds a shot without being overly wet and one which resists pitting by golf balls.

The methods and specifications outlined in the following pages represent the best thoughts of the Green Section staff and of numerous soil scientists who have given serious attention to the problem. It is hoped that they will result in more satisfactory and less troublesome putting greens throughout the nation.

1. Subgrade - The contours of the subgrade should conform to those of the proposed finished grade, with a tolerance of plus or minus 1". The subgrade should be constructed at an elevation 14 inches below the proposed finished grade. The subgrade should be compacted sufficiently to prevent future settling which might create water-holding depressions in the subgrade surface and corresponding depressions in the putting surface.

Where terrain permits, it is possible to build the subgrade into the existing grade or to cut it into the subsoil. It is not necessary to elevate or "build up" the green unless design considerations dictate the desirability of doing so.

It will be noted that courses of materials above the subgrade consist of 4 inches of gravel, 1½ to 2 inches of coarse sand, and 12 inches of topsoil. Thus, the total depth will be 17½ to 18 inches. However, this fill material will settle appreciably, and experience indicates that 14 inches will be the approximate depth of these combined materials after settling.

2. Drainage - Tile lines of at least 4-inch diameter should be so spaced that water will not have to travel more than 10 feet to reach a tile drain. Any suitable pattern or tile line arrangement may be used, but the herringbone or the gridiron arrangement will fit most situations.

Cut ditches or trenches into the subgrade so tile slopes uniformly. Do not place tile deeper than is necessary to obtain the desired amount of slope. Tile lines should have a minimum fall of .5%. Steeper grades can be used, but there will seldom be a need for tile line grades steeper than 3% to 4% on a putting green.

Tile may be agricultural clay tile, concrete, plastic, or perforated asphalt-paper composition. Agricultural tile joints should be butted together with no more than ¼" of space between joints. The tops of tile should be covered with asphalt paper, fiberglass composition, or with plastic spacers and covers designed for this purpose. The covering prevents gravel from falling into the tile.

Tile should be laid on a firm bed of ½" to 1" of gravel to reduce possible wash of subgrade soil up into tile line by fast water flow. If the subgrade consists of undisturbed soil, so that washing is unlikely, it is permissible to lay tile directly on the bottom of the trench.

After the tile is laid, the trenches should be backfilled with gravel, being careful not to displace the covering over the joints.

3. Gravel and Sand Base -

a. The entire subgrade should be covered with a course of clean washed gravel or crushed stone placed to a minimum thickness of 4 inches.

The preferred material for this purpose is washed pea gravel of about ¼" diameter particle size. Larger gravel or stone may be used, but it is important that changes in size between this course of material and the succeeding one overlying it not be too great. Otherwise, smaller particles from overlying material will wash into the gravel, clog the pores or drainage ways and thereby reduce the effectiveness of the gravel.

The maximum allowable discrepancy appears to be 5 to 7 diameters. In other words, if ¼" pea gravel (about 6 mm.) is used, then the particles of the overlying course of sand should not be less than 1 mm. in diameter. If stone of 1-inch diameter were used, it would be necessary to include a course of pea gravel to prevent the movement of smaller soil aggregates into the stone.

b. When the gravel is in place, assuming that pea gravel has been used, a 1½" layer of coarse washed sand (commercial concrete sand is satisfactory) should be placed to a uniform thickness over the gravel.

The tolerance for error in the thickness of gravel and sand courses should be limited to plus or minus .5 inch.

A profile of a properly constructed putting green is illustrated in Figure 1.

4. "Ringing" the Green - When the courses of gravel and sand are in place and outlets have been established for subsurface water (through tile lines), the green should be "ringed" with the soil which is to be used for aprons and collars. This soil should be placed around the green and any contours established in such a way that they will blend into the putting surface.

The next step is to fill the depression, which represents the putting surface, with the prepared topsoil mixture described in the following paragraphs.

5. Soil Mixture - A covering of topsoil mixture at least 12 inches in thickness should be placed over the sand and gravel layers.

The soil mixture should meet certain physical requirements.

Permeability--After compaction at a moisture content approximately field capacity as described by Ferguson, Howard and Bloodworth (8), a core of the soil mixture should permit the passage of not less than ½ inch of water per hour nor more than 1½ inches per hour when subjected to a hydraulic head of .25 inches.

Porosity--After compaction, a sample of the soil mixture should have a minimum total pore space of 33%. Of this pore space, the large (non-capillary) pores should comprise from 12 to 18% and capillary pore space from 15 to 21%.

Information with respect to bulk density, moisture retention capacity, mechanical analysis, and degree of aggregation in the hands of a soil physicist may be helpful in further evaluating the potential behavior of a putting green soil.

Few natural soils meet the requirements stated above. It will be necessary to use mixtures of sand, soil, and organic matter. Because of differences in behavior induced by such factors as sand particle size and gradation, the mineral derivation and degree of aggregation of the clay component, the degree of decomposition of the organic matter, and the silt content of the soil, it is impossible to make satisfactory recommendations for soil mixtures without appropriate laboratory analyses.

The success of the method of construction herein described is dependent upon the proper physical characteristics of the soil and the relationship of that soil to the drainage bed underlying the green. Therefore, a physical analysis of soil should be made before the soil components are procured. When the proper proportions of the soil components have been determined, it becomes extremely important that they be mixed in the proportions indicated. A small error in percentages in the case of a plastic clay soil can lead to serious consequences. To insure thorough mixing and the accurate measurement of the soil components, "off site" mixing is advocated.

Any soil physics laboratory which is equipped with the facilities to carry out the measurement described by Ferguson, et al. (8) can prescribe a soil mixture for putting green use. Green Section offices can provide names of laboratories so equipped upon request.

6. Soil Covering, Placement, Smoothing and Firming - When soil has been thoroughly mixed off site, it should be transported to the green site and dumped at the edge of the green. Padding the edge of the green with boards may be necessary to prevent disturbance by wheeled vehicles of the soil previously placed around the outside of the putting surface. A small crawler-type tractor suitable equipped with a blade is useful for pushing the soil mixture

out onto the prepared base. If the tractor is always operated with its weight on the soil mixture that has been hauled onto the site, the base will not be disturbed.

Grade stakes spaced at frequent intervals on the putting surface will be helpful in indicating the depth of the soil mixture. Finishing the grade will likely require the use of a level or transit.

When the soil has been spread uniformly over the surface of the putting green, it should be compacted or firmed uniformly. A roller usually is not satisfactory because it "bridges" the soft spots.

"Footing" or trampling the surface will tend to eliminate the soft spots. Raking the surface and repeating the footing operation will result in having the seed or stolon bed uniformly firm. It should be emphasized that the raking and footing should be repeated until uniform firmness is obtained.

Whenever possible after construction, saturation of the soil by extensive irrigation is suggested. Water is useful in settling and firming the surface. This practice will also reveal any water-holding depressions which might interfere with surface drainage.

7. Sterilization of Soil and Establishment of Turf - These steps may be accomplished by following well-known conventional procedures.

The foregoing steps in construction have been used successfully in many greens in various parts of the nation. It should be emphasized that each step in construction is dependent upon all the others. It is inadvisable to use a blanket of gravel unless the proper soil mixture is used above. It is inadvisable to use the gravel and the proper soil mixtures unless the intermediate layer of sand is used to separate them. The courses of gravel and sand may result in saturation of the lower portions of the topsoil mixture unless the proper soil mixture is used.

In short, do not attempt to incorporate some of these steps into green construction unless they are all used in exact accordance with these recommendations.

The foregoing specifications tell the club how to proceed with the job of building a putting green, but they do not tell why one should follow these procedures. There is ample evidence in the body of published literature to support the methods herein advocated. For those who are interested in a study of the principles which are involved and which are used as a basis for the recommendations set forth, a list of references is appended.

