PROCEEDINGS

of

1963 TURF CONFERENCE

Sponsored by the

Midwest Regional Turf Foundation

and

PURDUE UNIVERSITY

LAFAYETTE, INDIANA

March 4-6, 1963

PROCEEDINGS OF THE

1963

MIDWEST REGIONAL TURF CONFERENCE

The 22 articles included in these Proceedings are condensations of talks by speakers before sections and divisions of the 1963 M.R.T.F. Conference. We appreciated the willingness of the speakers to participate and prepare material for your reading. See Table of Contents next page. Proceedings of each annual Conference since 1948 have been prepared. A limited number of 1959, 1960 and 1962 Proceedings are available at price below.

A copy of these Proceedings were mailed to:

1. The 563 attending the 1963 Midwest Regional Turf Conference.
2. One person of each Member Organization within the Midwest Regional Turf Foundation not represented at the Conference.
3. List of those in educational activities.

Additional copies are available at $ 1.00 each from:

W. H. Daniel, Executive-Secretary
Midwest Regional Turf Foundation
Department of Agronomy, Purdue University
Lafayette, Indiana

Attendance divided by interest as judged by registration card	
Golf Courses	310
Turf Materials & Supplies	125
Sod Nurseries & Landscape	51
Parks (most have golf courses)	9
Industrial Grounds	12
School Grounds	11
Cemeteries	5
Non-Profit & Educational	40
Total	563

Distribution by States	
Illinois	174
Ohio	121
Indiana	137
Michigan	38
Wisconsin	11
Missouri	17
Kentucky	30
Outside Midwest	17
Purdue	18
Total	563

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PRESIDENT'S REPORT

W. W. Milne, Supt., County Club of Detroit
Grosse Pointe Farms, Michigan

The continued interest in the Midwest Regional Turf Conference and Foundation here at Purdue University is still in evidence by the large attendance shown here again at the twenty-sixth meeting. The membership of the Foundation appears to remain at a steady level with many new groups and organizations becoming interested in the fine work being performed here at Purdue by Dr. Daniel and his associates.

The population explosion and the expansion of recreational areas forecasts that today and in the future many demands for knowledge in turf management, and indicates a long and lasting future for the Midwest Regional Turf Foundation.

The privilege of being President of the Midwest Regional Turf Foundation for the past year has been a most enjoyable experience. I would like to thank Dr. Daniel and his staff for the many courtesties shown to myself and the Board of Directors.

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REPORT OF EXECUTIVE SECRETARY

William H. Daniel
Purdue University

The Executive Secretary again wishes to personally express thanks to many people throughout the Midwest area who have so graciously assisted in the on-going educational program Particularly I'd thank those who have arranged for travel in local areas, and have assisted with planning for meetings and programs.

Over the years we have appreciated the service of many of you as members of the Board of Directors, and although you have not had extensive detail work to do in operating the day by day functioning of the organization, your interest is most appreciated. Actually, because the Foundation, by Memorandum of Agreement, is located within the Agronomy Department at Purdue, it functions primarily to support research and sharing information. Nevertheless, the enthusiasm, ideas, and support provided have been most appreciated. I would hope that you will maintain this interest so that we can continue to serve in an effective way.

Memberships have gradually increased through 1961 when a high of 384 was reached. There was a slight drop to 372 in 1962. Already in 1963 we have canvassed all golf courses in Indiana. In 1961 we canvassed all golf courses in the Midwest. Generally we have depended upon the enthusiasm of the individual who knows our Foundation to promote its membership among his co-workers.

Attached with this report are excerpts from the Standards which have been developed for certification of Evansville creeping bentgrass. We are pleased that a few knowledgeable stolon growers are cooperating in this program. It should give you the quality of stolons you have long wanted for vegetative creeping bentgrass. The first material should be available in the fall of 1963 from nurseries.

Also attached are more simple standards for certification of Midwest zoysia. In the release of this more vigorous, less fluffy Zoysia, we feel it is a particularly servicable grass for recreational turf. Plans are flexible so material may be provided to members and to both certified and non-certified growers within the limitations of the supply. It has taken five years to release the bentgrass, 11 years to release the Zoysia. These are not fly-by-night decisions.

Publications continue to be a limiting factor in our service as Midwest Regional Turf Foundation. However, this is true of many organizations. It is the one place where we anticipate having improved in 1963.

Your Executive Secretary has turned down numerous job offers over the years which would have taken him away from Purdue University and the enjoyable functions of working with you through Midwest Turf Foundation. This is one indication to you of how pleasant the work has been - thanks for your friendly cooperation.

SALESMANSHIP - YOUR JOB

Tom Mascaro, President, West Point Products Cooperation
West Point, Pennsylvania

Fellow Salesmen I address you as salesmen, because that is exactly what you are.

Everyone in this room is a salesman. The only difference between us in the product.

Let's take Dr. Daniel--he's a salesman. He sells ideas.

And there is Bob Burkhardt from Cleveland--he sells golf course equipment and supplies.

Over there is Carl Bretzlaff, Superintendent of the Meridian Hills Country Club--he sells his services.

Bill is paid to sell his ideas.

Bob is paid to sell equipment and supplies.

Carl is paid when he sells his services.

We are all salesmen--only the product is different. And, we are all making a living from the same thing-Turf.

Anyone of us can change jobs. Bill could sell equipment. Carl could sell ideas. Bob could sell his services as a Superintendent.

Most of us think alike. The difference between us is that each of us knows a little more about certain things.

But knowledge alone does not spell success. We must also sell our ideas.

What is Salesmenship?

It is merely the art of finding out what people want, and then helping them to get it.

Let's analyze the Superintendents job--as a salesman. First--you are selling your services--to your committee, to your workmen and every member of the club. That is a lot of people to sell so first, you find out what these people want. Then--your job is to help them get it.

What do the members want. The golfers want primarily one thing. A low <u>score</u>.

Anything you can do to knock one stroke off a golfers game--you've got it made.

What do the non-golfing members want? Beauty and pleasant surroundings.

Let's start off by getting into your car, and driving to the club. What does the entrance to the club look like? Is it neat and inviting? Is the grass trimmed? Is the sign in good shape or is a new one indicated?

Pull into the driveway, what do you see? Does it please the eye?

Into the parking lot. Is it well marked? Is it easy to unload clubs and equipment? Is it nice enough for ladies in high-heels and evening gowns to walk to the club house entrance? (Not all husbands drop their wives off at the front door.)

As you walk from the parking lot to the club house entrance, what do you see? Beautiful flowers and shrubbery, or trash and dead plants.

Enter the club house.--What is the view from the window, especially the dining room. Is it a beautiful sight to behold?

Are there fresh flowers on the tables--that you grew?

Remember this one point above all else, growing good turf for the golfing members is damned important, but you must realize that the average country club has less than half its membership as golfers. What are you doing for the other half of the membership? Make them realize that you exist. How?, by studying the things that affect them. Find out what they want--then help them get it.

Do the unusual--something that will get people talking about you. This is salesmanship. A variety of exotic flowering plants? A sand bowling court? Grass tennis courts? Fish pond--a lake for fishing--pleasant walks through a wooded area? These are some of the things you can do for <u>all</u> the members.

But you say, this is added responsibility. Where do I benefit?

Seldom are we paid for anything before it is done. It is only after we have accomplished something that we receive compensations.

A job with more responsibility is worth more--and you can, by simply increasing your responsibilities, make your job worth more.

Everything does not have to be accomplished in one year. Draw-up a five-year plan, and have something new coming along all the time.

You shouldn't and don't have to brag about your accomplishments--they will speak for themselves.

Plan each project well. Get all the details and information you can. Become an expert on the subject--and make certain this is what the members want.

They may not realize they want it, but if you are a good salesman, you can sell them in what they want.

There are many things you can do to make your job more important. Seriously consider a two-way radio communication with the club house, your shop, or your workmen. This will not only save you countless hours--it will also let everyone know that you exist.

The person who objects to a good communication system because he is afraid everyone will bother him, is really asking to be left alone. And that's what happens--no one knows he exists.

A good clean, well labled turf nursery is a necessity today. It not only helps you test new grasses, methods and machinery, it is also a place to hold sales conferences. Your greens committee chairman and officials will understand and appreciate more what is needed if they visually see the problemsand how you can overcome them.

Plan a field day on your turf nursery for the members--they have turf problems too--and you can help them.

Present an over-all plan for a new workshop, office and equipment building. Work it out in detail to show how such are expenditures will actually save the club money.

These are only suggestions. You probably have many ideas of your own. List them.

Then break your list down into a form that will make it possible to complete.

You must take into consideration your own time and ability, cost and what the members want.

Don't spend the rest of your life taking orders--become a salesman--sell your ideas and begin giving orders.

Find what people want--then help them to get it.

Your job--Become a good salesman.

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EVANSVILLE CREEPING BENTGRASS

CERTIFICATION PLANS AS OF MARCH, 1963

W. H. Daniel - Turf Specialist

Note - In 1961 a release was decided for Evansville Creeping Bentgrass - a dark green, dense, vigorous selection. Plans for certification in Indiana and interstate certification in Illinois, Michigan, Kentucky, and Missouri have been developed. In the fall of 1963 it appears 5 or more nurseries will have a limited supply of stolons.

Note - For complete specifications write for both Indiana Certification and vegetatively propagated Grass Standards. These are excerpts interpreted for the reader's general information.

Breeder's stolons will be maintained in the greenhouse where bentgrass does not flower. Foundation stock shall be grown at the Agronomy Farm under supervision of W. H. Daniel. Nurseries qualifying for Certification will purchase foundation stock and from the planting area may sell Certified stock for 25 months if kept clean and free of seedheads. Each certified planting must be on land free of bentgrass, and methyl bromide sterilization is recommended. Proper use of pre-emergent chemicals is also encouraged. Each field must be rogued,kept free of seed, and will be inspected at least once each year.

Each certified grower must apply for Certification each spring, pay state application fees of $40.00, and field fees of $10.00 each year. Also the grower must pay $0.10 per 2 bushel bag for each certification tag and maintain records of sales to aid in follow-up of performance.

Obviously cleanliness in processing stolons, and at least 90% live sprigs free of noxious weeds is specified in certification. Although certification may add 10% to the total cost of stolons, it was necessary and desirable to assure golf courses a known pure selection. All future users of Evansville stolons are asked to help make sure extensive efforts worthwhile.

PROPOSED RELEASE FOR

MIDWEST ZOYSIA - 1963

W. H. Daniel, Turf Research, Dept. of Agronomy
Purdue University

Midwest, a more vigorous, darker green, wider leaf, longer internode Zoysia has been released by Purdue in 1963. W. H. Daniel, Turgrass Research in the Department of Agronomy, reported progress made in a 10 year program. Initially research was toward fine textured types, but they lacked winterhardiness. About 1957 coarse, vigorous, open types became our goal, and extensive planting of seedlings, first 1000, then 300, then 450, were made from over 60 sources of seed, including seed from earlier preferred types we have grown.

Visitors at Fall Field Days had seen these comparisons. Actually we have had Zoysia tests at 10 different locations on the turf plots since 1950. Most of these used the best of the last planting, plus new seedlings available.

Readers know of Emerald, a fine textured variety, preferred in the mid-south. Most widely known and used is the Meyer zoysia, a medium textured, winter-hardy, slow growing selection, officially released in 1950 by the U.S.G.A. and U.S.D.A.

Research by W. C. LeCroy towards a Ph.D. provided the detailed comparative data proving the preferred characteristics (Ph.D. Thesis 1963).

Midwest zoysia was chosen for its darker color in the summertime, long internodes, thus more open turf, fast spread - twice as fast as Meyer, and medium wide leaf texture. Plans for release are as follows:

A. Breeder's stock shall be maintained in greenhouse, or turf plots at Purdue under direction of W. H. Daniel.

B. Foundation increase shall be, as it is with other crops, by Agricultural Alumni Seed Improvement Association, a non-profit group, on their farm near Lafayette. A portion of the sale price is returned to the A.E.S. for research support.

C1 Vegetative increase may be sold as foundation stock to growers in Indiana requesting certification.

C2 Upon request the foundation seed groups in other states can get foundation increase for their certification.

C3 Certified increase will be sold to all requesting in any area, depending on availability. Priority will be established, as needed, by the Director of the Experiment Station. Limited material will be available in the summer and fall of 1963. Adequate supplies should be available during 1964.

Certification for Zoysia in Indiana is being prepared. It will be similar to bentgrass, but requirements will be easily met. Interested growers should contact certification for specific information.

Requests for material should be directed to:

Ag. Alumni Seed Improvement Association, Hy. 52 N.W., West Lafayette, Indiana,or
W. H. Daniel, Deparment of Agronomy, Purdue University.

Already some 50 inquiries have been filed and will be contacted.

CHARACTERIZATION OF ZOYSIA THROUGH THE MICROSCOPE

Wm. C. LeCroy, Graduate Student
Purdue University

Through the use of the microscope and prepared slides, the internal structure of various grasses can be compared. The general procedure used to make the slides is outlined as follows:

The desired part of a grass plant in the preferred stage of growth was selected, cut into short lengths and placed in FAA, a killing and preserving solution-a mixture of 50% ethyl alcohol, 40% formaldehyde and 10% glacial acetic acid. When the FFA had penetrated the plant pieces thoroughly, all the water was removed from the material by taking the tissue through five series of alcohols, each containing less water. The last is a mixture of anhydrous ethyl and tertiary butyl alcohols. Usually three to four changes of this grade are made to be sure all the water has been removed from the tissue.

The tissue was infiltrated with wax in an oven at a temperature just above the melting point of the parawax. The wax was concentrated by pouring off part of the solution and replacing it with melted wax. This was continued until the tissue was in pure parawax. Zoysia tissue is somewhat hard, so tissue mat, a harder wax, was later selected as the preferred embedding medium. The parawax can be melted off and replaced with melted tissue mat. The tissue mat was changed three to four times to assure all of the parawax had been removed. The tissue mat containing the plant pieces was then cast into molds, and mounted on a wooden block.

The microtome used was a rotary microtome, an instrument having a stationary knife holder and the holding device which moves up and down in a straight line at right angle to the knife edge. The thickness of the sections cut are from 15 to 20 microns. A micron is one-thousandth part of a millimeter; a millimeter being approximately 0.04 of an inch. These sections were mounted on a glass microscope slide and double stained, then covered.

From such prepared slides it is possible to compare the internal structure of various grasses. Zoysia belongs to the group of grass plants that has the vascular bundles of the stem in two circles, the smaller bundles near the periphery, the other of larger bundles somewhat deeper within the stem. The Zoysia leaf is very different in structure from most leaves. The leaf consists of vascular bundles separated by large thin-walled cells that extend from the lower, almost to the upper surface. Such cells permit the leaf to roll readily in response to moisture deficits. Starting from the midrib every fourth bundle is of a roundish shape while those in between are triangular in outline. Throughout the vascular bundles are many heavy walled cells. The last two vascular bundles near the leaf edge have many more of these cells. These heavy cell walls could account for the difficulty encountered in the mowing of Zoysia and the slow rate of decay of the cut leaves. The buds, or growing plants, appear to be that of a typical grass producing stolons. Many slides of cross-sections of the stem or runners produced above ground and below ground were examined under the microscope. There appears to be no difference in the structure of the two stems.

The leaves of Zoysia have many hairs on both upper and lower surfaces. Such a plant certainly can tolerate a wide variety of climate conditions. Besides this microscope study much data has been taken in field plots. Based on this work a new selection, Midwest was released in 1963 from Purdue University.

HOW BLUEGRASS SPREADS

C. W. Lobenstein, Dept. of Plant Industries
Southern Illinois University, Carbondale, Illinois

Basically most bluegrasses spread by upright tillers, by underground horizontal rhizomes, or by extensive seed dissemination. Among the various *Poa* species, *Poa annua* usually spreads by tillers and by extensive production of seed. Canada bluegrass spreads largely by rhizomes, producing few tillers. Common bluegrass, or its varietal derivatives, spreads by a combination of all three.

Briefly reviewing the morphology of the bluegrass plant, the true stem does not elongate until a seedhead is produced. Thus, the stem remains a compressed section, called the crown, normally located $\frac{1}{4}$ - $\frac{1}{2}$ inch below ground level. From the nodes on the crown all new leaves arise, each succeeding leaf being enclosed by the sheath of the preceding one. New buds form at the base of each new leaf and may later give rise to either new vertical shoots called tillers, or to rhizomes which break through the enclosing sheath, elongate some distance underground and eventually emerge from the soil. Each emerging rhizome, or tiller, thus forms a new crown and the process is repeated. A rhizome consists almost entirely of stem tissue, a tiller largely leaf tissue; yet, both arise from the same type of bud. Why individual buds develop differently is a challenging research question. Normally the lowermost buds develop into rhizomes, whereas tillers tend to rise from higher buds.

Light reaching the tip of the emerging rhizome, or tiller, stops elongation; absence of light results in continued growth. If a new tiller, or rhizome is shaded in thick turf, or heavy thatch, elongation may continue until the new crown is actually formed above ground level.

Rhizome development is, of course, dependent on the normal health of the plant and sufficient active leaf area to furnish necessary energy. Heavy nitrogen fertilization and other conditions favoring excessive leaf growth may greatly reduce rhizome development. Excessive mowing, or disease will also cause reduction. Some workers have argued different seasonal trends in rhizome development, but essentially as long as conditions are favorable for the grass plant to remain healthy and growing with reasonable vigor, it will continue to produce rhizomes. To say that more rhizome growth occurs in late summer, fall, or early spring, may mean only that these are the seasons normally most favorable for bluegrass growth. During the elongation and maturity of a seedhead, rhizome development slows down. After trying to seed, that particular crown dies.

Rhizomes growing during the summer months do tend to grow longer before emerging than those produced early, or in the fall. The "why" is not really known; possibly this is a function of energy reserve in the plant; more likely it may be due to some light, or temperature induced regulative compounds produced within the leaves, or the rhizomes themselves. Typically, rhizomes on ordinary bluegrass and many selected clones do not branch until the tip emerges and is exposed to light. The frequently observed increase of numerous short, new "sprout-like" rhizomes in the later summer and fall, most likely occurs after the first tip has emerged, and formed a new crown; thus, releasing lateral buds along the rhizome from apical dominance of the terminal section. Branches normally arise in successive sequence starting at the terminal end of the rhizome, and seldom do buds near the base of a rhizome develop.

Our studies have been particularly concerned with rhizome development because it is largely by this means that established plants can most rapidly move out into unoccupied areas left bare by seedling losses, disease, mower, or divot injury. Extensive rhizome and accompanying root development therefrom surely must result also in a more durably knit turf for sodding purposes, as well as greater foraging ability and drouth tolerance.

G. A. Etter, working in the St. Louis area in the early 1950's, recorded an excellent study of the bluegrass plant and its seasonable development. His observations are published in the Annuals of the Missouri Botanical Gardens, 1951-53. Many others have also recorded fine studies of bluegrass morphology. In most cases, the plants have been native bluegrass and commonly in meadow, or pasture situations. Because of increased interest in developing better turf varieties of bluegrass, we have undertaken characterization of the sod-forming ability of some clones and selections.

We chose 25 representative types, propagated them vegetatively and planted single, unbranched tillers at 1 ft. intervals. Observations and measurements were made during the growing seasons of 1961-62. Principal attention was given to those characteristics which would be important in healing and recovery following heavy stress periods. Table A. expresses total rhizome growth in feet, produced from single tillers during the periods shown. The results show that late summer development of rhizomes is as great or greater than fall development. Comparisons of 125- and 160-day periods (2 & 3) shows marked increase during the months of July and August for nearly all selections. The work by Etter and others generally indicate a similar trend. The fact that some selections apparently develop a larger portion of rhizomes later during the fall and spring seasons is illustrated by the "Shade" selection.

The capacity of some vigorous clones to produce comparatively more rhizomes at any season of the year is borne out by data in Table A. Similar capacity by mature sods is shown in another experiment.

TABLE A. Total Rhizome Growth from Single Bluegrass Tillers in 4 Growth Periods.

Dates	Days No.	Merion ft.	K-5-47 ft.	Newport ft.	Shade ft.	16-F ft.	16-C ft.	16-B ft.
5/30 to 7/25/62	65	0.9	0.5	0.3	1.4	1.5	1.8	2.2
3/20 to 7/25/62	125	1.5	5.8	5.2	19.	10.	15.	27.
3/20 to 8/30/62	160	6.8	7.3	26.	19.	47.	58.	84.
5/15 to 11/15/61	180	7.5	8.2	--	44.	46.	55.	87.

Table B., as well as other measurements not shown, indicate that greater rhizome development by vigorous clones, compared with Merion, is largely a matter of increased rhizome numbers (1), rather than significant increase in length of individual rhizomes (5). However, length per rhizome for vigorous types is still greater than standard varieties.

Table B. Sod-Forming Characteristics of Bluegrass Clones in Ratio to Merion

	Average Growth from Single Tillers						
	Merion	K-5-47	Newport (Ratio to Merion)	Shade	16-F	16-C	16-B
1. Number of rhizomes:							
65 days	1.0	0.7	0.3	0.9	0.8	0.9	1.6
125 " (dates as	1.0	1.9	2.1	5.6	2.4	5.0	10.4
160 " Table A.)	1.0	1.1	3.8	5.0	7.0	8.5	12.4
180 "	1.0	0.9	-	3.4	3.5	3.7	7.6
Avg. 4 experiments	1.0-	1.2	2.1	3.7	3.4	4.5	8.0
2. Tillers per crown:							
Avg. 4 experiments	1.0	1.3	0.6	1.0	1.8	1.0	0.8

Table B (Continued)

3. Total emerged shoots:							
Avg. 4 experiments	1.0	1.0	0.9	2.0	2.0	2.1	2.7
4. Shoots per sq. inch.:							
Avg. 2 experiments	1.0	1.1	0.8	0.9	1.0	0.7	0.7
5. Avg. length single rhizome:							
Avg. 5 experiments	1.0	1.0	0.9	1.4	1.7	1.6	1.3

Only a few clones were found to form more basal tillers from a single crown than does Merion (2). This characteristic should enhance turf density. However, an overly-crowded condition may actually not be desirable. The total number of shoots developed from a single parent crown during a growing season by virtue of a series of "daughter" crowns thus is a function of both the number of rhizomes and basal tillers successively formed on each emerging crown. Clone 16-B, when compared with Merion, produces an 8-fold number of rhizomes (1), but because of low tiller number per crown (2), the total emerged shoot ratio is reduced to less than three-fold (3).

The fact that more vigorous clones do produce slightly longer rhizomes and in greater numbers results in rather sparse turfs as they are initially established in a bare area. This is in sharp contrast with Merion and a few others which exhibit a more "clump" habit of growth, filling an area more densely, but spreading and invading much more slowly. Because of open spaces within an area occupied by vigorous types, density expressed as shoots per in^2 (4) is much lower than Merion types. However, within a single growing season most of these will usually form a sufficiently dense turf because the spaces are rapidly filled with successive new rhizomes. This is borne out by density counts taken in 1-year old sods formed by the respective clones. Some, such as 16-F, K-5-47, and A-10, actually exceeded Merion in density. Other coarser types, such as 16-B and 16-C were satisfactory, but did not quite equal Merion.

To determine if the above relationships hold in older sods, a series of experiments were conducted in 3-year old sods of the respective clones. Eight-inch soil cores were removed to a depth of six inches in October 1961. Total active rhizomes were measured, the soil was replaced and compacted, and the process was repeated in the same cores in June and November 1962.

As in release plantings, the 16-series and "Shade" exhibit not only more consistent year-round production of rhizomes, but also produce greater numbers and total length during either period. The decrease in the ratio-to-Merion in the latter part of the season is essentially due to increased Merion activity during this period. Thus, the relative differences in favor of vigorous clones is more evident during the spring and summer period. Incidentally, this is also the period of longest days. Merion, producing few very long rhizomes and more tillers per crown, occupies the bare area at a slower rate, but occupies more densely as it goes; while 16-B, 16-F, etc. will have new crowns appearing over a much larger area in a shorter time.

Table C. Length and Ratios for Rhizomes Invading 8 inch core area

	10/20/61 to 6/11/62 ft.	Ratio to Merion ratio	6/11/62 to 11/3/62 ft.	Ratio to Merion ratio	Original 3-yr. sods 10/62 ratio
Merion	0.4	1.0	1.4	1.0	1.0
Delta	0.4	1.0	2.1	1.5	0.7
Newport	0.1	0.3	4.2	3.0	2.6
Shade	2.6	6.4	5.6	3.9	3.2
16-B	5.3	13.1	5.7	4.0	3.5
16-C	7.8	19.0	8.3	5.8	3.6
16-F	8.3	20.5	8.8	6.2	3.2

Table D. Number and Ratios for Rhizomes Invading 8 inch core area

	10/20/61 to 6/11/62 no.	Ratio to Merion ratio	6/11/61 to 11/3/62 no.	Ratio to Merion ratio
Merion	3	1	19	1
Delta	3	10	19	1
Newport	1	10	34	2
Shade	17	5	45	2
16-B	42	13	63	3
16-C	43	13	65	3
16-F	54	17	64	3

Again as in release plantings, invasion activity seems largely a matter of increased rhizome numbers. However, in this case the greater length of 16-F and 16-C noted earlier is obvious in the results shown in Table C. These observations result in the question of what contributes to such diverse variations among the respective clones. What structural or physiological differences, which are most likely under the control of genetic factors, bring about these variations?

Since each rhizome arises from a single bud at the leaf base, is it possible that plants producing the greatest number of leaves per tiller also produce the greater number of rhizomes because of larger bud potential? Experiments in which number of leaves produced during 75 days in the field during the summer and in 90 days in the fall in the greenhouse, failed to support this assumption. In fact, "Dwarf", which usually produces more total rhizomes than Merion but far less than vigorous clones, consistently produced the largest number of leaves per tiller, while Newport produced the fewest. "Dwarf" consistently produced few shoots per tiller and the least dense turf of all clones studied in all periods up to 1 year in length. Merion was neither very high nor very low in total leaf number; yet, was consistently low in rhizome production. Apparently total bud potential per crown is not a major factor in this question.

Area of active leaf surface present at the end of 75 days growth in the field was also determined for shoots developing from a single tiller. In this respect "Dwarf" was much lower than any other clone, 16-B the highest, Merion well above the average of 16 clones. The differences were consistent where plants were clipped to

2", or allowed to grow unclipped. "Dwarf" has a very broad leaf blade with a short sheath tending to present the leaves more parallel to the ground than normal. Under these conditions and higher number of leaves per tiller, it should show distinct advantage under mowed conditions, but it did not.

We have conducted some experiments using various growth regulating compounds to determine possibility of altering bud development by biochemicals. Other workers in Canada are investigating the same question at a basic physiological level. Work with quackgrass and Johnsongrass rhizomes offer much useful information in this respect. Our results with the growth regulators are too incomplete at this time to attempt to draw any conclusions, but some very interesting changes have been induced with some of the materials.

At the present, we can quite safely conclude that it is bud activity, regulated by some internal controls, rather than bud number which is most directly related to regenerative and spreading characteristics of bluegrasses. The clone which produces the most illers and the most new crowns from emerging rhizomes will naturally possess the larger number ofactive leaves, the thus greater leaf surface per unit area.

TESTING BLUEGRASS SEEDLINGS

Charles Berry, Graduate Student, Purdue University

In the absence of Mr. Eric Melkerson, who recently completed his M.S. degree at Purdue, I am presenting some of his work and some of the basis on which his work was done.

Seedling Testing

Improved varieties of Kentucky bluegrass, *Poa pratensis*, one of the most important turfgrasses over much of the U.S., are needed. Although considered largely apomictic, much morphological variation is found in Kentucky bluegrass populations, which include an unlimited number of biotypes, or an intricate complex of races, varieties, and forms.