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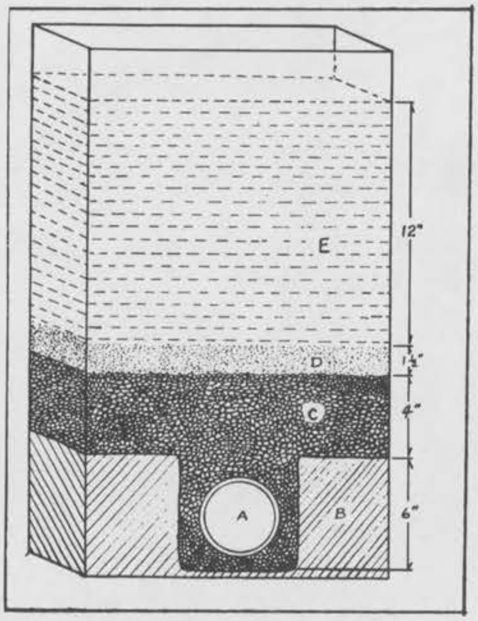
Figure 1

CROSS SECTION OF A PUTTING GREEN PROFILE SHOWING A TRENCH AND TILE LINE



A. 4-inch diameter tile.
B. Subgrade of native soil or fill material.
C. Gravel—preferably pea gravel of approximately ¼" diameter. Minimum thickness 4 inches.
D. Coarse sand—this sand should be of a size of 1 mm. or greater. One and one-half to 2 inches in thickness.
E. Topsoil mixture. Minimum thickness of 12 inches.

FACTORS INFLUENCING DISEASE DEVELOPMENT ON PUTTING GREEN TURF

Michael J. Healy[1]

For the past three years, I have worked with the Helminthosporium leaf spot disease of creeping bentgrass on putting greens in central and northern Illinois. During the summer of 1963, I acquainted myself with the range of symptoms of this disease, the time of occurrence of symptoms, and the effectiveness of various fungicides used for prevention and control of this disease. Starting in the spring of 1964 and continuing until the Fall, field symptoms were again observed and recorded. Positive identification of the leaf spot organism (Helminthosporium sorokinianum) was accomplished by studying the fungus in pure culture after isolating it from suspected diseased leaf tissue.

During 1963 and most of 1964, I experienced difficulty in reproducing symptoms by artificially inoculating healthy creeping bentgrass plants grown in the greenhouse. At the 5th Illinois Turfgrass Conference held last year, I had suggested two methods of overcoming this difficulty in producing either artificially induced leaf spotting or leaf blighting. To obtain blighting of leaves, I had subjected the plant to a 108°F temperature for a period of one hour before inoculation. While this heat treatment often rendered the plant more vulnerable to attack by the fungus, the temperature used was so critical and needed to be controlled so exactly that any slight temperature increase above 108°F would kill the plant without fungal infection. In order to produce consistent leaf spotting, I found it necessary to inclose the pots of plants used for inoculation in a moist plastic bag for a period of 10 to 12 hours before inoculation. Again, this method did not prove to be completely satisfactory since the level of leaf spotting produced was not high enough to facilitate the study of infection and symptom development.

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In the spring of 1965, I again found it necessary to look for possible explanations why adequate disease development could not be produced in artificially inoculated plants. Obviously, creeping bentgrass plants grown in the greenhouse are not subjected to as many "less-than-optimal" growing conditions as bentgrass plants grown as putting green turf. From observation of putting green turf culture and reference to work done by other researchers, a new method was devised to successfully inoculate greenhouse grown plants. Instead of looking for methods to make the plant more susceptible to attack by the fungus, I looked for ways in which the fungus might be able to infect the host plant more effectively, based on the environment the fungus is exposed to when it is located in putting green turf.

The putting green surface is exposed to a great amount of moisture for long periods of time. Not all of this moisture, however, results from rainfall or irrigation and not all of this moisture is composed of water alone. Three other sources besides rain or irrigation water contribute to wetting plant surfaces. The first source is dew. Dew consists of condensed water vapor formed on cooled plant surfaces. This phenomenon may occur from early in the evening until late the following morning, if atmospheric conditions are proper. The second source is wound exudates, composed primarily of plant saps which are formed as a result of the numerous freshly cut leaf surfaces produced by frequent mowing of golf greens. The third source of liquid for wetted leaf surfaces is the guttation fluid produced by plants when the transpiration rate is low and the roots are rapidly absorbing water. Guttation fluid usually consists of a large assortment of sugars, nutrients, and salts.

The possibility existed that the various compounds found in plant wound exudates or guttation fluid might in some way enhance the ability of the fungus to infect the host. Five substrates were tested for their effectiveness in producing leaf spotting when used as spore suspension substrates. These five substrates were:

1. Plant extract. -- Leaves of Washington creeping bentgrass were suspended in distilled water and then homogenized in an osterizer for 3 minutes. Plant debris and chloroplasts were removed and the liquid sterilized using a bacteriological filter. The resultant liquid should closely resemble the naturally occurring wound exudates.

2. Barley guttation fluid. -- Because of the difficulty in collecting adequate amounts of guttation fluid from creeping bentgrass plants, barley guttation fluid was used. It had been previously shown that barley guttation fluid used as an H. sorokinianum spore suspension substrate enhanced the infection of Seaside creeping bentgrass.

3. 0.2 M D-fructose. -- Fructose is a common sugar constituent of many grass plants. Sugar storage is mainly in the form of fructose groups or fructosan. Since either the guttation fluid or wound exudates may consist partially of fructose, its possible affect on fungus growth and infection ability was considered important.

4. 0.1 M L-glutamine. -- Under certain growing conditions, this compound is found in great abundance in the guttation fluid of certain plants. Original work with bluegrass indicated that nitrogen deficient plants fertilized with some type of ammonium fertilizer would be stimulated to produce large amounts of glutamine which would end up in their guttation fluid. The phenomenon of copious glutamine production is a result of ammonium being combined with glutamic acid (a common amino acid found in the plant). Under ordinary conditions, the soil microflora convert ammonium to nitrate before it is taken up by the plant.

Under certain conditions (when the plants are nitrogen deficient and readily available ammonium ions are present in the soil), ammonium is taken directly into the plant. Since ammonium ions can be toxic to the plant, if present in high concentrations, the ammonium ions are combined with glutamic acid to form glutamine. While there is no presently available evidence that large quantities of glutamine are sometimes present in creeping bentgrass guttation fluid, the possibility exists.

5. Water. -- It was necessary to compare the results of the other 4 substrates with water alone. Dew, rain and irrigation water may be considered to be primarily composed of water alone.

Inoculation of Washington creeping bentgrass plants with washed spores of H. sorokinianum suspended in each of the 5 substrates produced the following results (Table 1). The result of concentration level of both L-glutamine and plant extract on leaf spot severity is presented (Table 2). The plants used in these tests were inoculated and then placed in plastic bags and maintained at 78^{o}F for a period of 48 hours, at which time the plastic bags were removed. Plants were rated for leaf spot development 12 hours later.

Results of these experiments indicate that both the plant extract and glutamine significantly increased leaf spotting of inoculated Washington bentgrass leaves. Since the plant extract used here approximates the wound exudates produced daily on putting green turf, it is highly probable that these exudates do affect the severity of naturally incited leaf spot outbreaks. It is also interesting that glutamine alone produced a high infection index level, since the production of glutamine has been shown to be dependent on certain fertilization practices. An optimum concentration level for infection was found for glutamine, but not for the plant extract (Table 2).

The reason for increased leaf spotting using the glutamine and plant extract inoculum substrates was then determined by examination of the infected leaves. The growth of the fungus on leaves was altered in such a way that it was able to produce many more infection structures or appressoria than spores applied to leaves using water, fructose, or barley guttation fluid as the spore suspension substrate. It was also observed that the size of each leaf spot was directly proportional to the number of fungal penetrations in that area, i.e., the more penetrations, the larger the leaf spot.