With the increase in interest in sports, such as golf, football, baseball, polo, as well as increased interest in park areas, roadsides, cemeteries, and an innumerable variety of turf use areas, we need grasses which are better adapted and developed for each specific use. Let us consider golf courses as an example. Many golf course superintendents have faced, or are now facing the problem of the demands of the golfer for fairways, which are often cut at 3/4" or less; yet, many outstanding men have observed that cutting bluegrass shorter than 1-1/4" results in a much weakened grass. What is to be done?

One of the important steps to the ultimate goal is the testing of bluegrass seedlings, since from such programs new morphological types can be found. These can be an improvement in one or many of the vegetative and physiological characteristics which are combined to make up a turfgrass.

In our program of seedling testing, we attempt to take into consideration a wide range of turf characteristics. The evaluation of these characteristics range from specific measurements to an objective visual rating. However, all these class ratings have a definite bearing on the overall score for a plant, or clonal tiller being observed. One must keep in mind the fact that the grass plant performing most uniformly, or consistently satisfactory for all, or most all traits, may be a better grass in the long run than a plant exhibiting only a single outstanding feature. However, those exhibiting an outstanding feature could well be observed from the standpoint of potential parents for breeding work.

In our evaluation and subsequent selection of grasses, we must ever keep in mind the varied uses to which these grasses might be subjected, from the small, fine leafed, close cut grass for fairways, front lawns and patios, to the vigorous, wear resistant grass with dense, tight sod, and an extensive root system used on such areas as roadsides and airplane landing strips.

As has been mentioned earlier, a wide range of turf characteristics are included in our seedling testing program. The general classes of characteristics are:

1. Top and turf characteristics, including leaf color, leaf angle, leaf width, sheath length, vigor periods, growth vigor, and many more.

2. Crown characteristics, including rhizome length, rhizome internode length, rhizome depth under the sod, and tillers per new crown.

3. Disease resistance, including leafspot, stem and leaf rust, powdery mildew, snow mold, stripe smut, and others.

4. Seedling characteristics, including speed of seed germination, rate of seedling growth, and speed of rhizome initiation.

5. Space planting characteristics must also be remembered since ultimately most all our turfgrass must come from field plantings.

The evaluation of all these characteristics is done by a rating system composed of a relative 1 to 9 scale, whereby the plant of poorest quality in the test is given a 9, followed upward to a rating of 1 given to the plant exhibiting the characteristic in its most desirable form. This system has both advantages and disadvantages. One of its most oustanding advantages is the fact that ratings over several years for a particular plant are easily comparable, making the total evaluation of the individual much easier.

These illustrations indicate the importance of a seedling testing program in the development of new and improved Kentucky bluegrass varieties for present and future turf demands.

BASIC PRINCIPLES OF POTASSIUM USE ON TURF

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Supplying adequate K is only one small part of a top turf management program. Taking care of K needs is relatively easy, compared to removing other limiting factors, if available diagnostic tools are used.

What is the Situation in the Soil?

A recent summary of soil tests by W. H. Daniel shows the following:

	Percent Testing Medium or Less			
	Putting greens	Fairways	Lawns to be planted	Established lawns
Phosphorus	4%	47%	68%	21%
Potassium	80%	66%	93%	64%

"All lawn soils are deficient in N, a few are deficient in P, and most are deficient in K." Purdue Extension Circular 438.

Why the Low Amounts of K in the Soil?

High leaching loss in greens. In 1940 Scarseth emphasized the loss of K from greens by leaching. The process is simple. Frequent use of ammoniacal N in the form of ammonium sulfate, or urea, places the K from the soil colloid. Watering then leaches the K out of the rootzone.

$$\text{Soil)}\,K + NH_4^+ \underline{\qquad\qquad} \text{Soil)}NH + K^+ \text{ (leaches)}$$

Exactly the same principle is used in the quantitative determination of exchangeable K in soils in the laboratory. The soil is leached with a salt solution such as NH acetate. The amount of K in the beaker is then determined. Hard water containing Ca and Mg also serves to help leach K.

The frequent use of N and water on greens is essential. It does emphasize, however, that conditions are set up for much leaching of K and that careful attention must be given to maintenance of K supply.

The same principle applies to lawns which are irrigated, or in heavy rainfall areas, but less so to unirrigated lawns. Heavier and heavier rates of N are being applied and hence the condition is more critical every year.

High removal. Frequent clipping and removal of clippings cause a steady drain. Noer has estimated that average annual removal in fertilized greens to be about 5.2# N, 1.6 lbs. P_2O_5 and 3.3# K_2O per 1000 sq.ft.

Roberts of Iowa has shown the ratio of $N:P_2O_5:K_2O$ to be 10:2:5 in the foliage of Kentucky bluegrass. Obviously removal from lawns would be related to disposal of the clippings and intensity of fertilization and irrigation. Sod production results in considerable removal.

Recognizing needs

The important characteristic of a leader is his diagnostic approach.

Deficiency symptoms. Clear cut symptoms on turfgrass leaves are rare. Causes of yellowing or browning on the leaves are very difficult to pin down, particularly on the very short leaves in greens.

Hidden hunger. Sometimes plants are in need of more fertilizer, but do not yet show visible signs. This is an insidious thing and hidden hunger can eventually lead to problems. Soil tests help to avoid it. Tissue tests help to identify it.

Soil tests. Soil testing is based on the principle of determining the general soil fertility level. An estimate is then made as to how much fertility is needed to supplement the soil supply, to meet the needs of the plant. With the many new chemicals being applied to turf and high pH conditions, much more research is needed as to the effects on accuracy of soil tests.

Tissue tests. Tests on the leaves of many crops have been quite effective in determining general K level. Careful interpretation is important, however. With low rates of N, K may accumulate in the plant and show a high K tests. With adequate rates of N, the K in the plant may be used and show a low test. Tissue tests are particularly important in July and August when the turf is under more stress from heat, disease, and nutrient depletion.

Balanced Fertilization

There, of course, is no such thing as a balanced fertilizer. Balanced fertilization, however, refers to fertilization according to soil and crop needs. For example, if a soil is low in K, a fertilizer high in K would be required. On the other hand, if a soil was high in K, a fertilizer low in K would be adequate. The fertilizers would be much different in terms of analysis, but would meet soil and plant needs.

The balance between N and K is becoming increasingly important. Adequate N is important in turf management, and K must be increased accordingly on many soils.

Another problem relates to the matter of pH. When hard water is being used in irrigation the pH of the putting greens may be increased to the point where it is difficult for the plant to take up K. Data from Iowa on corn illustrates the point.

Milliequivalents per 100 gm. of corn plant	K	Ca	Mg.
High lime soil	23	55	101
Normal soil	107	32	39

Job of Plant is to Capture Sunshine

Basically the job of the plant is to capture light energy and use it in photosynthesis to make sugars.

$$CO_2 + H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} \underset{\text{(sugars)}}{C_6H_{12}O_6} + O_2$$

In most plants an important task is to provide a maximum effective leaf surface. Continual clipping places turf in a unique position, however, as the leaf surface is continually reduced. Hence, it is doubly important to keep the leaf surface as effective as possible. Chlorosis, due to nutrient deficiencies including K, must be avoided. It is important that the leaf be highly functional at all times.

Important Jobs of Potassium

Potassium has many functions, but only a few will be mentioned.

Helps move carbohydrates from leaves to roots. The leaves and roots are connected by vascular bundles - the so-called "pipelines." In plants starved for K the pipelines become badly plugged and roots starve. On K deficient plants roots are limited.

Plants have little capacity to take in other nutrients and to resist pests and other growth hazards.

Drouth resistance. Plants well supplied with K have a lower rate of transpiration than soft lush plants low in K. This combined with a more extensive root system makes for greater drouth resistance.

Rootzones are often low in oxygen because of a variety of reasons, including heavy watering, traffic, etc. This reduces K uptake and hence higher rates are needed for adequate plant growth.

Disease retarder. It is generally accepted that K deficient plants are more subject to certain diseases. For example, a leafspot disease, Helminthosporium, has been shown to be more widely prevalent on Coastal Bermuda or corn low in K. Part of this effect may be due to the accumulation of such compounds as sugars and nitrates to make conditions more favorable for the development of fungus diseases once the plant is infected. This does not mean that fertilizing with K will eliminate the necessity for controlling diseases, but such outbreaks will be less disastrous and more easily controlled when the supply of K is adequate. The grass will be "tougher" in the important July and August period and soft lush growth with N alone will be avoided.

Continuous clipping prevents the plant from maturing and makes it continually susceptible to disease attack. Hence, any practice that encourages vigor will be effective in conditioning the plant against disease. Work in Rhode Island shows that these hardier plants are also better able to resist hard frosts.

Turf density. A common problem with some grasses is maintenance of stands. Much stand loss is attributed to winterkilling. However, it is often emphasized that more plants starve out than are killed out. Research has shown the importance of addition of nutrients, including K, on low fertility soils to induce branching of roots and increase density of the turf.

Protein formation. Potassium aids in converting nitrogen compounds to complete protein. Teel at Purdue has shown that orchard grass low in K accumulates certain free amino acids and intermediate nitrogen compounds. Just what effect this has on vigor of turf is not clear.

How Much is Needed?

In Midwest Turf News and Research No. 16 - W. H. Daniel suggests the following annual ranges -

	Pounds per 1,000 sq.ft.					
	Heavy feeding			Average feeding		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Established putting greens	10	2	5	8	2	4
New putting greens	8	2	4	6	2	3
Irrigated lawns, tees & fairways	6	2	4	3	1	2
Unirrigated lawns	4	1	2	2	1	1

The need for adequate N on turf has been well recognized for many years. In the past fertilizers have tended to be high in P_2O_5 as compared to K_2O. N:2:1 is an example. In recent years grades have moved to the N:2:2 ratio. From the soil test summary data and the recommendations above, it appears that in the future the fertilizers should be higher in K_2O than P_2O_5 in many turf situations. N:2:4 is an example. Of course, N:2:2 can be used with an occasional supplement of KCl. Soil tests should be used to help determine specific needs.

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AIDS THROUGH THE MICROSCOPE

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This is often called the "Space Age," but all ages have been. We have no more space than ever, but we may know more about how much there is.

Space was no problem for Adam, but when Eve joined him in the Garden of Eden, she immediately not only had to have more space, but started rearranging what was there. Later in history, the family cave became crowded, and someone was forced out to look for new space. The old homestead was like that too. It stood tall in front and petered out toward the back with each new lean-to room a little lower.

Space is not necessarily vast; it may only be half vast. There are lots of small spaces that interest us, and we need to know more about these small spaces. Just consider for a moment that the chemical reactions inside of the cells of plants are the basis of our entire food supply.

The microscope is for looking at small things and small spaces. This is possible because of lenses which were developed from studies of the human eye, itself a system of lenses. In 1267 Roger Bacon wrote a book that assembled knowledge and led to the development of eye glasses. In 1299 some guy wrote, "I am so affected by years that I cannot read without those glasses they call spectales." A simple microscope was invented by Janssen in 1590, and the telescope by Lipperschey in 1609. Galileo made his own telescope in 1609; and, while it magnified only 3 times, he started the science of modern astronomy. A microscope and a telescope have a lot in common; one makes little things look bigger, the other makes distant things seem closer.

We use many kinds of lenses to help us look and the following five have use in identifying turf diseases:

1. Simple reading glass; magnifying about 1.5 times (cost $2.00).
2. Simple magnifying glass in a stand mount; magnifying about 2 times (cost $2 to $3).
3. Hand lens, a combination of lenses; magnifying about 10 times (cost $3 to $20).
4. Stereomicroscope, useful especially for examining leaf surfaces; magnifying most in the range of 5 to 40 diameters (cost about $300).
5. Compound microscope, used most for examining very small objects, such as spores, in thin liquid mounts on glass slides; magnifying mostly in the range of 100-1000 times. This is the most versatile instrument because with a low power 3 x object and low power eye piece, it will magnify only 30 times. By using top lighting (a flashlight will do) it may be used for examining leaf surfaces; thus, substituting for a stereomicroscope (cost about $150 to $350).

For the most part a microscope is necessary for the identification of the fungi that cause disease. The following features characterize the pathogenic agent in some common turf diseases:

1. Pythium. The filaments (mycelium) are colorless and have no crosswalls; mycelium mostly in tissue of root and crown region. Spores rarely seen.
2. Rhizoctonia. The mycelium is brownish and has crosswalls; branching is

at right angles; first crosswall in the branch is slightly away from the parent filament; in and on tissues especially the collar region. No spores produced. Brown patch.

3. Fusarium. Mycelium on the surface of turf in loose pinkish mats; crosswalls present; spores usually abundant, colorless, sicle-shaped, with numerous crosswalls. Pink snow mold.
4. Helminthosporium. Mycelium sticking out of stomata in leaf spot, with crosswalls, brown; spores cylindrical, brown, several crosswalls. Melting out, or eye spot.
5. Curvularia. Mycelium sticking out of stomata, brownish, with crosswalls; spores brown, about 4 crosswalls, the end cells paler. Fading out.
6. Collectotrichum. Mycelium within the leaf tissues, rupturing the leaf surface to form a pustule-like lesion with brown spike like setae that are particularly characteristic. Anthracnose.
7. Septoria. Mycelium within the leaf tissue; fruit bodies like little black igloos with only the top breaking to the surface; spores produced in the igloos (pycnidia) are colorless and thread-like with crosswall that are difficult to distinguish. Leaf blight.
8. Pleospora, Pyrenophora, Pseudoploea. Hard,black, igloo-like fruit bodies imbedded in dead and dying leaves; spores in 8's inside of colorless sacks (asci) that are enclosed in the fruiting bodies; spores brown or brownish, several-celled, with criss-cross walls.