Numerous areas of research could be initiated based on the findings presented here. The compound or compounds in the plant extract which increase the infection potential of this leaf spot fungus should be identified. Next, these or similar compounds should be looked for in the naturally produced wound exudates associated with putting green turf. Methods of decreasing the amount of infection stimulating compounds found in wound exudates (e.g., altering fertilization practices or application of chemicals) might be of significant practical value in disease control.

During this 3-year study, there were numerous cases when isolation from diseased creeping bentgrass leaf tissue yielded organisms not considered pathogenic to this specie of grass. For the most part, these saprophytic fungi were considered secondary invaders and no inoculation tests were made. In particular, isolation from severely infected putting green creeping bentgrass tissue observed on several golf courses in the northern part of the state this year produced no known pathogenic fungi. While symptoms of these diseased greens strongly suggested typical severe leaf spot and/or blight damage, none of the leaf spot fungi were isolated. Twenty-two golf courses in the state of Illinois and 4 in the state of Missouri have been selected for a one-year study to determine, by isolation and subsequent identification, the species of fungi present in both the dead leaves in the thatch layer and the apparently diseased leaves on the putting surface. Leaf tissue from two putting greens on each course will be used in the isolation studies, and samples will be collected three times during the growing season. The first collection was made early in October of this year and the next two will be made in the spring and summer of 1966. Using the same techniques outlined in this paper to increase the infection potential of the leaf spot fungus H. sorokinianum, the more commonly isolated and presently considered nonpathogenic fungi will be tested. It will be my job to show that under certain conditions, some of these organisms may indeed by pathogenic to creeping bentgrass, especially when this grass is maintained as putting green turf.

Table 1. Results of inoculating Washington creeping bentgrass leaves with spores of *H. sorokinianum* in five substrates.

Substrate	Infection index[1]				
	Exp. 1	2	3	4	Average
Plant extract	758	266	829	778	658
0.1 M L-glutamine	632	336	852	756	644
0.2 M D-fructose	239	270	129	371	252
Barley guttation fluid	216	255	130	349	238
Distilled deionized water	138	87	220	135	145

Table 2. The affect of L-glutamine and plant extract concentration on infection of inoculated Washington creeping bentgrass leaves.

Substrate	Infection index[1]			
	Exp. 1	2	3	Average
Distilled deionized water	102	95	137	111
0.0001 M L-glutamine	216	202	173	197
0.001 M L-glutamine	254	331	216	267
0.01 M L-glutamine	280	369	302	317
0.1 M L-glutamine	154	327	261	247
1/1000 plant extract	147	213	155	172
1/100 plant extract	156	202	258	205
1/10 plant extract	203	288	331	274
1/1 plant extract	464	500	451	472

[1]Obtained my multiplying the average number of leaf spots per leaf per treatment by the total percentage of leaves exhibiting any leaf spotting.

LOOKING BEHIND THE FUNGICIDE LABEL

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The Long Road of Research

Many factors determine whether a fungicide, newly discovered in a laboratory of a company manufacturing pesticides, will eventually be offered for sale to control plant diseases. The road of research that develops a new fungicide--or any pesticide--is a long one and may involve 7 to 10 years or more, many thousands of hours of labor, and cost 3 million dollars.

The research chemist, biologist and veterinarian must learn as much as possible about the effects of a new fungicide upon many different forms of life. Toxicity to man and other animals is carefully studied and the great majority of the most toxic are discarded without further study. When sufficient information concerning formulations, dosages, safety, and effectiveness is acquired, the compound may be released to U.S.D.A. and State research workers to develop further methods of application, additional uses and to compare the new material with currently used products to decide which is most suitable. Applied research at various State agricultural experiment stations, as well as private experimental research farms and laboratories, usually takes at least three years before recommendations are made for use of the material.

If the prospective fungicide has proven successful, the manufacturer will have studied market opportunities, applied for a patent, developed special manufacturing processes, built a pilot plant, applied for label registrations and, perhaps, even contemplated building a factory to produce the new fungicide.

On to Washington

Before a new product can be offered for sale through interstate commerce, it must be granted registration by federal regulatory agencies. Registration is not given to the fungicide itself, but rather for each individual use of the product. Securing federal registration provides a final careful scrutiny of all data completed during the long research program on performance, safety and residues. Some 20 pounds of double-space typing on paper, giving detailed scientific laboratory, greenhouse and field research report data, are required for an average package label.

The U.S.D.A.'s Part

A manufacturer must submit formal documents in Washington, D. C. of his proposed labeling and adequate research data to support all claims made for the product. The documents are filed with the United States Department of Agriculture under the Federal Insecticide, Fungicide, and Rodenticide Act of 1947 as amended, administered and enforced by the Pesticide Regulations Division of the Agricultural Research Service. This law regulates the interstate distribution of economic poisons including agricultural, household, and industrial pesticides.

The labeling and supporting data are carefully reviewed by U.S.D.A. specialists--including bacteriologists, biologists, chemists, entomologists, nematologists, pharmacologists, plant pathologists, plant physiologists, and veterinarians--to determine the following: (1) Will the product be effective against the diseases named on the labeling, and can it be used effectively without causing damage to the plants or objects to which it is applied? (2) Does the label bear warning and caution statements that are adequate, when complied with, to prevent injury to the user or other persons, pets, livestock, fish or wildlife that are exposed? (3) Will the directed use of the fungicide leave illegal residues on harvested food or feed? In addition, the U.S.D.A. conducts intensive research on pesticides to assure the development of effective and safe use practices. The U.S.D.A. also examines the validity of the residue information and determines whether or not a residue is truly present.

If all the U.S.D.A. specialists involved are convinced that the product is necessary and useful and can be applied effectively and safely without leaving illegal residues on food or feed--when label warnings and directions are carefully followed--it is acceptable for registration.

Now the F.D.A.--Residues and Tolerances

If a residue exists, and the fungicide is to be used for the production of food or feed crops, the Food and Drug Administration of the U. S. Department of Health, Education and Welfare is called into the picture. This agency receives the comprehensive reports submitted in the form of a petition requesting a residue "tolerance." The F.D.A. examines the many facets of information, including the minimum dosage of the fungicide required to produce a toxic effect, the maximum residues found, the foodstuffs involved, the consumption patterns for these foodstuffs, the maximum daily intake of these foods, possible extreme intakes of such foods, and other factors.

Because of possible carry-over to meat or milk products, forage plants and plant residues used for feed are included. Ornamental shrubs, trees, flowers and turf are not included in the law (Miller Amendment of Public Law 518, passed by Congress in 1954) at present.

At this time most fungicides are involved only when applied as sprays or dusts to the edible portion of the plant or as seed or soil treatments. Materials applied to the soil, the seed, or seedlings in the plant bed are exempt when none of the chemical is present at harvest.

The F.D.A. has set up the following procedure for establishing a tolerance:

1. When a manufacturer applies to the U.S.D.A. for registration of a product under the Federal Insecticide, Fungicide, and Rodenticide Act with

directions for use on a food crop in a manner that will leave residues on the harvested food, he is told that registration will not be issued until a tolerance is established to cover the residues.

2. The manufacturer must then assemble and submit to the F.D.A. residue data to show conclusively the level of residues likely to result and toxicity data to prove that such residues on the food or feed would be safe.

3. The U.S.D.A. must certify to the Food and Drug Administration that the pesticide is useful for the proposed use and express an opinion on the adequacy of the residue data. Specialists in the F.D.A. then carefully evaluate the data to determine whether a tolerance is justified.

4. If the residue and toxicity data are found to be adequate, a tolerance is established and the Department of Agriculture can issue registration. (This legally enforceable level is set far below the point at which residue might be harmful to consumers.) If the data are determined to be not adequate to justify the proposed tolerance, the F.D.A. will refuse to establish the proposed tolerance and may establish a tolerance at a lower level or a zero tolerance if the data warrant such action. In no case will the Food and Drug Administration establish a tolerance greater than is needed to cover the residue resulting from the proposed use.

5. When a pesticide is registered for use on a food crop on the basis of a zero tolerance or on a no-residue basis, it means that the directed use will not leave residues on the harvested food at levels that can be detected by chemical analysis. This has often meant that the development of a much more sensitive method invalidates the zero tolerance or no-residue acceptance. (Example: In 1950, DDT and certain other chlorinated pesticides could be determined to about 0.1 and 0.5 p.p.m. (parts per million) in many crops. With the development of gas chromatography, residues of less than 0.01 p.p.m.

may often be determined. In water, residues of less than 1 p.p.b. (parts per billion) can be determined. This is equivalent to being able to identify 1 second of time in 32 years. Under ideal conditions, using pure compounds not complicated with plant or animal tissues, the most modern equipment is now capable of detecting 3 parts per trillion, equivalent to identifying 1 second in 10,666 years!)

The U.S.D.A. is conducting a pioneer monitoring program in which the presence of any commercial pesticide residue in soil, water, plants and wildlife is being measured in selected test areas of the United States. Information gathered in this program will be used to provide even greater protection for men and animals.

Finally, the Label!

The pesticide label is a very important technical and legal document summarizing results of millions of dollars spent in research. The directions tell the user how to apply the fungicide most effectively and, at the same time, keep the ultimate residue on food crops within the "tolerance" granted under law.

1. Every Pesticide Label Must Show:

   (1) Name of product, brand or trademark under which the fungicide is sold,

   (2) Name and address of manufacturer, registrant, or person for whom manufactured,

   (3) The net content statement,

   (4) The registration number assigned to the fungicide,

   (5) An ingredient statement--name and percentage, by weight, of each active ingredient, and total percent of inert ingredients or name of each active and each inert ingredient in descending order and relative abundance in each category and the total percentage of inert ingredients,

   (6) Warning or Caution Statement

      (a) An economic poison must show warnings pertaining to ingestion, skin absorption, inhalation, and flammability or explosion. Appropriate warnings are also provided for the protection of fish and wildlife.

(b) Economic poisons that are highly toxic to man must show "POISON" in red on a contrasting background, "DANGER," skull and crossbones, and statement of antidote, including directions to call a physician immediately--in the immediate vicinity of the skull and crossbones and "POISON."

(c) Directions for use--optional on label, may appear on accompanying printed or graphic matter. Registered labels that do bear directions for use give the names of crops or sites to which the product is intended to be applied, the diseases or fungi to be controlled, dosage rates, a schedule of application that would provide effective control of the diseases or fungi claimed, and any appropriate limitations in dosage or time of application consistent with residue requirements.

2. Other Label Information That May Be Required:

(1) Data to support any or all claims on the labeling,

(2) A complete statement of the composition of the product, including the percentage, by weight, of each of the active and inert ingredients, if such information does not appear on the label,

(3) Any pertinent information about inert ingredients,

(4) Any other information pertaining to physical or biological properties of the fungicide, e.g., caution against use on certain plant species or varieties known to give a phytotoxic response to the product and against known incompatible combinations with other pesticides.

3. It Is Unlawful To:

(1) Represent a fungicide or other pesticide for use different than what the registration specifies,

(2) Sell pesticides in containers other than the manufacturer's original one,

(3) To destroy, alter, deface or detach the label from a container, and

(4) Dilute or change a fungicide in the manufacturer's original container.

The label on every pesticide container is an important legal document. It represents years of hard work and much expense. The user has every reason to expect all claims on the label to be fair and reasonable. The law imposes many safeguards for the public, but the most important act depends upon the user. All the research and precautions in the world are of no value if you, the consumer, refuses to "READ THE LABEL."

Additional Reading

1. Regulations for the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act (with current interpretations). From the Code of Federal Regulations.

2. Clinical Handbook on Economic Poisons. Emergency Information for Treating Poisoning. U. S. Department of Health, Education, and Welfare, Public Health Service.

3. U.S.D.A. Summary of Registered Agricultural Pesticide Chemical Uses (2nd Edition, with supplements). For sale by Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. $3.75.

4. Fungicide, Nematocide, and Preservative Tolerances and Use Restrictions Approved by U.S.D.A. as of January 1, 1965. Report on Plant Diseases No. 1000 (Revised). Department of Plant Pathology, University of Illinois.

5. Modern Fungicides and their Uses. Report on Plant Diseases No. 1002, Department of Plant Pathology, University of Illinois.

6. Pesticides and Public Policy,

The Search for Abundance,

Open Door to Plenty,

Fact and Fancy. A reference checklist for evaluating information about pesticides. All 4 leaflets available from National Agricultural Chemicals Association, 1145 - 19th Street, N. W., Washington, D. C.

7. Pros and Cons of Pests, Pest Control and Pesticides. World Review of Pest Control, Spring, 1962, Volume 1, Part 1.

8. Chemicals and Pests. Science, September 28, 1962.

ARSENIC AND LOW PHOSPHATE SOILS

C. W. Lobenstein

In the hands of experiences and careful managers, the use of arsenicals has proven to be a successful means of controlling crabgrass, Poa annua, and certain other weeds in fairways and other turf areas. In many cases, the use of lead or calcium arsenate is more or less standard practice. On the other hand, many instances of misfortune and serious turf injury from arsenicals have also been observed. Safe use of an arsenical program requires knowledge of the relative arsenic and phosphate levels in each particular turf area.

A pre-emergence arsenate herbicide program is dependent upon the fact that if sufficient arsenic ions are present in the rootzone, the plants may absorb so much arsenic, instead of essential phosphate, that they are killed. Since certain turfgrass species apparently tolerate somewhat higher levels of arsenic than susceptible weedy types, herbicidal selectivity is obtained. This is especially true if the turf species is firmly established before treatment. Success, then depends upon very careful control of the arsenic and phosphate levels in the top layer of the rootzone so that the weedy species absorb toxic quantities of arsenic in the place of phosphate while the desired turf species apparently escape injury.

Since many turf soils which have received reasonably good fertilizer applications regularly may be fairly high in phosphate content, the use of phosphate fertilizers preceeding or soon after arsenate application frequently may be discouraged. This might suggest that an arsenical program ought to be even more effective on soils of low phosphate content. From the point of view of weed control, this might be true; however, many people can testify that there are limiting minimum phosphate levels below which this program will "control" the desired grasses too.

Thus, general recommendations of immediate application of available phosphate in cases where injury occurs to desired grasses, due to arsenical application, should be a strong reminder that the margin of arsenic-phosphate levels between desired and undesirable "control" is frequently quite narrow and variable. Some general observations of thinning and other weakening of turf following arsenical use, also suggest that reduced root development may be causing considerable "hidden injury" that is not immediately evident.

The necessity for caution in use of arsenicals, especially on low phosphate soils, was dramatically illustrated in tests at the Dixon Springs Agricultural Center during 1964-65. Since the soil where the turf plots are located is typically low in available phosphate, (the P_1 soil test averages 10-15 lbs. available phosphate per acre), this is an ideal place to measure the permanent effects of arsenate upon root and turf development under field conditions.

A commercial form of granular tri-calcium arsenate was applied to established Common Kentucky bluegrass in early April of 1964 and also in 1965, at rates of 0, 10, 15, and 20 pounds per 1,000 sq. ft. The check plots (0 lbs.) were treated with Dacthal at standard rate (10 lbs./1,000) to minimize any differences between the check and treatment plots in crabgrass competition. At the same time, one-half of each arsenate-rate plot received an application of 20 pounds of 0-20-0 (1.7 lbs. P) per 1,000. Six pounds of ammonium nitrate was applied twice annually to all plots and they were mowed as needed, at 2½ inches. No supplemental water was applied except one application in September 1964 during the extended drought of that year. All treatments were replicated four times.