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THE ISOLATION AND GROWTH OF FUNGI THAT CAUSE PLANT DISEASES

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Isolation in pure culture is often not necessary in determining what fungus is causing a disease, because some fungi sporulate readily on diseased material, allowing ready identification. Also, some fungi, such as the rusts and the mildews, do not grow on media, as they require a living host. Therefore, before isolation, examine the tissue with low magnification (50-100X) for spores or fruiting bodies. Even if lacking, take a moistened razor blade and gently scrape the surface of the lesion (dig out any fruit bodies). Add scrapings to a drop of water on a microscope slide and examine with the low and high power of the microscope, use a cover slip with high power. If the fungus has not sporulated, or for some other reason a pure culture is desired, the following instructions are given: (A reference useful in identifying fungi on turf is "Diseases of Turfgrasses by Houston B. Couch, Reinhold, N. Y.)

Leaf, petiole, and stem lesions

1. Cut lesions, including healthy tissue, into pieces of 1/4 to 3/4".
2. Submerge lesions in 1% sodium hypochlorite (1 pt. of liquid bleach to 4 pts. of water) from 5 seconds to 1 minute. Shake off excess.

3. Using a flamed forceps, place 5-6 pieces, well separated, on sterile, moist filter paper, or on water agar in petri dishes.

4. Observe for spores-fruit bodies from the second day on. If no organisms appear after 1 week, or if the immature fruit bodies previously present failed to develop, repeat Step 1, but wash the tissue in a screen mouth jar under running tap water for 10 minutes; follow by 2 rinses in sterile water and repeat Step 3.

5. After fructifications of pathogen appear, you may identify fungus and stop here. If you wish a pure culture, transfer spores using a fine needle to acidified PDA, PLA or V-8 juice agar (encourages sporulation). The PDA is acidified by adding 1 drop of 25% lactic acid per plate and is used to inhibit bacteria.

Fine roots and damped-off seedlings.

1. Wash roots thoroughly with running tap water.

2. Dip small roots, or pieces of roots, in 1% sodium hypochlorite for 10 seconds to 2 minutes, shake off excess. Wash other roots in running tap water for 10 minutes; then rinse twice in sterile water.

3. Using a flamed forceps, place 3 pieces, well-separated, on water agar.

4. Transfer bits of agar containing mycelium from the outermost edge of developing colonies to separate test tubes, or plates of PDA. Do this 2 - 4 days after plating and do not acidify the media.

Supplies and Equipment

Compound microscope--a sterioscoptic binocular microscope useful
Microscope slides and cover slips
Dissecting forceps
2 dissecting needles
1-pint mason jar fitted with a screen lid
Knife, or single edge razor blades
Chromel inoculating needle with handle
Liquid bleach (clorox, purex, etc.)= sodium hypochlorite
Lactic acid
250 ml. glass graduate cylinder
For media and other glassware requirements, see end of media section.

Media and Its Preparation

Three simple media are enough to allow you to isolate, grow and induce sporulation of many of the fungi that cause plant diseases. Bacterial plant pathogens and saprophytic fungi will usually grow well on two of these media. The ingredients of these media are as follows:

	Potato dextrose Agar (PDA)	V-8 Juice Agar
Water 1 liter (l.)	water 1 l.	water 1 l.
Agar 15 grams (g.)	agar 15 g.	agar 15 g.
	potatoes 200 g.	V-8 juice 200 milliliter (ml)
	dextrose 10 g. (glucose)	Calcium carbonate 3 g.

Agar is used as the hardening agent; it melts at 100° (212° F) and hardens about 43-44° C (109-111° F).

Preparation of PDA. This medium is sold dehydrated by Difco, or Baltimore Laboratories. Add 15 g. of agar to 500 ml. of boiling water, continue heating and stirring until agar is dissolved. In the meantime, simmer peeled sliced potatoes in 500 ml. of water for 20 to 30 minutes. Screen potato water through cheesecloth and add to melted agar. Add dextrose, bring mixture to 1 liter, stir thoroughly and dispense to containers for sterilization.

Preparation of V-8 Juice agar. Dissolve agar in 800 ml. of boiling water, add V-8 juice and calcium carbonate ($CaCO_3$), mix and pour into containers for sterilization. This medium has a lot of sediment.

Filling of containers. Prescription bottles or erlenmeyer flasks are generally used to hold media. The prescription bottles are less work as they have screw caps which also allow long time storage, as drying out is slight. Flasks and test tubes require cotton plugs. The media dries out rather quickly unless refrigerated. Plugs are made by folding a narrow strip of cotton so that it fits 1 to 2″ into the container and 3/4 to 1″ above. It should be tight enough that when in place, it will support an empty 250 ml. flask, or test tube. When filling containers that are to be plugged, avoid getting the inside of the necks wet with media as this will cause the plugs to stick.

Bottles and flasks should not be filled more than ½ with media as the agar will boil over in sterilization. Test tubes are filled 1/3, and, after sterilization, are slanted to give a greater surface for fungus growth. Place test tubes on their side with a support of 3/4 to 1½″ at the neck to give a 1 - 2″ slant. Avoid getting the cotton plugs wet with media.

Media must be sterilized: Media should be sterilized before the agar hardens, otherwise add 15 minutes to ordinary sterilization time. Twenty minutes at 121°C (15 lbs. pressure) is adequate for containers up to 500 ml. using an autoclave. With a pressure cooker, extend time to 30 minutes. After pressure is down, remove containers and allow to cool before pouring agar into petri dishes, about the temperature when the container is still too hot to handle with the bare hand.

Petri dishes must be sterilized. It is convenient to have a supply of sterile petri dishes on hand. Three or four dishes may be wrapped in newspaper, or more in paper bags, and sterilized in an oven at 140° C (284°F) for 3 hours. Keep in a dust-free place prior to pouring. If you are in a hurry, they may be sterilized in the pressure cooker, or autoclave, for the same time given for the media.

Pouring of plates. After the agar medium is sterilized, it may be poured immediately or allowed to solidify and be remelted when needed. Pour plates in a quiet, clean room. Wipe off the table tops with a disinfectant such as hyamine (recommended) ½ g. per liter of water; mercury bichloride 1 pt. to 1000 pts. of water (very poisonous); or 1 part liquid bleach (sodium hypochlorite) and 4 pts. water (hard on the hands and the equipment). Wash hands and face and remove, or cover over with a clean lab apron any dirty clothing. Line up petri dishes at the edge of the table, and, lifting one side of the lid as little as possible, pour the liquid agar to a depth of 1/8 to 1/4″. Work slowly and prevent agar from dripping on the outside of the bottom plate. After pouring, rinse out agar left in bottles with hot water. Don't save any that is left over. Do not move plates while agar is hardening.

Equipment needed for media preparation and sterilization.

1 or 2 liter enameled graduate cylinder (Pitcher form)
250 ml. glass graduate cylinder
6-8 quart pot
large mixing spoon
small funnel
triple beam balance
4 or 8 oz. prescription bottles with caps (Erlenmeyer flasks 250 ml. can also be used)
petri dishes
test tubes or screw cap vials
cotton, non-absorbent preferred
21 qt. or larger pressure cooker, or autoclave

Most of this material can be purchased at a hardware store, or a large mail order house, the prescription bottles and vials at the drug store, and the more technical items from a scientific supply house. Dehydrated media and the few special ingredients can be gotten from Difco, or Baltimore Laboratories.

List of a few supply houses	Item
Aloe Scientific Co., 9556 River St., Schiller Park, Ill.	scientific supplies
Baltimore Biological Lab., 2201 Aisquith St., Baltimore 18, Md.	culture media some reagents & stains
Difco Laboratories, Detroit 1, Mich.	culture media some reagents & stains
Fisher Scientific Co., 1458 N. Lamon Ave., Chicago 51, Ill.	chemicals & scientific supplies
General Biological Supply House, 8200 S. Hoyne Ave., Chicago 20, Ill.	teaching & scientific equipment - some media ingredients
E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 20, Ill.	Chemicals and scientific supplies

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TURFGRASS DISEASE CONTROL

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Turfgrass diseases vary in severity from year to year, and from one locality to another, depending on the environment (principally moisture, temperature, humidity, and grass nutrition), the relative resistance or susceptibility of the grass host, and the causal organism. For diseases to develop, all three factors must be present and in "balance." For example, if the environment is favorable for a disease, and the disease-producing organism is present, but the host plant is highly resistant, little or no disease will develop. Similarly, if the causal organism is present and the host is susceptible, but the environment is unfavorable, the disease usually does not appear.

We can put this relationship in the form of a simple equation:

Susceptible grass	+	Disease organism		
+		+	=	DISEASE
Proper environment	+	Method of distribution		

No disease will develop if <u>any one</u> of the above ingredients is lacking. Effective disease control measures are aimed at "breaking" this equation in one of the three basic ways: (1) the susceptible plant is made more resistant or immune; (2) the environment is made less favorable for the causal organism and more favorable for the grass plant; and (3) the disease organism is killed, or prevented from reaching the plant, penetrating it, and producing disease.

Let's discuss these three basic methods of control:

1. <u>The grass plant is made more resistant or immune</u> --This is the ideal method of control. All grass breeders, and everyone else concerned with turf, are hoping to develop more resistant grasses. Some progress has been made. We now have grass varieties that are somewhat resistant to dollar spot, snow mold, leaf spot, rust, powdery mildew, and other diseases. But, this important control measure is still in its infancy. For some diseases like brown patch, where the causal fungus is composed of an infinite number of biotypes, or strains, the development of highly resistant or immune grass varieties is remote and may never come about. Before such grasses can be developed and released, sources of resistance in wild or cultivated grasses must be found. Then comes the long, time-consuming process of working this resistance into otherwise desirable grasses. We will probably never have a lawn or fine turfgrass that is resistant to all common diseases.

   Another way to make the grass more resistant is through proper nutrition. Dollar spot, pink snow mold, or Fusarium patch, powdery mildew, brown patch, and other diseases are less serious where a uniform level of soil nutrients is maintained in the root zone. This may mean making fewer and lighter applications of fertilizer, plus keeping the three major nutrients, N, P, and K, in balance. When nitrogen is high in relation to potash and phosphorus, you may be heading for trouble, especially in hot weather!

   Grass cut at the proper height also has more resistance than turf that is scalped. Without sufficient green leaves to manufacture food to produce new leaves, roots, and stolons, the grass is definitely weakened. Grasses in a lawn, park, fairway, or golf green grow under artificial conditions and are more subject to attack by disease organisms than they would be in their natural environment. Healthy, vigorously growing, adapted turfgrasses--that are properly managed--can best ward off disease attacks.

2. <u>The environment is made less favorable for the causal organism and more favorable for the grass plant</u>. Fungi that cause turf diseases require much the same sort of environment that turfgrasses require: food, moisture, oxygen, and a favorable temperature. The basic concept here is to grow grass in an environment that will be unfavorable to the growth, multiplication, and spread of disease-producing fungi. This we can do by:

   a. <u>Keeping the grass blades as dry as possible</u> for as long as possible. Fungi with the exception of the powdery mildews, require free moisture on the grass plant for 3 to 12 hours, or more to infect a plant. Poling, brushing, and hosing are means of removing dew and guttated water in which these organisms thrive. There are reports of superintendents' applying non-toxic, surface-active detergents to grass that prevented dew from clinging to the grass blades. The fungi couldn't penetrate without moisture, and no disease developed. Poor surface and subsoil drainage causes compaction and soil aeration problems. Roots are suffocated from lack of oxygen, or are "drowned." The result, too frequently, is disease. "Dead," humid air over a pocketed turf area causes disease problems. There is no wind to dry off the grass blades. If we could keep grass dry--and this includes the thatch--we would have no disease problems aboveground. Root rots that cause "wilt" of golf greens in July and August are commonly due to overwatering of the root zone to keep the turf soft. Keeping the soil near the saturation point prevents normal root growth and favors the growth of organisms like Pythium, a common water mold. Proper water control is the single, biggest environmental factor in keeping disease in check on golf greens, or other frequently watered turf areas.

b. Eliminating the dead grass (mat or thatch) in which disease-organisms thrive. Removal helps to "starve out" these fungi and forces them to compete unfavorably with the multitude of bacteria and fungi in the soil, many of which are antagonistic, or even parasitic to the disease-producing organisms that attack grass. The thatch also acts like a sponge in holding excess moisture. Elimination of thatch has cut the fungicide budget of many golf clubs in half.

c. Keeping large trees away from greens or installing root barriers.

d. Not injuring the grass by careless use of pesticides, using a mower out of adjustment, leaving the cup too long in one spot, walking or riding on turf that is soggy, removing half or more of a grass blade at one mowing, etc. Remember that anything you do to grass to weaken it may lower its natural resistance, allowing a disease organism to "take over."

3. The disease organism is killed or prevented from reaching the plant and producing disease. We have talked about removing moisture and thus preventing a fungus from penetrating. We could also mention using sand, or other sharp particles to improve surface and subsurface drainage and aeration. You can probably think of other ways to prevent distribution of the organism. But, the principal means of control here is chemical. We can apply a soil fumigant to the turf area before planting and kill fungi, nematodes, insects, and weed seeds--all at once, using a single chemical like methyl bromide, chloropicrin, Vorlex, Vapam, or V. P. M. Soil Fumigant. The expense is fairly high, but more and more of this type of control is being used before seeding, or sodding greens, tees, stadium turf, and even home lawns. Generally a polyethylene cover is placed over the treated area to retain the fumes of the fumigant. The only problem is that disease and nematode problems may become <u>more</u> severe later because of lack of competitive fungi, bacteria, and nematodes in the treated area. Once a disease-producing organism is introduced (blown, washed, or tracked) into a treated area, there is no "biological check and balance."

This discussion brings us to the use of turf fungicides on a preventive schedule--applied <u>before</u> the disease strikes. We recommend that you follow the manufacturer's directions on the package label as regards rates to use, interval between applications, compatibility with other chemicals, grasses on which the chemical is to be used, etc.

The method of application is very important. We suggest using at least 5 to 10 gallons of spray per 1,000 sq.ft. to adequately wet the grass blades, thatch, and top quarter inch or more of soil. I would use 5 gallons of spray against such diseases as powdery mildew and rust, which attack only the grass blades. Other diseases, such as dollar spot, brown patch, Pythium, melting-out, and snow molds, attack the crown and root area before growing on and over the grass surface. Here 10 gallons per 1,000 sq. ft. is barely adequate. For diseases like brown patch, where the causal fungus is known to survive in the form of sclerotia buried in the soil, 15 gals. would probably do a better job.