Visual ratings of turf cover and general quality were taken at monthly intervals during the two growing seasons. Differences that could be detected are shown in Table 1. In October of each year, duplicate 4-inch core samples for each plot were taken to a depth of 6 inches. Live shoots were counted and weighed and roots from the soil cores were washed and weighed. Results from the 1964 treatments are shown in Table 2. General results from these tests to date can be summarized as follows:

During 1964, which might be characterized as a difficult growing season with an extended drought during the late summer and fall, visual ratings showed no important differences between rates of arsenic application whenever supplemental phosphate was applied. Even where phosphate was not applied, injury symptoms did not appear until quite late (Table 1-A).

When the same test was repeated in 1965, which was a very favorable season with much better rainfall distribution, injury was evident much sooner and was much more severe--even when supplemental phosphate was applied (Table 1-C).

The average rating values indicate, for both years, that the 10 pound arsenate rate apparently caused about as much visible injury as the heavier rates. On the other hand, the severity of root reduction in the 1964 tests, (Table 2), appeared to increase directly with increasing arsenate rates.

Application of supplemental phosphate appeared to prevent root inhibition in that year. However, the 1965 visual ratings of plots receiving arsenate in 1964 indicated that some injury still may have occured even in spite of supplemental phosphate (Table 1-B).

In both years, the beneficial effects of phosphate on such low-test soils was evident throughout the year, irrespective of arsenic level. This was shown in visual ratings, and in 1964 phosphate appeared to be even more important than arsenic level in determing shoot number and weight.

The P_1 soil test data also provide a good demonstration of the very limited movement of phosphate to any depth into soils from a surface application.

Arsenicals are undoubtedly not the only herbicides causing reduced root development or other forms of masked injury to the plants we seek to protect. However these very limited tests, as reported, do illustrate several factors that must be continually recognized as one uses chemical herbicides for turf protection:

a) Injury can occur which may not be expressed or observed until perhaps even the next growing season,

b) The type of growing season most certainly does affect occurence and degree of injury from herbicides,

c) Visual observations of the turf above-ground may not always be adequate to evaluate degree of injury (or benefit) from any treatment,

d) In the case of arsenicals, attention must be given to maintenance of adequate available phosphate levels in the rootzone. Recommendations for reduction of phosphate levels to attain greater herbicide efficiency should not be carried to such an extreme that the turf itself is exposed to more serious injury

Table 1. Turf cover and general quality ratings following application of tri-calcium arsenate to bluegrass at Dixon Springs, Ill.

	Pounds of tri-calcium arsenate per 1,000 sq. ft.							
	0[a]		10		15		20	
Rating (c) Date	-P	+P[b]	-P	+P	-P	+P	-P	+P
				Applied 4/10/64				
8/9/64	8.0	8.5	8.0	8.5	7.5	8.8	7.8	8.8
9/12/64 (A)	8.0	8.5	8.0	8.8	7.5	8.8	7.8	8.8
10/12/64	7.8	9.3	5.8	9.3	5.3	9.0	5.5	9.0
7/16/65	8.8	9.5	7.8	9.5	6.3	9.5	5.0	9.0
9/17/65 (B)	8.3	9.3	6.0	8.3	4.5	6.8	3.3	6.5
10/22/65	7.5	7.8	6.5	6.8	5.8	7.0	5.0	6.3
				Applied 4/20/65				
7/16/65	8.5	9.5	5.8	8.8	6.0	8.5	6.3	8.5
9/17/65 (C)	7.0	8.5	1.8	4.8	1.3	5.8	1.8	5.5
10/22/65	8.3	8.8	2.0	6.5	1.8	6.5	2.3	5.8

(a) Dacthal @ commercial rate applied to check
(b) +P received 20 lbs. 0-20-0 per 1,000 at initial date
(c) Rating of 10 equal to most desirable cover and quality

Table 2. Shoot and root development of bluegrass following application of tri-calcium arsenate in 1964 at Dixon Springs, Illinois.

	Pounds of tri-calcium arsentate per 1,000 sq. ft. (a)							
	0		10		15		20	
(b)	-P	+P	-P	+P	-P	+P	-P	+P
Live shoots (no.)	89	102	75	102	69	107	79	115
Shoot weight (grams)	1.50	1.90	1.14	1.68	1.33	1.69	1.66	1.88
Root weight (grams)	5.3	5.9	4.1	5.4	3.2	6.2	2.9	5.8
P_1-lbs./A 0-2"	16	124	35	118	35	127	27	115
2-4"	11	15	24	18	10	17	10	21

(a) Applied 4/10/64
(b) Avg. of eight 4-in. cores taken 10/12/64

SHRUBS FOR USE AROUND RECREATIONAL AREAS

M. C. Carbonneau[1]

Hundreds of requests for information and recommendations concerning various shrub and plant materials come into our office yearly. Recommendations are made with the understanding that environmental conditions can change or be changed to affect the performance of particular plants. This should be kept in mind when purchasing, planting, and caring for plant material.

Plant material used in public or recreational areas must meet several requirements to be most effective. The following are mentioned to give guidance in selecting ornamental plants:

1. The plant material must be reliably hardy in your location. Golf courses located in the southern part of Illinois could be planted with a wider range of material than those in the north. The importance of winter hardiness is often forgotten when purchases are made. This is not an attempt to discourage you from trying new plant material as it appears in the trade. However, it is wise to ask someone who knows before you invest in plants with which you are not familiar. A local nurseryman will be most willing to guide you in making your decision, as he will be interested in your return business.

2. The plant material should require a minimum of maintenance (shearing, pruning, fertilizing, etc.). It is important to know the rate of growth, the ultimate size, various growth characteristics (rank vs. compact), leaf size, etc. Determine the best time to prune the plant for best recovery of flowers, fruit and foliage. It would also be wise for you to learn how to prune properly. This will allow you to keep a plant in proper conformation and cut down on replacement.

3. The plant material should be relatively free from insects and diseases. With proper inspection before you purchase plant material, you can cut down on

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future trouble and work. The insect and disease problem is very important. This is indicated by the number of requests which we receive. It would be well to investigate a particular group of plants to see what the disease and insect problems might be before purchasing any new material. Many of the more expensive plant items require less spray care than cheaper materials. Consequently, you may be able to save considerably by spending a little more in the beginning. Any landscape plant has drawbacks or problems, but the amount of annoyance or frequency of occurrence of the problem is the factor to consider.

4. The plant material should be adapted to the existing soil and climatic conditions. If you have a native alkaline soil and want to grow azaleas and rhododendrons because a member of the club requests these, you are in for quite a soil preparation and maintenance project. Are the plants going to be exposed to strong, drying winds? The wind problem can be severe in Illinois. Certainly, you may want to choose plants that can take the wind. What about shade? Many recommended plants will not do well in the shade, and often failures result because this was not considered during selection.

5. The plant material should give an effective display throughout the year. Winter as well as summer characteristics can be interesting. Flower colors can also provide a pleasing display. Fall color and fruit can be very striking. All plants do not provide attractive flowers, fruit, fall color and winter interest. However, plant selection should be made so that you have all of these features on the golf course or recreational area. A solid evergreen planting can be very boring and uninteresting. A mixture of several flower colors can likewise be very confusing to a person,so give this some thought.

The following are some desirable common woody ornamental plants grown and used in the Midwest.

S indicates that sun is required; Sh indicates that plant will grow in shade.