High pressures are not necessary! It is much more important that the fungicide be applied evenly. In most cases the best way is to use a multi-nozzle boom and apply the chemical equally in two directions. The time interval between spray applications should vary with temperature, expected disease, grass condition, chemicals used, and amount of rainfall or artifical watering. The spray interval may be as short as two or three days in hot, wet weather, or stretch out to two weeks if the weather is cool and dry. Some fungicides give some protection for a week or 10 days even when four to six inches of water has fallen as rain, or been applied by sprinkler. Another chemical may last only two or three days under similar conditions. The problem is complex and one that you have to "feel out" for yourself, based on your knowledge of the chemical and its past performance, the problem turf area involved, past fungicide and other records, and knowledge of the factors that cause a particular disease to flare up. It is only through keeping records that you can hope to determine why a certain fungicide failed--or did a good job. All the fungicides in the world cannot replace a poor turf management program.

The equipment you use is also important, especially on a golf course. How fast can you get around and complete a spray application? If Pythium strikes, is this fast enough? These are questions you have to answer for yourself. The important thing is to get uniform coverage of the grass. You may have to put in a commercial spreader-sticker, or wetting agent, to insure wetting of the grass blades and better penetration of the thatch and soil surface.

Table 1 gives a summary of turfgrass diseases and the fungicides that have been reported by various research workers as giving some degree of control. The success (or possible failure) you have with these fungicides, however, will depend on how well you have put the pieces of the overall turfgrass disease control picture together.

For additional information on lawn diseases, read North Central Regional Extension Publication No. 12, "Lawn Diseases in the Midwest"; "Slime Molds," Report on Plant Diseases No. 401; and "Diseases of Bluegrass Lawns," Report on Plant Diseases No. 400.

Table 1 - follows

Table 1. Summary of turfgrass diseases reported to be controlled by various fungicides.

	DISEASES							
	Melting out; leafspot	Brown patch	Rust	Powdery mildew	Fairy ring, toadstools, mushrooms, puffballs	Dollar spot	Snow mold	Pythium
Acti-dione thiram[3]	yes	yes	yes	yes		yes		
Caddy						yes	yes	
Cadminate						yes		
Cad-trete						yes		
Calo-clor		yes			yes	yes	yes	
Calocure		yes			yes	yes	yes	
Captan	yes							
Dyrene	yes	yes	yes			yes	yes	
Karathane				yes				
Kromad	yes	yes[1]	yes	yes		yes	yes[2]	
Maneb		yes	yes					
Ortho Lawn & Turf	yes	yes		yes		yes	yes	
Panogen Turf Spray	yes	yes			yes	yes	yes	
Phenyl mercury[2]	yes	yes			yes	yes	yes	
Sulfur			yes	yes				
Tersan	yes	yes	yes			yes		
Tersan OM	yes	yes	yes		yes	yes	yes	
Thimer	yes	yes	yes		yes	yes	yes	
Zineb	yes		yes					yes
Dexon								yes

1/ Calo-clor or Calocure (1-1/2 ozs. per 1,000 sq.ft.) should be added to Kromad to control brown patch and snow mold.

2/ Trade names of phenyl mercury: PMAS, Puratized, Tag, Liquiphene Turfgrass Fungicide Merbam 10, Puraturf, etc.

3/ Only Acti-dione-thiram is suggested for use on bentgrasses. Acti-dione RZ may cause injury.

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THE MYSTERY AND MADNESS OF SPRING DEAD SPOT

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About a week ago an alert young superintendent read me the following quotation from a paper he held in his hand:

> "Now that all golf course maintenance problems have been solved, perhaps we can get on with some of the other aspects of operating a golf course."

Did you know that all maintenance problems have been solved? Of course not! And, yet the quoted statement was made more than 34 years ago -- it comes from the February 1928 issue of an important publication, which still today is outstanding in helping turf managers solve their problems.

One reason why all maintenance problems will never be solved is the fact that there are constantly arising new problems that turf managers never even suspected before. For example, during recent years a number of damaging turf diseases have appeared that weren't even known to exist 34 years ago. One of these is the one about which there's been so much mystery and madness in the bermudagrass growing areas during the past few years. Mystery because while the damage was, and is, quite evident, the basic cause hasn't been pin-pointed. Madness because of the previously vain and frantic attempts to bring the rascal under control.

Just What is SPRING DEAD SPOT?

Bermuda is gradually spreading farther and farther into the Midwest for use on tees and fairways. In Kansas and Oklahoma every turf manager knows of the severity of damage caused when dead spot hits. There are at least two reasons for the question:

1. Spring Dead Spot is practically unknown. During a trip last summer to one of the Eastern turfgrass conferences, I questioned a most respected and able young plant pathology student as to what he knew about SPRING DEAD SPOT. His answer was a hearty chuckle. "Quit poking fun," he said. "Every now and then we get reports of a so-called turf disease called 'Spring Dead Spot', but we're beginning to feel that this is largely a figment of somebody's imagination." By chance I happened to have some color slides of some midwest golf course fairways severely riddled by Spring Dead Spot, and I showed these to this young man. Never have I seen an attitude change so radically. Now his mood was of sober reflection. "You know," he said, "If you hadn't shown me these I'd never have believed it." He is now one of those actively helping to find a solution to the problem.

2. The second reason is that as of right now we really don't know just what it is. Oh! We know what grasses it attacks -- practically all the bermudas, especially U-3 and the other hybrid varieties. And we know in what areas it attacks -- generally speaking, the northern tier of the bermuda growing states, on a line roughly from Tulsa to Kansas City, to St. Louis to Indianapolis, to Philadelphia to central New Jersey, and the area immediately to the south of this line. We're aware of the symptoms -- completely dead areas in a pattern of roughly circular shapes which simply don't green up when the rest of the grass emerges from winter dormancy. We know that without effective treatment a dead spot of this current spring will again be a dead spot

next spring, in the exact location, except perhaps in a larger area. We know that if left untreated, or treated ineffectively, a dead spot will either not fill in with live bermuda at all, or will permit the growth of only a few weak runners, toward late summer, or early fall, which will not survive the following winter.

We know that usually before the dead spots fill in with live bermuda, weeds and crabgrass invade the spots, further reducing the probability that desirable turf will be re-established. And finally, we know that prior to this year none of the hundreds of products and techniques screened for potential control have been to any degree effective.

Yes -- we know many things about SPRING DEAD SPOT, except WHAT IT IS. Is it a fungus disease? A mite? An insect? An unexplained pattern of dormancy?

Where Did SPRING DEAD SPOT Come From?

An article in the June 1958 issue of the USGA GREEN Section "MID-CONTINENT TURFLETTER" entitled "WINTERKILL OF BERMUDAGRASS." Written by Jim Holmes and Monty Muncrief, under the guidance of Dr. Marvin Ferguson, it points out that "a great deal of bermudagrass died." The article explains that there were two primary causes of the winterkill. The first was desiccation, or drying out, and the authors refer to a USGA JOURNAL article of November, 1953 on desiccation. "The second cause of loss", say the authors, "was disease." On almost all areas where winterkill occurred, large spots or lesions caused by fungal activity were found on the bermudagrass rhizomes. There is very little information available on this type of disease activity, which occurs below ground. Therefore, it is not possible to say whether disease alone could have caused loss of turf. There is little doubt that it contributed to that loss.

The article goes on to point out (remember this is back in 1958) that "This is an area that is virtually untouched, and much research is needed to determine the degree of damage and the possibilities of successful control."

SPRING DEAD SPOT Research in Action

Even while the Green Section was urging research in the SPRING DEAD SPOT problem, the keen and perceptive minds of scientists already were at work seeking to challenge this damaging pest.

"A disease, which is now called SPRING DEAD SPOT, was observed in a bermudagrass (Cynodon dactylon) lawn at Stillwater, Oklahoma during the spring of 1954. Since that time, this disease has been found throughout much of the state on lawns, golf courses, and many other public and private turf areas. The prevalence and severity of SPRING DEAD SPOT has steadily increased, and during the past 3 years has become the most important disease of bermudagrass in Oklahoma.

Conversation and correspondence with turf managers has led to the conclusion that this disease may have been present, at least locally, for many years. The only concrete information, however, came from Mr. Bob Dunning, of Tulsa, Oklahoma, who believes, in the light of present investigations, that he observed SPRING DEAD SPOT as early as 1936.

Reports which indicate the distribution of the disease are rather vague. It was reported from Kansas in 1959, and was observed at Lincoln, Nebraska, the same year. Following a discussion of the disease at the Annual Conference of the Oklahoma Turfgrass Association in December, 1959 various individuals reported that this, or a similar disease, had been seen in Pennsylvania, Missouri, and Arkansas."

WHAT'S BEING DONE TO CONTROL SPRING DEAD SPOT?

Many approaches to the problem have been tried, including some of the following:

1. FUNGICIDES AND INSECTICIDES - Professor Wadsworth and Dr. Young have pushed on with their work, testing many compounds, with only a vague promise of success. Until recently, the insecticide, Dieldrin, showed the most promise, but control seemed limited to retarding the spread of the dead spots, and in their size being reduced from one year to the next.

2. MAT AND THATCH REMOVAL - this was thought to be essential in controlling the disease, and many tests have been run on thatch-free areas previously riddled with dead spots. The theory was sound -- since mat and thatch are normally breeding grounds for fungi they likely help the development of SPRING DEAD SPOT. But, thus far the theory has not found support. The dead spots re-appeared in the de-thatched areas just as they did in the areas where the thatch remained.

3. WATER WETTERS - these have been tried, but thus far without success, so far as I've been able to learn.

4. FERTILIZER STUDIES - have been carried out with the thought that some types of fertilizers and application techniques might promote SPRING DEAD SPOT, while others might retard it. Thus far no real relationship has been found between a particular fertilizer, or fertilizer group.

5. BASIC GRASS PLANT RESEARCH has been carried on, at least to some extent. Several disease organisms, particularly *Helminthosporium* varieties, have been found in the dead areas, but inoculations of good bermuda turf with these organisms has failed to reproduce the disease. In the East some experimental bermuda plots have been attacked by the same disease. Up there it has been called "Winter-die-back", and other names, but to my knowledge no control measures have been develcr d, or even suggested.

CURRENT RESEARCH AND TESTING

Beginning some 3 years ago or more, our own research people at St. Louis recognized the magnitude of the problem and the fine work being done by researchers to solve it. Starting with a study of Wadsworth's and Young's work, an intensive screening program was undertaken by our research people on St. Louis golf course bermuda turf areas. While a causal agent has not yet been found, it was deemed worthwhile to start with control agents to see if the dead spot invasions could be thwarted by one or more of them. Literally hundreds of compounds and techniques were considered -- many were tested -- most were ruled out as ineffective.

In the fall of 1961, the search was boiled down to a study of some 19 fungicide formulations, each replicated three times, on a wide U-3 bermudagrass turf area on a disease riddled country club fairway in St. Louis. These replicates, plus check plots, were overtreated in one place with various fertilizer treatments, and in another place with thatch removal areas. (By the way, neither the thatch removal ncr the fertilizer plots bore any relationship to the SPRING DEAD SPOT incidence).

A variation not previously mentioned was timing. Two separate complete series were run, one series beginning in September, while the bermuda was still sturdy and green; the other series beginning in January when the grass was dormant. Both continued into April. During the entire winter all areas were constantly checked to see if the dead spots could be detected during the dormant period. They could not. Areas thought to be dead greened up beautifully in the spring, while others were thought to be live and viable turned out to be the center of dead spots. Of all the formulations and techniques tested, only two stood out above all others as giving good to excellent control.

I believe that a real break-through has been made toward effective SPRING DEAD SPOT control. Technical difficulties, now corrected, prevented a commercial product from being marketed this year, but the additional time is being used in consolidating information, refining tests, running further tests in widely separated areas and on many bermuda varieties; testing on both overseeded and non-overseeded bermuda areas to determine the effect on cool-season overseedings, etc. Shortly more answers will be available than ever before, and a commercial product is expected to be available for routine use by fall 1963.

CONCLUSION - WHAT OF THE FUTURE?

It is axiomatic that every problem generates its own solution -- every question generates its own answer. And, so it is with SPRING DEAD SPOT. From the time Bob Dunning first observed this disease in 1936, a period of some 22 or 23 years elapsed before Wadsworth and Young actually came to grips with it as a problem that needed attention. But, while learning about the problem and pin-pointing its characteristics is a tremendous forward jump, the answer, or solution, usually emerges in the form of a product or service; and to develop the product or service, the facilities and resources of industrial firms are usually called upon. In each case the persons actually troubled with the problem are called upon for some assistance. It is for this reason that some of you here today are running tests to prove the value, to yourselves and others, of products that will solve the problem.

What better example is there of the fact that only teamwork and cooperation - between Experiment Stations, Industry, and the fellow with the problem - can bring about a satisfactory solution! It is with this kind of cooperation that the mystery of SPRING DEAD SPOT begins to vanish, to be replaced by knowledge, and an understanding of the problem. And the madness of searching in vain for a solution to the problem disappears in the face of promising controls.

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A DISEASE CHECKLIST WHEN ADVERSITY COMES - BENTGRASS

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There have been numerous "check lists" published with regard to anticipating turf maladies resulting from various fungi, nematodes and men. Such check lists are merely guides, as the author and the users are well aware that fungi and nematodes do not have the necessary facilities to read and understand such lists. Nonetheless, quite accurate predictions can be made concerning which morbid factors are likely to exist under a given set of conditions. One of the simplest and perhaps the most accurate system of "checklisting" is connected with the seasons of the year. Of course, a knowledge of the disease syndrome is necessary. Let's establish the distinct seasons, then check list what can be expected when adversity comes.