DECIDUOUS SHRUBS

Scientific Name	Common Name
Low Shrubs (1-4 feet)	
Abelia grandiflora	Glossy Abelia - S or Sh - White flowers, Southern half Illinois
Cotoneaster apiculata	Cranberry Cotoneaster - S or Sh - Red fruit
Chaenomeles lagenaria	Flowering Quince - S or Sh - Pygmy or dwarf forms - Salmon, red, pink flowers
Deutzia gracilis	Slender Deutzia - S - White flowers
Euonymus alatus "Compactus"	Dwarf Burning Bush - S - Red autumn color
Spirea bumalda	"Anthony Waterer" - S or Sh - Pink flowers, autumn color
Small Shrubs (4-6 feet)	
Berberis mentorensis	Mentor Barberry - S or Sh
Cornus alba siberica	Red Twig Dogwood - S - White flower, red branches, winter color
Cornus stolonifera flaviramea	Golden Twig Dogwood - S - White flowers, yellow branches, winter color
Hydrangea quercifolia	Oakleaf Hydrangea - S or Sh - White flowers, red autumn color
Ribes alpinum	Alpine Currant - S or Sh - Yellow autumn color
Philadelphus lemoinei	Lemoine Mockorange - S - White flowers
Viburnum carlesi	Koreanspice Viburnum - S or Sh - Fragrant white flowers, purple autumn color
Medium Shrubs (6-10 feet)	
Cornus mas	Cornelian Cherry - S - Yellow flowers, red fruit
Forsythia intermedia (cultivars)	Showy Border Forsythia - S - Yellow flowers
Lonicera fragrantissima	Winter Honeysuckle - S or Sh - White flowers

Scientific Name	Common Name
Syringa chinensis	Chinese Lilac - S - Purple or white flowers
Syringa vulgaris	French Lilac - S - White, pink, red, purple flowers
Viburnum Burkwoodi	Burkwood Viburnum - S or Sh - White, fragrant flowers
Viburnum lantana	Wayfaring tree - S or Sh - White flowers, Red and black fruit
Viburnum trilobum	American Cranberry Bush - S or Sh - White flowers, Red fruit
Viburnum tomentosum	Doublefile Viburnum - S or Sh, White flowers, Red fruit, Autumn color
Vibrunum tomentosum sterile	Japanese Snowball - S - White flowers

Large Shrubs (10-25 feet)

Chionanthus virginicus	White Fringe Tree - S - White flowers
Magnolia soulangeana	Saucer Magnolia - S - Pink flowers
Magnolia stellata	Star Magnolia - S - White flowers

BROADLEAF EVERGREENS

Recommended for protected locations in the southern portion of Illinois. Some plants will grow in the northern portion but should be introduced only after trial.

Low Shrubs (1-4 feet)

Euonymus fortunei "Vegetus"	Bigleaf Wintercreeper - S or Sh
Ilex crenata "Hetzi"	Hetz Japanese Holly - Sh - Partial sun
Ilex crenata "Stokes"	Stokes Japanese Holly - Sh or partial sun
Ilex crenata "Convexa"	Convexleaf Japanese Holly - Sh or partial sun

Medium Shrubs (4-6 feet)

Berberia julianae	Winter Barberry - S or partial shade
Buxus sempervirens	Common Box (Hardy strains) - S or Sh

Scientific Name	Common Name
Mahonia aquifolium	Oregon Holly Grape - Sh - Yellow flowers
Pieris japonica (acid soil)	Japanese Pieris - Sh or partial sun - White flowers

Large Shrubs (6-10 feet)

Pyracantha coccinea "Lalandi"	Firethorn - S or Sh - White flowers, orange fruit
Rhododendron catawbiense (acid soil)	Catawba Rhododendron - Sh - Pink, white, purple flowers
Viburnum rhytidophyllum	Leatherleaf Viburnum - S or Sh - White flowers

NARROWLEAF EVERGREENS

Low Shrubs (1-3 feet)

Juniperus chinensis "Sargenti"	Sargent Chinese Juniper - S
Juniperus horizontalis plumosa	Andorra Creeping Juniper - S
Juniper horizontalis "Douglasi"	Waukegan Creeping Juniper
Taxus cuspidata densa	Dense Japanese Yew - S or Sh
Taxus media "Wardi"	Ward Anglojap Yew

Medium Shrubs (4-6 feet)

Juniperus chinensis "Hetzi"	Hetz Chinese Juniper - S
Juniperus chinensis "Pfitzeriana"	Pfitzer Chinese Juniper - S
Taxus cuspidata intermedia	Compact Japanese Yew - S or Sh
Taxus media "Browni"	Brown Anglojap Yew - S or Sh
Taxus media "Sebian"	Sebian Anglojap Yew - S or Sh

Large Shrubs (6-15 feet)

Juniper chinensis "Keteleeri"	Keteleer Chinese Juniper - S
Juniperus virginiana "Canaerti"	Canaert Eastern Redcedar - S
Taxus cuspidata capitata	Upright Japanese Yew - S or Sh

Scientific Name	Common Name
Taxus media "Hicksi"	Hicks Anglojap Yew - S or Sh
Thuja plicata "Atrovirens"	Darkgreen Giant Arborvitae - S
Thuja occidentalis "Pyramidalis"	Pyramidal Eastern Arborvitae - S
Tsuga Canadensis	Canadian Hemlock - S or Sh

1965 TURF INSECTS

Roscoe Randell

WEBWORMS

Sod webworms did less damage in 1965 than for the past three years. This was true in large areas of sod such as golf courses and parks as well as the many home lawns.

Life Cycle - The insect passes the winter as a larva in a closely woven silk case. Larvae of any size seem to overwinter successfully. The larva resumes feeding in the spring, grows rapidly and pupates. It emerges as a moth in about 10 days. During the past two years in central Illinois, peak moth emergence has occurred the first week in June. The female moth lays eggs individually, dropping them a few inches above the lawn. Egg hatch occurs in a few days and the tiny worms begin to feed and build a silken case or tunnel. Full-grown larvae are about one inch long. They are grey to dusky green in color with a dark brown head and brown spots on the body.

Second generation moths emerge during late July and early August. There is often a partial third generation.

Damage - Brown irregularly-shaped patches appear in sod areas. The larvae clip off the grass blades just above the sod. Damage is much more evident during dry periods when the infested areas are slow to recover or the grass plants die.

Detection - Heavy moth flights at dusk flying over the sod area in a zigzag pattern is a good indication of a webworm infestation. Careful examination of the sod for larvae in their silken cases or tunnels and fresh grass clippings is the only positive means of detection. A good time to make these inspections is about 10 days after a heavy moth flight. Examine any brown spots which appear in the lawn.

Control - A well-kept lawn, fertilized and watered, will support a considerable population of webworms without serious damage. A lawn in poor condition will be seriously affected by an equal number of webworms.

Most lawn areas are able to support first generation webworm infestations. If present, these larvae can be found during late June and early July. Second generation infestations are usually more severe. Damage from these larvae can appear from August 15 through the middle of September. Chemical control is often necessary at this time. The insecticides can either be applied as spray or granules. If applied as a spray, use 100 to 200 gallons of water per acre, or 25 to 50 gallons per 10,000 square feet.

For specific insecticides see condensed recommendations in the attached table.

GRUBS

A few cases of grub damage to lawn areas were reported during 1965. For control in established sod, the chemical should be watered into the soil thoroughly. For new seedings, mix the chemical into the soil before seeding. For specific insecticides and rates, see condensed recommendations in the attached table.