1. Cold	2. Cool to Warm	3. Warm to Hot	4. The entire season
a. Wet	a. Wet	a. Wet	
b. Dry	b. Dry	b. Dry	

I. Season - Cold and Wet

a. Fungi: The checklist for proper procedure here is more accurate and well understood than it is for any other season because the environment can be more closely predicted.

1. Insure drainage both surface and sub-surface. Puddled water (or ice) can be devastating.

2. Do not allow greens to "go into winter" in a lush-overfed condition. Preferably turf should be slightly on the hungry side.

3. Continue regular short height of cut until turf growth ceases.

4. Most golf course superintendents advocate an early fall aeration, early enough so that Poa annua is not encouraged at the expense of bent and insurance that aerator holes will "heal" prior to cold weather.

5. Thoroughly irrigate greens prior to "securing" watering system.

6. Apply a "snow mold" preventive fungicide according to manufacturer's recommendations. Make a second application during a mid-winter thaw.

7. Do not allow a continuous (from the soil upward) ice sheet to remain in place for longer than 21 days. If an ice sheet is present for this length of time it must be removed. Under extreme cold conditions mechanical removal is recommended. Loose snow cover, or an ice cover which has a layer of snow beneath, is not considered dangerous.

8. Apply the snow mold fungicide again when turf begins to grow in the spring. We have found that this application may be of far greater importance than realized by many.

9. Commence mowing as soon as turf initiates growth.

10. As is the case at all times, follow proper maintenance practices.

b. Nematodes:

1. Eelworms are either dormant, or are in the egg stage during cold weather. To date our knowledge indicates that nothing can be done in regard to their control at this time. However, if topdressing is prepared during cold months it should be sterilized if at all possible. If soil is too cold for sterilization it should be treated as soon as the soil temperature allows.

c. Man:

1. The "adversity check list" here usually concerns a bipod known as Homo sapiens carrying a sled, or toboggan. Various practices designed to counteract this malady, such as fences, brush piles, mean dogs and shotguns have been employed; usually with only limited success. Winter sport enthusiasts can be extremely damaging to greens and other turf areas. We have found that good fences are about the best deterrent. Occasionally law enforcement officials are employed.

2. Turf can be damaged excessively if play is allowed when the soil has thawed to a depth of 1 or 2 inches. Either play should be restricted at these times, or alternate tees and greens should be made available. An excellent practice to follow is "keep as much traffic as possible off greens and tees during cold, freezing weather." Sometimes playing the last nine only may be a compromise.

II. Season - Cool and Dry

a. Fungi: If one could be assured that an open, dry winter were ahead, there would be much less need for taking the many precautions listed in Fungi - Wet above. However, there is never a guarantee of this, so such precautions must be taken. Furthermore, where open, dry winters are frequent:

1. Either place snow fence in proper places around greens, or pile brush on greens, or both. Considerable work has been done with regard to placing clear plastic on putting surfaces when drouth conditions are expected. This definitely eliminates desiccation damage, and is being used by several clubs, particularly in Canada. However, the time used and expense is considerable. A new green, just planted late, may need protecting badly.

2. If desiccation has been a frequent problem in the past, the superintendent should see to it that a large, mobile water tank is available. During periods of extreme drouth a minimum of 250 gals., and preferably 500 gals., of water should be applied to each green. Two such applications may be necessary under severe conditions.

3. Many superintendents will operate their watering system earlier than considered safe if desiccation is severe. The course is watered, then the system is redrained, if necessary, in order to avoid freeze damage. They believe such a practice is preferable to taking the chance of losing considerable turf.

Season - Cool to Warm, or Warm to Cool - This includes both spring and fall.

1. Wet:

a. Fungi: Most diseases are more damaging in a wet environment. The most common are the genera of: Sclerotinia, Corticium, Fusarium, Gloeocercospora and Helminthosporium.

1. The turf manager must recognize and identify the various symptoms, be familiar with the chemical control procedures, and apply fungicides as needed. I firmly believe that an adequate preventive fungicide program is as important during this period as any other

season of the year.

2. Drainage, both surface and sub-surface, is paramount. If drainage is not adequate, steps must be taken to insure adequate drainage.

3. The soil must contain adequate oxygen (air) to allow proper physiological root and biological activities. The soil also must be sufficiently "loose" so the root exploration and growth are not impeded. If the soil is "tight" and compacted it should be loosened. Many tilling tools are available for this purpose.

4. An excess of organic matter (mat-thatch-grain) encourages disease development so it must be avoided. If excess material is present it can be removed through mechanical means, and by encouraging biological activity.

5. Nutrient levels should be balanced and adequate. Soil tests are usually required every 2 to 5 years. An excess, dearth, or imbalance of plant nutrients can encourage disease activity.

6. Check constantly to assure that bentgrass turf areas are not being overwatered, which encourages disease activity.

7. Tree root competition and shade weakens turf and predisposes it to the ravages of parasitic fungi.

b. Nematodes: The spring season, or just when roots have initiated vigorous growth, is the time to attack the nematodes.

1. Presence of parasitic nematodes must first be established; then the number estimated. Obviously nothing should be done if there are no, or few parasites present. However, in all the samples I have had screened, parasitic nematodes have been found. Collect pint soil samples from the entire area in question. Take 1/2 inch cores to a depth of 4 to 5 inches. Mail, or take them immediately to a qualified nematologist (most land grant colleges now employ such men) and ask him to report the counts of parasites present. If a sufficiently large population is detected, I suggest that test areas of 200 to 500 sq.ft. be established as follows:

   a. Aerate soil.
   b. Apply 1/2 the recommended rate of nematocide. Nematocides currently in use are: Fumazone, Nemagon and VC-13.
   c. Water-in deeply and thoroughly.
   d. In 1 week to 10 days apply the remaining 1/2 dose. Water-in thoroughly.

   The following fall and again the following spring extract soil samples from the treated areas and from adjacent non-treated areas. Submit these samples to the nematologist in order to determine degree of control. Also, maintain a visual check to determine any continuous improvement in treated areas. If control is evident, treat entire areas.

2. The first indication of nematode infested grass could be considered as lethargic turf, or turf which remained consistently diseased and "poorly" regardless of the maintenance programs followed. It is my opinion that nematodes are responsible for considerably more troubles in turf main-

tenance than is attributed to them.

c. Men: Many items in the disease checklist which appear on the detrimental side of the ledger can be attributed to men. Examples are:

1. Dull mowing equipment. Mishandling of machinery, and careless behavior by workmen fall into this category. Surely everyone recognizes the weakening or damage to turf which results from scalping. During periods of stress all heavy equipment should be kept off the greens and turf except in cases of absolute necessity.

2. Excessive play, especially during periods of surplus moisture, encourages disease activity. However, it is difficult to avoid.

Dry:

a. Fungi: Generally potential damage as a result of fungi activity is considerably decreased during the periods of dry weather. The superintendent should be careful not to overwater greens and tees during periods of drouth. Applying fungicides is wise - the exception of the rule is the evidence of Helminthosporium. This particular fungus is frequently damaging on high-dry areas.

III. Season - Warm to Hot - when stress to turf is most severe.

1. Wet:

a. Fungi: In that higher temperatures and excess moisture encourage development of fungi and discourage development of bentgrass - all known precautions must be taken to insure healthy, vigorously growing turf and to discourage development of fungi:

1. Be familiar with both the fungi, which are known to be damaging at this time of year (which includes practically all of the fungi known to be parasitic on grass) and the chemical control means for these fungi. An adequate supply of fungicides must be on hand.
2. Follow a regular preventive fungicide program during these periods of stress.
3. All maintenance practices become more exacting at these times. Errors in judgment, or mishandling of chemicals and equipment, are compounded.
4. Major improvement, or major change should not be undertaken at this time. Use resources to keep turf growing in as healthy condition as possible.
5. If it is apparent that disease activity is caining the upperhand, it is an excellent idea to request advice from an authority on turf diseases.

b. Nematodes:

1. Samples can be taken at this time of year in order to determine the degree of infestation if there is reason to believe that parasitic nematodes are active. However, to the best of our knowledge at the present time, treatment should be delayed until the following spring.

c. Man:

1. Workmen should be made aware that turf is in its most susceptible stage during hot-wet periods, and taught to operate accordingly.

2. Dry - All should be the same when the weather is hot

IV. Season - The Entire Season: The entire picture is considered here:

1. Equipment must be constantly in good dependable working order. For an example, if the spray machine used to treat greens was to "break down" on the fourth of July, it must be either repaired or replaced immediately. Therefore, parts which experience indicates are subject to breakage should be stocked.

2. The work force should be trained and kept constantly aware of their role in the overall course maintenance picture, especially when "adversity comes."

3. An adequate supply of pesticides should be on hand.

4. A friendly, understanding relationship should be maintained between members (players) and the superintendent. Obviously, such a relationship will be extremely helpful to both the players and the superintendent if "adversity does come."

5. Keep a constant check for signs of turf weakness, or symptoms of disease activity. If it becomes obvious that a specific area regularly shows disease symptoms, the source of the trouble should be determined, a plan for correcting the condition formulated, and such a plan carried to completion.

6. Specifically staying on top of the job and the use of good common sense begins and ends all checklists.

We have been discussing primarily bentgrass, tees and greens. However, many clubs have reached such a high level of turf maintenance that bentgrass fairways are receiving similar treatment. The practice of applying fungicides to fairway areas, and in general following similar programs as for greens, is increasing. If one expects to maintain bentgrass - *Poa annua* turf in the fine condition expected by many, it is becoming apparent that these extra steps are necessary.

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NATURES SEQUENCES OF WEED INFESTATIONS

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The study of changes in plant populations of a given area is the relation of the plants to their environment. This is a special field of its own, known as ecology. The changes are basically the survival of plants more adapted to the soil and climatic and management conditions of a given region. Rachel Carson has made a great to-do about biological balance being changed by modern chemicals. This balance was actually changed when man, the thinking animal, came on the scene.

Numerous studies in California (and elsewhere) show that when man conquered the region his burning, grazing herds of animals, cultivating the land and building roads, towns, ditches, etc., produced great changes in the natural vegetation. Native grasslands are now no longer dominated by perennial grasses - they are largely introduced species. When, for instance, the original vegetation is modified by excessive and continuous grazing, there first appears a sparse stand of summer annuals with winter annuals. This is followed by a short stand of winter annuals; then unpalatable range weeds, or poisonous plants, with a sparse stand of winter annuals. If the misuse continues the end result is bare, or nearly bare soil.

This is not only a Western problem. Literature can be cited in all parts of the country that man has failed in his obligation to nature. His ignorance and greed has decimated some of the finest crop and grazing lands in the world.

Levy in 1940, cited the key importance of light as the primary factor in plant competition. He says, "Light intensity tends to promote change, that is, the plant which can keep its canopy in the light assumes and maintains dominance, but the moment it becomes shaded by a more vigorous rival, it loses dominance and may ultimately be eliminated from the community."

This single statement is the basis for the vast majority of weed invasion and control studies. Although proposed for pasture lands, it is equally important in studying the invasion of weeds into turf. Turfgrasses as we use them are largely grown under artificial, stressed conditions. They must not only survive, but must look pretty and serve to support special uses.

Let us consider how we help to encourage weed invasion. There are only about 6 basic reasons:

1. Impoverished Soil - Most turf weeds are capable of growing well under low fertility conditions. The best example is the relation of clover and nitrogen. When nitrogen is withheld from most grasses their growth rate is reduced. Clover supplies its own nitrogen from the air and is not affected. Other weeds, however, are simply capable of good growth under low fertility conditions. Examples of this are Carpet and Bahia grasses in the South. If bermudagrass is not kept actively growing, these weedy types invade and can exist permanently without further fertilization. For this reason Bahia is widely used in highway work in Florida. Smaller golf courses in South Georgia and Florida have carpetgrass fairways because it doesn't require fertilizers.

   Good fertility includes a pH level that will make all plant food elements available, adequate, N, P and K, and the other minor and trace elements required by the plant. Of growing concern are extremely high analysis fertilizers that carry few of the beneficial impurities found in older materials. There is little sulfur in triple superphosphate, for example, but it is abundant in old 20% super, or ammonium sulfate.

2. Deficiency of available water. Inadequate water, even only for short periods of time, can cause wilting. Wilt and subsequent thinning of the canopy of turf enables the sun to penetrate to the soil and encourage weed seed germination.

   Dryness in many cases wilts the desirable turf, while weeds, more deeply rooted, continue to grow. This gives them the canopy advantage, and hence, dominance.

3. Wet Soils. All too often, wetness is the principal cause of turf decline. We want an irrigation system to SUPPLEMENT natural rainfall, only. In the West, where rainfall is sparse, irrigation is the primary source of water, but not

here in humid regions.

Poa annua would not be as great a problem if over-irrigation was not so widespread. On irrigated golf course fairways, for instance, where is the most Poa annua? Usually it's down the middle, where the most water is supplied and not along the edges where sprinklers do not reach.

Over-watering reduces the root system of the grass and causes a general thinning of the turf. Here too, the canopy is lost and weeds that like wet conditions - sedge, Poa annua, moss, algae, etc., proliferate and achieve dominance.

4. Impermeable Soils. These are wet and dry - they hold water above them for a long period of time because it can't penetrate and leach away. Little has been absorbed, so when evaporation removes the collected water, these are often quick to dry out and difficult to rewet. Soils of such density have poor oxygen supplies for plant roots. The tougher weeds, such as knotweed, can grow profusely.

   Such soils are found where construction or erosion has carried away the topsoil, leaving only the subsoil. They are also found in low lying, swampy areas. Not too long ago such areas were not considered for housing, golf, or recreational areas. The modern need for more land has made their use necessary. And, someone must grow grass on them.

   Man contributes to this problem by making a good normal soil impermeable by simply overworking it. Traffic is a major cause of turf and soil deterioration today. Golf, home and athletic fields enter picture in every section of the country. Compaction is provided by those who use an area and by the equipment of those who maintain it.

   The Cotton Bowl in Dallas hosts 50 football games a season. An 18 hole public golf course in Milwaukee has sold over 700 tickets on one Sunday. Thousands of visitors trample the bluegrass paths of a rose garden. A park's picnic areas are reserved for the entire summer before the snow melts. It is this kind of traffic that means more care and more area required for this, the "Outdoor Generation."

5. Improper Management. This includes sins of omission, as well as sins of commission. To illustrate this could take hours without repeating a single instance. The common errors include mowing bluegrass too short, thinning the canopy, and allowing weeds to proliferate. It includes mowing too infrequently, misuse of fertilizers, misuse of chemicals, over-irrigation, misuse of cultural tools, such as aerifiers and vertical mowers - just any number of things.

   A back door evidence of bad management is the purchase of poor quality seed. In almost every instance, if turf is to be planted at all, it is well worth the cost to specify only the best. As little as 0.5% weed seed can eventually cost 2 or 3 times the price of the highest quality seed because of the need for subsequent weed control. Sins of omission include failure to protect against diseases and insects.

   Just think of the thousands of dollars Dr. Daniel has spent evaluating weed killers and the millions of dollars spent by consumers for them -- primarily to cover up mistakes. Yes, mistakes - by agronomists, by the real pros - golf course superintendents, by gardeners and maintenance men, and by the homeowner. If the day ever comes when we can set up and abide by a real, perennial program of fertilization, pest control and cultural practices, this "Operation Coverup" can be discontinued, or reduced. Without the drain of talent and dollars into herbicide screening, think how much basic scientific information could be produced here at Purdue. Then, multiply that figure by the number of Experiment Stations and companies in the United States. Then, progress of real turfgrass research could be accelerated tremendously.

6. Unadapted varieties. This is a minor, but nevertheless important phase of weed invasion. A great noise is being made about the juxtaposition of grasses in the U. S. -- bentgrass moving South and bermudagrass moving North. Through highly skilled management this can be done to some degree, but like everything today it has been oversold. Can you imagine a 9-hole golf course in Georgia, having a $ 10,000 total budget with bent greens? It was done. The same would be true of bermuda-fairways up here. If a club or homeowner does not recognize the hazards involved, only weeds will succeed.

   One of the most famous con jobs in history involved planting stolonized bent greens in Miami. Even with the best management possible they didn't survive.

   The Zoysia bubble of a few years ago is another example. I wish I had all the dollars spent in Milwaukee on those plugs. Naturally they winterkilled the first year.

   Unadapted variety means not only geographical adaptation, but to special cases in a given area. For instance, trying to grow bluegrass or bermuda in the shade, planting fine-leaved fescues in low, wet areas, or trying to make Poa trivialis survive on a dry, south-facing slope in the open sun. There are adaptations that must be considered in almost every area.

In summary, the sequence of natural weed invasion is the summary of man's existence. His vanity makes him attempt the impossible, or at least the impractical. Weed invasion is natures way of saying, "don't get too smart, bud, 'cause you still have me to contend with!"

All these factors - soil chemistry, soil impermeability, over-dry, or over-wet conditions, poor management and unadapted varieties all reflect on man, since he can control them to some degree.

The battle against weeds will never end as long as man forgets the basic principles of What Makes Grass Grow and relies simply on the artificial killing of weeds. The old saying is still true, "The best weed control is just good turf!"

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PRINCIPLES IN APPLYING CHEMICALS

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Chipman Chemical Company, Chicago, Illinois

When one first considers discussing the principles in applying chemicals to turfgrass areas, one might think that this well-known topic about which considerable has been written, could be summed up in two or three minutes with one or two well-chosen sentences. But, upon a little deeper consideration, it is realized that there is a lot that could be said, for as often as these principles have been worked over, it is of value to review them every once in a while. We all tend to overlook the obvious.

General Considerations

In making an application of any chemical to turf, we have three factors: equipment, the chemical, the man. To elaborate a bit -

Equipment - it goes without saying that good equipment is a necessity. When replacing current equipment, or buying new equipment, it is most important to buy the best that one can get, not only in terms of workmanship, but to make sure that it is properly selected and designed for the job that has to be done. In this area of consideration there is nothing one can think of that would make a poor job than an under-powered, or over-powered spray rig with an improperly rated pump, hose, pipe and nozzle.

The chemical - Be it a fertilizer, a fungicide, a herbicide, or an insecticide, it must be selected to do the required job. For example, one would not use a pre-emergence crabgrass killer a week after the crabgrass seedlings first emerged, and one must be sure that the selective herbicide chosen must be active on the pest plant in question. Far too often the chemical is blamed for poor results when the recommendations for the use of that chemical are not followed. This points up to the old familiar slogan - "READ THE LABEL"too often is taken for granted. Further, federal regulations require that products be useful and the recommendations factual. Follow the directions then and use correct rates. Check also for those rates recognized by local authorities.

The chemical selected must be properly formulated so as to be most useful. A cheap or poorly made emulsifiable concentrate could precipitate and clog nozzles and screens. The "down time" to correct this situation would cost more than the money saved on such a formulation.

A dusty granule could cause leaf burn from the dusty particles, or an uneven granule would flow through the equipment unevenly, causing "skips" and "misses", or over-concentration and "hot spots."

The man doing the Job. Does he understand his equipment? Does he understand the chemical? Is he aware that too little, or too much will be a waste of time and money, or cause injury? The superintendent tells the foreman who tells the worker. Do all understand? Is he trustworthy? Will he shut down when trouble occurs, or will he keep on going no matter what? Does he know enough to shut down? Keep educating and checking your personnel.

Now, let's be a bit more specific. You have a quality piece of equipment; a properly selected chemical for the job; trained and conscientious man to make the application. So far so good. What do we do next - crank it up and go out and do the back nine fairways? Not quite so fast!

Is the equipment in good working order? When was it checked last? Is the spray tank clean? Are you sure? Better look. An old gallon or two of another chemical on the bottom could cause trouble. Are the calibrations right? Worn nozzles pass more gallons per minute than new ones. Pressure regulators tend to stick a bit. Worn gaskets leak causing pressure losses. Classify this as "mental maintenance" as much as physical. Calibrate your sprayer, or spreader regularly, following the manufacturer's directions.

Buy or use a good speedometer, throttle setting vary depending on the engine tuneup.

Check the nozzles and screens; new nozzles are cheaper than a poor job.

If possible make applications from two directions, putting on each one half of the total in a criss-cross pattern.

General Maintenance Considerations

In season, prepare and use a check list system for mechanical upkeep, and insist on a clean and orderly shop. Out of season clean and put equipment away properly, oil all moving parts, drain, flush and clean spray tanks, loosen up on fittings, replace worn parts in the fall - not in the spring. We are all too busy in the spring to do these things. Last but not least, recalibrate before putting equipment back in operation.

SUMMARY

No. 1 - Good equipment - properly understood as to what it will do and what it won't do.

No. 2 - Good chemicals - properly selected for the job and properly used.

No. 3 - Good manpower - properly trained and properly responsible.

The chemicals we are using today, and even more so in the future, are getting more and more sophisticated and more and more expensive. We cannot afford improper applications because of the danger of injury to desired grasses, or poor control of the weed, or the economic losses.

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WATER - AMPLE AND AVAILABLE

Tom Mascaro, West Point Products Corporation
West Point, Pennsylvania

Recently a National Broadcasting Company Special featured a story of the water problem along the Colorado River. The feature was entitled, "The Trouble With Water -- Is People." This was indeed a fitting title. Certainly we, as a nation, have not been wise enough to forseė the demands for this generation. Let us hope that we can plan now to insure adequate water for the coming generations. In the meantime, we must cope with the problem at hand. One of the strong points brought out by the NBC's Special was the glaring fact that we waste more water than we usefully consume.

We in the turfgrass industry should seriously study this statement. When a water shortage occurs, golf courses, parks and home lawns become a prime target for criticism of usage. The people and the press demand that all turfgrass areas be denied water. Whether they are justified in this demand or not the health of the people comes first. But, such a demand is too one-sided. While everyone is demanding that water be denied to turfgrass areas, homeowners, industry and everyone else go right on wasting it.

There are many reasons for this attitude. Perhaps some are that the use of the water is so obvious and that the average person does not realize the tremendous investment in turfgrass areas. Since it is impossible to change this attitude of the public, we must make every effort to protect ourselves. We should make every effort to analyze our own water situations. This study should cover every phase of water supply and water management.

Insured water supplies can be created in the form of reservoirs and lakes. They not only enhance the beauty of the turfgrass areas, but they also provide us with water when the going gets tough. Lakes or reservoirs can be located to take full advantage of drainage water from the turfgrass areas.

Tile drains will conserve water. Turfgrasses over a well-drained area are deeper-rooted; therefore, will withstand longer periods of drouth. New tile lines should be installed wherever needed. Old lines should be checked to determine if they are operating. Silt and tree roots in old systems often render them useless.

Water can be conserved by cultivation of turfgrass areas. It has been demonstrated many times that run-off water can be reduced by 80% on turfgrass areas that have been cultivated. Through cultivation, not only are water reserves built up, but also a deeper root system is encouraged, which in turn can draw water from greater depths.

Thatch reduces water penetration. Its control is necessary to reduce run-off. Wetting agents are being used to increase water penetration. This has merit, except that many of us feel these materials should be used only to help us through a critical situation. There usually is a basic cause for lack of water penetration, and this, of course, should be corrected.

Water management ranks high in turfgrass culture. It has been observed many times that over-watering is more of a problem than under-watering. Soils containing an adequate supply of organic matter derived from grass roots are dynamic. They support roots and all the micro-organisms needed for healthy plant growth.

Soils expand when they are wet and contract when they dry. With the intelligent use of water soils can be made to expand and contract, thereby aiding aeration processes.

We have touched only the highlights of water management. We should continue research and education to help us reach a position where water is ample and available for all the things we would like for the enjoyment of mankind.

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AQUATIC WEED CONTROL

John E. Gallagher, Amchem Products Company
Ambler, Pennsylvania

The increased demand for recreational facilities has stimulated considerable research in the field of aquatic weed control. During the last five years, this public pressure has been responsible for greatly expanded research programs supported by state and federal agencies. As these programs become co-ordinated and begin to function more efficiently, we can expect to find concrete benefits in the way of specific recommendations for controlling weeds in lakes and ponds.

For the purpose of this discussion, it would be well to mention briefly some of the differences between aquatic and terrestrial weed control.

1. We are dealing with water, a different growing media. As a result, the plants differ in structure, having less complex translocation systems. We talk in rates of ppm (parts per million) rather than lb/A (pounds per acre) because many of the herbicides are used as total concentration treatments -- the whole body of water must be treated. Granular formulations of some herbicides are available and they are used on the surface area basis where normal pound per acre recommendations apply.

2. We must consider other uses for the particular body of water (unless completely land locked within the confines of your property) what potential dangers a herbicide treatment can cause to your neighbor's cattle, fish, or crops downstream.

3. The primary and alternate use for the water body. Fishing, boating, swimming, etc., all are factors to be considered before choosing a herbicide.

4. Check with your State Conservation Department to see if a permit is required.

5. Finally, some new weed control terminology must be learned and some new weed species identified. Just as in terrestrial situations, weeds vary in their response.

Aquatic weeds are classed as submergent, emergent, emergent floating, free floating, or marginal. This is a general classification and some weeds fit several classes. One additional group is the algae; one-celled plankton algae, filamentous algae, or the higher plant-like algae, such as Chara.

Aquatic weed control has advanced to the stage of having answers to some problems, but there are more limitations than with terrestrial weed problems.. We must be more exact in timing of applications and more accurate in rate of application. We must realize that plants growing in a water environment may be more difficult to wet with sprays.

Also, we must be aware of the factor called "contact time." By contact time we mean the period of time required for the chemical to be in contact with the plant. This is very short in moving streams and can be quite long in still ponds. Contact time can be quite critical if fish tolerance is important.

To summarize - the field of aquatic weed control is developing rapidly. Until it becomes more familiar to you, check with your college extension weed specialist before undertaking any weed control program.

This somewhat abbreviated listing of available aquatic herbicides can be used as a starting point to help solve your particular problem aquatic weeds.

Algae

Plankton and filamentous - (no satisfactory control for higher algae).

a. Copper sulfate 1 ppm
   Apply when water temperature is above 60°F
   (2.7 lb. per acre ft. of water = 1 ppm)

b. Endothal (aquathol) 1-5 ppm

Submergent Plants

There is a wide variety of submergent species and no one chemical will control all. An effective aquatic control program may use two or more chemicals over a period of three years.

a. Silver (2,4,5-TP)
   Liquid or granular. The most commonly available formulation is Kurosal. This is most effective when applied early in the growing season at rates of 25 lbs. granular, or 1 gal. liquid per acre foot.

b. 2,4-D
   This is the least expensive material for the specific weeds it can control. For submerged species such as milfoil (Myriophyllum), coontail (Ceratophyllum) or waterstar grass (Heteranthera sp.) use rates of 20-40 lb. active ingredient as directed.

c. Endothal
   Liquid or granular. This contact acting herbicide is effective on a large range of submerged species and has a high degree of fish tolerance.

Free-Floating Plants

Duckweed

a. Diquat	0.5 ppm
b. 2,4-D ester	1/2 lb. in 5 gal. kerosene/A

Emergent Floating

Lillies, water hyacinth, etc.

a. 2,4-D granular	20-40 lb./A
b. Silvex, granular	20-40 lb./A
c. Amitrol-T (for water hyacinth)	1/2 - $1\frac{1}{2}$ lb./A
d. 2,4-D spray	6- 8 lb./A

Upright Emergent

Cattails - phragmites - rush

a. Amitrol or Amitrol-T	5- 10 lb./A
b. Dalpon	20 lb./A

EXCERPTS FROM ILLINOIS NATURAL HISTORY SURVEY
CHEMICALS FOR AQUATIC WEED CONTROL - SUPPLEMENT NO. 2, 1963

Table 1. Recommended dosages of various herbicides for the control of some aquatic plants.