CONDENSED INSECTICIDE RECOMMENDATIONS FOR LAWN INSECTS

Insects	Insecticide[1]	Dosage per 10,000 Sq. Ft.[2]	Suggestions
True white grubs (NHE-23) Annual white grubs (NHE-23) Japanese beetle larvae (NHE-32) Green June beetle larvae Ants (NHE-111, Cir. 887)	Chlordane dieldrin	2 lb. 8 oz. 12 oz.	Provides 5-year protection. In established sod, apply as granules or spray, and water in thoroughly. For seeding, mix in soil before seeding. Do not plant vegetable root crops in treated soil for 5 years.
Ants (NHE-111, Cir.887) Cicada killer (NHE-79) and other soil-nesting wasps (NHE-17)	diazinon	1 lb.	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest after dark. Seal in with dirt.
Earthworms	Chlordane	2 lb. 8 oz.	As for grubs. Control seldom necessary.
Lawn webworms (NHE-115)	carbaryl diazinon	2 lb. 1 lb.	As sprays use at least 25 gal. of water per 10,000 sq. ft. Do not water for 72 hrs. after treatment. As granules, apply from fertilizer spreader.
Armyworms (NHE-21) Cutworms (NHE-77) Chinch bugs (NHE-35)	carbaryl	8 oz.	As sprays or granules. Use 5 to 10 gal. of water per 10,000 sq. ft.
Leafhoppers (NHE-22)	carbaryl methoxychlor	8 oz. 4 oz.	As a spray.
Millipedes and sowbugs	As for webworms.		
Mites (NHE-58)	Kelthane malathion	2 oz. 6 oz.	Spray grass thoroughly, 20 to 25 gal. of water per 10,000 sp. ft.
Chiggers	diazinon	8 oz.	Spray grass thoroughly. Use at least 10 gal. of water per 10,000 sq. ft.
Slugs (NHE-84)	Slug baits	Scatter in grass.	Where slugs are numerous

1. The following insecticide formulations commonly contain these amounts of active ingredients by weight. Carbaryl, 1 1/4 lb. of 80% W. P. contains 1 lb. actual carbaryl; chlordane, 1 gal. of 45% E.C. contains 4 lb. actual chlordane; diazinon, 1 gal. of 25% E. C. contains 2 lb. actual diazinon; dieldrin, 1 gal. of 18.6% E. C. contains 1 1/2 lb. actual dieldrin; Kelthane, 1 gal. of 18.5% E. C. contains 1 1/2 lb. actual Kelthane; malathion, 1 gal. of 50-57% E.C. contains 5 lb. actual malathion; methoxychlor, 1 gal. of 25% E.C. contains 2 lb. actual methoxychlor.

2. Amount per 10,000 square feet (1/4 acre) is in terms of the active ingredient. Do not allow people or pets on lawn until spray has dried.

SOD PRODUCTION

E. D. Johanningsmeier

<u>History</u> - The production of nursery grown sod has been changing rapidly in recent years. When Mr. Godwin first started to produce nursery sod that was sufficiently higher in quality to use for lawns and special turf areas, there were very few aids available in the way of weed killers, insecticides, fungicides and modern fertilizers. The only fertilizers available were natural organics, ammonium sulphate and, a little later, some very low analysis farm fertilizers such as 2-12-6. The only chemicals available were sodium arsenite for weed control and lead arsenate for soil insect control. Common Kentucky bluegrass was the predominant grass used, occasionally blended with fescue; and, of course, bentgrass for special turf areas and some was also used on lawns. The quality of the sod had to be developed through frequent mowing, adequate fertilization and, in general, good management practices. At that time, the sod was harvested with hand sod knives and kickers in small square or rectangular pieces. It is difficult for those of us familiar with the industry today to imagine the amount of physical labor required to produce and market an acre of sod when the industry had its beginning. There was a short time between the cutting of sod with hand knives and sod kickers and the time of the first power sod cutter when sod was cut by pulling a blade on a short of sled arrangement through the sod with a tractor. The development of the power sod cutter was the most important advance in harvesting and selling sod. The first power cutters were 12 inches wide, and then the width was increased to 16 inches. A few years later, automatic cutoffs became available and were slow to be accepted. In Michigan today, there are approximately five 18-inch cutters sold for every 24-inch cutter sold. Practically all cutters are equipped with automatic cutoffs that are dependable and cut the sod in

uniform lengths. Six of the largest growers in Michigan are using only 24-inch cutters.

Production - The preparation of seed beds has not changed as far as the requirements are concerned, since the inception of the sod industry. The seed bed for a very small bluegrass seed needs to be somewhat different than the seed bed for a grain of corn. This has been true ever since the first sod was produced. This phase of sod production is the one link that will remain close to other agricultural endeavors. The seeders used today insure uniform distribution in planting of the seed. Other equipment used in seed bed preparation has been greatly improved through the years, making this one of the simplest operations in sod production. Many producers have found it necessary to have extensive irrigation systems for providing adequate moisture if normal rainfall does not occur. By irrigating, they can insure a good stand of grass. Most of these systems are portable aluminum pipe; however, some growers have installed permanent trancite or cast iron water mains along roads through the fields.

Cutting and Handling - The power sod cutters have made it possible to market much greater quantities of sod, but there is still a need for increased mechanization since three men are required to roll the sod as fast as each cutter can cut it. There have been several attempts to produce a machine for rolling sod that is as dependable and efficient as a mechanized cutter. Some of these machines have been partially successful. One machine worked quite well in peat soil, but did not handle sod produced in sandy loam with small gravel stones in the seed bed. We have just recently learned that Mr. Wiley Minor of Princeton Turf Nursery in New Jersey has developed a machine that will cut and palletize sod considerably faster than the practice commonly used in most production areas today. This machine would also eliminate the physical labor required to place the rolled sod on a conveyor for loading trucks since the pallets could be handled with fork lift equipment. Several growers are using pallets and fork lifts instead of conveyors, even though they are cutting and rolling the sod in the conventional manner. Most of the conveyors and material handling equipment have been engineered and built by individual growers to suit specific needs. The sod industry has grown to a point where manufacturers are becoming interested in developing specialized equipment so that the material handling should be greatly simplified in the very near future.

Grasses - Merion bluegrass was the first improved variety to be released and widely used for sod production. It provided impetus that today has not been equaled. The sod produced from Merion was enough better to cause many home owners to take out their old lawns and sod with Merion. Today we have as many new bluegrasses in addition to Merion such as Park, Delta, Arboretum, Newport and Windsor. In addition to these, there have been vegetative selections made that are tolerant of shade and some low growing types that will withstand closer mowing. Many of the new grasses have been developed by agricultural experiment stations and some by private research in the industry. The ones that have been granted plant patents are certain to have a great impact on the sod industry if their performance continues to be good. There will, undoubtedly, be many more improved varieties released in the years to come, hopefully, one that is as well suited to shade conditions as bluegrasses are to the sun.

Chemicals - The introduction of 2,4-D, and other broadleafed weed control chemicals, has been the third most important factor in the development of sod. Today we have an abundance of chemicals for the control of practically all broad-leafed weeds. We have highly effective insecticides and fungicides if they are needed, although disease control is accomplished more by variety of grass growth and cultural practices.

Future - Estimates on the number of acres of sod in production in Michigan have ranged from 15,000 to 50,000 acres. The figure of 100,000 acres in sod production for the states of Michigan, Ohio, Indiana, Illinois and Wisconsin would not be unreasonable. The requirements for many of the metropolitan areas outside of Michigan have exceeded the amount of sod locally available; therefore, approximately 70 per cent of the sod grown in Michigan has been exported to surrounding states. It is estimated that Michigan has 200 growers of nursery sod. This consists of two major groups. One group of large sod growers having 500 acres or more and another group, much greater in number, having smaller acreages ranging from 25 acres to 100 acres. The greatest potential for further growth in this industry is in metropolitan areas smaller than Detroit and Chicago that do not have a local supply of quality nursery sod. Some large sod producers have started small branch nurseries in other states and in small cities. If, and this is a big if, construction lets up or tapers off in Michigan, we may have more sod than we know what to do with unless it can be marketed in other states. If the economy continues to boom, there will be a good market for all the sod that is now in production. We do expect to see a considerable change in marketing techniques and product image in the next few years with the growing of more special grasses and the almost certain advent of improved material handling equipment. Sod will become more of a product and less of a commodity. As in everything, the future holds one very important factor that is necessary for everyone: it is a challenge. We expect to meet it.

BLUEGRASS VARIETIES, *POA PRATENSIS* L., AND HOW THEY DIFFER

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Success in plant breeding is dependent, in large measure, on the germ plasm available to the investigator. Unfortunately, it is in this critical area that one often encounters serious shortcomings in the improvement of perennial grasses. Problems associated with inadequate source material may be complicated further by practical difficulties involved in maintaining and evaluating large numbers of perennial plants. Primary material is accumulated through field collections either from local or foreign sources. In some, but not all species, collections may be augmented by selections received from other institutions and by named varieties.

It is obvious, therefore, that improved guides to field collection work could contribute substantially to efficiency in grass improvement. Effective procedures for increasing the frequency of superior genotypes in a given series of collections should provide better material for selection work with corresponding savings in maintenance and evaluation.

Several attempts have been made to study the effect of climatic and edaphic factors on the characteristics of Kentucky bluegrass (*Poa pratensis* L.) collections. Kentucky bluegrass, a facultative apomict, is widely distributed in cool, humid regions in North America and Europe. Smith et al. (1) examined 800 seed collections from 27 states. They found somewhat lower percentages of aberrant types in accessions from interior or continental regions, but collections grouped according to geographic regions exhibited no significant differences in reaction to diseases. Smith and Nielsen (2) collected clones from 10 Wisconsin pastures. Significant differences were found among good and poor pastures for

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proportions of plants resistant and susceptible to powdery mildew and leaf rust. These differences were not closely associated with soil type, available moisture, or management.

Kentucky bluegrass seed and clones have been obtained, for the most part, from cool environments, where, in general, the species is well adapted. In spite of the importance of disease resistance in developing improved turf and forage varieties, little effort has been made to sample outside the accepted range of adaptation for sources of disease resistance. This study was planned to characterize bluegrass plants that were persisting in the warm-humid southeastern United States, and to compare the disease reaction of these collections with local accessions.

Materials and Methods

In the spring of 1961, cores of vegetative material were collected from three pastures on the Black Belt Substation, Marion Junction, Alabama, and from two farms in Howard County, Maryland (at approximately 32-1/2^{o} and 39-1/2^{o} north latitude, respectively). The sites had been undisturbed for 30 or more years, except for one Alabama pasture that had been plowed but not planted to bluegrass in the previous year. Collections were restricted insofar as possible to well-developed clones, but otherwise plants were taken at random. Although an attempt was made to obtain a minimum of 50 clones per collection site, samples varied in size because of excessive mixtures in some cores and loss of plants in shipping and planting. Comparisons were based on 46, 54, and 68 clones from each of three Alabama pastures, respectively, and 43 and 26 clones from two Maryland pastures. Two additional collections were available from Maryland. These consisted of 6 clones from a pasture of questionable age in Howard County, and 11 clones from a bluegrass mixture experiment that had been established at the

Plant Industry Station, Beltsville, in 1953. All sampled areas were characterized by relatively fertile soil and fair to good drainage.

Individual tillers were separated from the vegetative samples, rooted in the greenhouse, and planted at Beltsville in the fall of 1961. The space-planted nursery consisted of unreplicated six-plant rows from each collection. Mixtures were identified at anthesis in the spring of 1962. In the fall of 1962, seed harvested from identical plants within rows was used to establish two progeny tests. Each clone was represented by an unreplicated 4 x 4 foot solid-seeded plot and approximately 20 spaced-plants. The solid-seeded plots were damaged severely by snow mold (Fusarium spp.) in the spring of 1963 and by leaf spot (Helminthosporium vagans Dresch.) in both 1963 and 1964. Disease incidence, as judged by common bluegrass checks, was comparatively uniform over the solid-seeded progenies.

Leaf rust (Puccinia graminis Pers.) scores were taken in the clonal nursery in 1961, while notes on snow mold, leaf spot and recovery from leaf spot damage were obtained from the 4 x 4 foot plots in 1963 and 1964. Off-type plants were noted in space-planted progenies in 1963 and 1964. In 1963, 17 promising selections and appropriate check varieties were seeded in 5 x 10 foot plots, in a randomized block experiment with three replications. Leaf spot ratings were obtained from this experiment in 1964.

Results and Discussion

Individual isolates were divided into disease susceptible and tolerant categories as shown in Table 1. This arbitrary classification on the basis of disease scores indicates a higher proportion of rust tolerant plants in southern material, but a definite trend in favor of less snow mold, greater leaf spot tolerance, and better recovery from leaf spot damage in the northern group.

Degree of apomixis as measured by percentage of uniform plants within progenies is given in table 2. Southern collections appeared to include more progenies with none or few aberrants. Conversely, highly variable progenies were more frequent in the northern group.

Values for associations between northern and southern collections were highly significant for leaf rust, leaf spot, recovery from leaf spot damage, and apomixis (Table 2). However, snow mold injury was not significantly associated with the two regions in which collections were made.

The distribution of isolates within northern collection sites was similar with respect to disease reaction, recovery from leaf spot, and apomixis. There was some indication that the Beltsville collection may have differed from those obtained at other northern sites in having a higher proportion of leaf spot resistant isolates. This trend will have to be re-examined because of the relatively small number of clones involved in the comparison.

In contrast with northern sites, there were marked differences among the three Alabama pastures. The two undisturbed pastures did not differ materially, but significant differences existed between these two pastures and the renovated pasture.

Size and vigor of individual plants in the renovated southern pasture indicated that many plants became re-established from rhizomes of old relic clones. There is a possibility, however, that seedling plants became established following renovation. The presence of seedlings could have contributed to the similarity in response between clones collected from this pasture and those obtained at northern sites.

Differences between bluegrass collections made within and outside the region of adaptation can be attributed to differences in selection pressure. Kentucky bluegrass clones were well defined and widely spaced over the southern pastures. Highly apomictic, leaf rust tolerant plants appeared to have had a selective advantage in these grazed but otherwise undisturbed sites. On the other hand, survivors were less resistant to leaf spot than northern accessions, indicating little selective advantage for leaf spot tolerance. Early plant dormancy induced by high temperatures, and the effect of higher temperatures in checking the development of the leaf spot organism could have reduced the influence of leaf spot on plant survival.

Kentucky bluegrass stands were relatively uniform at all northern sites. Clones could be identified at each location but, in comparison with southern pastures, the task of delineating individual plants was comparatively difficult.

In the replicated plot experiment, only 4 of 17 selections, all from northern sources, were significantly superior to common bluegrass in leaf spot tolerance. The remaining selections, 8 from northern and 5 from southern sources, were comparable with common.

In Maryland and the mid-Atlantic region, leaf spot tolerance makes a substantial contribution to the persistence and performance of Kentucky bluegrass varieties. The greater frequency and higher levels of leaf spot tolerant isolates found in Maryland would increase the value of these local collections over those from Alabama.

Summary

Vegetative Poa pratensis collections from Alabama and Maryland were grown at Beltsville, Maryland, and evaluated for disease reaction and apomixis.

Results suggest that severe selection pressure increased the frequency of highly apomictic clones within surviving populations. Natural selection for disease tolerance was associated with local environmental conditions.

Northern material was superior to southern collections in frequency of isolates possessing a high level of leaf spot tolerance.

Bibliography

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Table 1

Frequency of disease susceptible and tolerant isolates, and differential recovery from leaf spot damage within northern and southern bluegrass collections

Leaf rust	Susceptible	Tolerant	Total
Northern	75 (88%)	10 (12%)	85
Southern	113 (67%)	55 (33%)	168
Snow mold			
Northern	54 (64%)	31 (36%)	85
Southern	122 (73%)	46 (27%)	168
Leaf spot			
Northern	54 (64%)	31 (36%)	85
Southern	141 (84%)	27 (16%)	168
Recovery from leaf spot	Poor	Good	
Northern	53 (62%)	32 (38%)	85
Southern	139 (83%)	29 (17%)	168

Table 2

Apomictic classes in northern and southern bluegrass collections

Source	Similar plants within space-planted progenies			Total
	90% and above	89-50%	49% and below	
Northern	25	44	16	85
Southern	98	63	7	168
Total	123	107	23	253