Group and Species	Chemical Active ingredient or free acid equivalent	Rate of Application	Remarks
FREE FLOATING AQUATIC PLANTS			
Duckweed, Lemna minor	Diquat	1 ppm.	Apply as a fine spray to floating plants on surface of water
	Endothal (L)	1/2 cup/gal	
	Penco 47 (L)	0.5-1 ppm.	
EMERGENT			
Arrowhead Sagittaria spp.	2,4-D ester (20%)G	1 lb/430 sq.ft.	Spread on water
	ester (4 lbs./gal)	1/4 cup/2 gals	Wet foliage
	amine (4 lbs/gal)	1/4 cup/2 gals	" "
	silvex ester (4 lb./gal)	1/4 cup/2 gals	" "
	potassium salt 6 lbs/gal	1/4 cup/2 gals	" "
	potassium salt (20%) G	1 lb/430 sq.ft.	Spread on water
	Diquat (2 lbs/gal)	1/4 cup/gal	Wet foliage
Bulrush Scirpus acutus	2,4-D		
	ester (4 lbs/gal)	1/2 cup/2 gals	Wet stems
	ester (20%) G	1 lb/430 sq.ft.	
Cattails Typha spp.	Dalapon	4 oz/gal and 3 caps detergent	Wet foliage
	amino triazole	2 oz/gal and 3 caps detergent	" "
	Diquat	1/4 cup/gal + detergent	" "
	2,4-D ester (4 lbs./gal)	1/2 cup/gal + detergent	" "
Creeping water-primrose Jussiaea repens var. glabrescens	2,4-D		
	ester (20%) G	1 lb/430 sq.ft.	Spread on water
	" (4 lbs/gal)	1/4 cup/2 gals	Wet foliage
	amine (4 lbs/gal)	1/4 cup/2 gals	" "
	silvex		
	Ester (4 lbs/gal)	1/4 cup/2 gals	" "
	potassium salt (6 lbs/gal)	1/4 cup/2 gals	" "
	potassium salt (20%)G	2 lbs/430 sq.ft.	
	Diquat	1/4 cup/2 gals	Wet foliage

Group and Species	Chemical Active Ingredient or Free Acid Equivalent	Rate of Application	Remarks
Waterwillow			
Justicia americana	2,4-D		
	ester (20%)G	1 lb/430 sq.ft.	Spread on water
	ester (4 lbs./gal)	1/4 cup/2 gals	Wet foliage
	amine (4 lbs/gal)	1/4 cup/2 gals	" "
	silvex		
	ester (4 lbs/gal)	1/4 cup/2 gals	" "
	potassium salt (6 lbs/gal)	1/4 cup/2 gals	" "
	potassium salt(20%)G	1 lb/430 sq.ft.	
	Diquat (2 lbs/gal)	1/4 cup/2 gals	" "
SUBMERSED NON-POTAMOGETONS			
Buttercup			
Ranunculus spp.	Diquat	0.5 ppm	Apply below water surface
Coontail	2,4-D		
Ceratophyllum demersum	ester (20%) G	3 ppm	"
	silvex		
	ester (4 lbs/gal)	2 ppm	"
	endothal (5%) G	3 ppm	"
Water milfoil	2,4-D (20%) G	2 ppm	
Myriophyllum spp.	silvex		
	ester (4 lbs/gal)	2 ppm	
	potassium salt (6 lbs/gal)	2 ppm	
	potassium salt (20%) G	2 ppm	
	Diquat	1 ppm	
	endothal (5%) G	3 ppm	
Waterweed			
Elodea canadensis	Diquat	1 ppm	
Slender naiad	Diquat	1 ppm	
Najas flexilis	2,4-D ester (20%) G	2 lbs/430 sq.ft.	
SUBMERSED POTAMOGETONS			
Curly leaf pondweed	Diquat	0.5 ppm	
Potamogeton crispus	endothal (L or G)	1 ppm	
Fineleaf pondweed	Diquat	1 ppm	
P. pusillus	endothal L or G	2 ppm	
Leafy pondweed	Diquat	0.5 ppm	
P. foliosus	endothal L or G	1 ppm	
Sago pondweed	Diquat	0.5 ppm	
P. pectinatus	endothal L or G	1 ppm	
	Penco 47	1 ppm	
FLOATING-LEAVED AQUATIC PLANTS			
American pondweed	endothal	1/2 cup/gal	
P. nodosus	endothal G	1-2 ppm	
ALGAE			
Chara spp.	Penco 47 G	2 ppm	
Filamentous	Penco 47 L	Manufacturer's recommendations	Apply to floating algae mats

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BASIC PRINCIPLES WITH PHOSPHORUS

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Phosphorus is one of the most important nutrients we have to consider. Few soils have enough available phosphorus so that some additions are needed for optimum growth. Soils in general are more deficient in phosphorus than any other single nutrient. This is probably the reason that the first commercial fertilizers used were phosphate fertilizers.

Phosphorus is an essential element in the nutrition of the plant. It is connected with utilization of starches and sugars. In fact, when plants are phosphorus deficient the starches build up in the plant and we get deficiency symptoms showing on the plants. Phosphorus is important for cell division and plant growth. Plants that are phosphorus deficient are slow growing and mature late. Phosphorus in the plant is found in the new growing tissue or meristemalic regions. Studies have shown that the phosphorus concentration in these regions may be 1000 times that found in the older cells in the plant.

Phosphorus is important for supplying energy for the biochemical processes within the plant. The high energy phosphate bond of ATP. adenosine tri-phosphate is a key factor in the biochemical reactions necessary for plant growth. While phosphate is very important to get a young plant started, it is also very important in providing adequate growth in the more mature plant.

Most soils are phosphorus deficient. Phosphorus is present in the soil in a number of slightly soluble compounds. These are aluminum phosphates, iron phosphates and calcium phosphates. In soils with appreciable organic matter we can also have a lot of the phosphorus present as organic phosphates. The total phosphorus in a seven inch layer of topsoil may vary from500 to 2000 lbs. per acre with many soils having about 1000 pounds. Much of this is in minerals which release almost no phosphorus for the plant.

We may have 200 lbs. of organic phosphorus. This becomes available when micro organisms break down organic matter, but this is a slow process and doesn't give us much. We may have 200 pounds present as calcium, aluminum and iron phosphates. These are the compounds that slowly release much of the phosphate that the plant gets. Besides this we have some phosphorus in the soil solution. We measured this on 135 Midwestern soils and found that many of them had about 0.05 ppm in this water that meant there was only 0.02 pounds per acre of phosphorus present in the soil water. Now, most plant species need 15 to 25 pounds of phosphorus per year (this is P not P_2O_5). Hence the amount in solution would supply very little of the plant's need. The plant removes what is in solution and then more comes into solution. This is the process by which most plant species get their phosphorus.

At this point I would like to tell you about some research that we have done which shows that the phosphorus only comes from the soil adjacent to the root. Because the water content of the soil is so low in phosphorus, the amount brought to the roots as the plant absorbs water is only about one percent of the plant's needs. The plant roots also grow to some phosphorus, but they can only grow to that amount in soil equal in volume to the volume of the roots.

Now roots occupy only about 3% of the soil's pore space, so that not more than 15 or 20% of the plant's need for phosphorus is obtained by the root gowing to it. Thus, diffusion is the process by which phosphorus reaches the root from the soil. Diffusion is a very slow process and it occurs because root absorption at its surface lowers the concentration in the soil at that point and phosphorus moves slowly to the root along this gradient. Phosphorus diffusion is very slow because the soil holds onto phosphorus very tightly. So that the way we make phosphorus more avaiable is to increase the amount of soluble P in the soil. This increases this gradient and more reaches the root.

Phosphorus is an anion, it has a negative charge. It has three negative charges. We call it trivalent. These charges must be balanced with some cations. When they are balanced with hydrogen we have phosphoric acid. When one is balanced with calcium and two with hydrogen we have monocalcium phosphate. This is the phosphate in superphosphate fertilizer. It, like phosphoric acid, is water soluble. When we balance two of these charges with calcium and leave only one balanced with hydrogen, we have dicalcium phosphate. This is also present in some fertilizers. It is less soluble than monocalcium phosphate. When all three negative charges are balanced by calcium we have tri-calcium phosphate. This is a very insoluble phosphate and is the form that we mine phosphate as. Rock phosphate is tri-calcium phosphate. In manufacturing we add acids to the rock phosphate so that part of the three charges are balanced with hydrogen and we have a soluble and avaiable form of phosphate.

When we add a phosphate to the soil it goes into solution in the soil water, but the iron, calcium and aluminum in the soil quickly link up with it and replace some of the hydrogens. This takes the phosphate out of solution and we often refer to it as fixed. The soil solution will change very little in phosphorus content because P fertilizers have been added. Hence, phosphate does not leach. It does not move very far from where you put it. A movement of P of one quarter inch is a lot of movement of phosphorus in the soil.

Now we have added phosphate, it is not in solution, how does it increase phosphorus availability? It does this by the fixed phosphorus going into solution rapidly to replace phosphorus absorbed by the plant. There is very little phosphorus in solution, what the plant gets comes from that, that is present as calcium, aluminum and iron phosphorus compounds in the soil. Adding phosphate fertilizer provides more of these that can readily supply the plant as it depletes the phosphorus at its root surface.

Plants rarely use more than 10 or 15 percent of the added phosphorus in the first year. Since only that phosphorus near the surface can get to the root and the root only occupies three percent of the soil, it is not hard to see why this is so. Hence, we add phosphorus which will be used in future years. One problem is that when phosphorus is first added the compounds formed in the soil readily go back into solution. However, with time these phosphate particles may get iron and aluminum oxide coatings and the availability of the phosphorus is reduced. Thus, on some soils which fix a lot of phosphorus the phosphorus must be added more frequently.

Phosphorus fixation is frequently measured in terms of what is available to a soil test. The oxide coated phosphate particles, or less soluble phosphorus compounds formed slowly, are not very soluble in soil test solutions, just as they are not very available to the plant root.

I would like to stress that phosphorus fixation has frequently been overemphasized. When we applied phosphate with a teaspoon it was important, but when we use a shovel and apply what is needed, fixation has much less significance. Placement has less significance the higher the rate of application. For a plant to be adequately fertilized the whole soil volume should be at an adequate level of phosphorus availability.

Since phosphorus doesn't move very far in the soil, it is important to consider heavy phosphate application when permanent sods are established so that the whole root zone will have adequate phosphorus nutrition.

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PRINCIPLES INVOLVED WITH RESIDUAL NITROGEN

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Hercules Powder Company, College Park, Maryland

This subject of Residual Nitrogen needs constant review before any audience of turf people. There is much more to be shared than is understood. In this talk I shall be speaking for the entire nitrogen industry. We have had more than ten years of experience with man-made residual nitrogen. What is experience?

"Experience is what enables you to make a different mistake the next time." Also, "learn from the other fellows mistakes - you don't have time to make all of them yourself."

Since 1927, when I started doing research on fertilizers for grass, there have been some remarkable developments, just as there have been in travel, communications and space flights. The developments with Residual Nitrogen have been profound, but, outside of a handful of dedicated organic chemists, research people, and some confirmed users, the principles of Residual Nitrogen are not well understood. My job is to help you gain a better understanding, to give you greater confidence to move ahead, and to enjoy the benefits of this technological development.

The term "Residual Nitrogen" defines itself to me as, "That nitrogen which remains unchanged in the soil after a certain growing period, constantly ready to continue furnishing food and energy to soil organisms when conditions are favorable for plant growth." I know right now that this explanation is not entirely satisfactory. I may have to resort to over-simplification to make my point.

Let's go back to the time the early settlers broke the prairie and planted crops. They did not need nitrogen fertilizer, or any other kind -- then. Their crops grew tall on the "Residual Nitrogen" that Nature had locked up in the soil organic matter (roots, stems, leaves of grasses). This N was delivered to the crops "on demand" by stirring the soil and providing a crop to utilize the N stored in the soil. Residual N at 16,000 lbs/A has been measured in deep midwest soils. Now that this storehouse of Residual Nitrogen is gone, chemistry tries to duplicate.

We have established one point--true Residual Nitrogen is <u>organic</u> in form. There is no mineral (inorganic) reserve of nitrogen. With minimum discussion we can rule out all soluble N materials. All of you know that soluble N doesn't last more than 2, 3 or 4 weeks at best; hence, the accepted "light and frequent" usage. The solubles do not furnish food and energy for bacteria, nor can they be stored in the soil ready to be released to plants "on demand." They are completely available almost instantly. They tend to degrade soils by breaking down aggregation. True, NH_4 groups can be held by clay particles, but the quantities so held are insignificant when we consider the true concept of Residual Nitrogen.

In Residual Nitrogen we are unalterably concerned with soil organisms and with organic sources of N. It is to our advantage to make conditions ultra-favorable to the soil microbes. Continued use of solubles has the effect of bypassing your helpers in the soil because soluble N feeds plants in a direct fashion. By and by the soil microbes have been literally starved out of existence. Imagine how you would feel if your chairman, the pro and the manager all went directly to your workmen and bypassed you! How long would it take for you to quit in disgust!

Residual Nitrogen is easier to explain by performance than it is with words. We will see a few slides shortly to help us in our understanding.

Organic nitrogen is of 2 kinds basically. (1) Natural organic, (2) Synthetic organic. The natural organic types, and there are several, are essentially accumulated residual fractions of plants and animals that had been used first for other purposes. Chemistry determines the content of the resulting product, but does not necessarily guide its formation. Natural organics have played a significant role in turf. They work with and through soil micro-organisms. They gave us the first direct step toward the understanding and utilization of the principles of Residual Nitrogen.

Soon after synthetic organics were developed about 20 years ago many studies were made whereby these organic N materials were compared for Residual Nitrogen. Considerable data have accumulated to show that the Synthetic Organics (ureaform by name) offer improved performance in encouragement of soil organisms in controlled release of N and in storage of Residual Nitrogen.

Let us stop right here for just a moment. Let me quote from some of the greatest authorities on soils. Norman, in Advances in Agronomy says, "The organic fractions constitute the vital and dynamic reserves of nutrients."

"There is NO mineral reserve of N."

"In a complex dynamic biological system there is no simple consistent pattern; relationships cannot be neatly defined in a single poly-syllable. The dominant factor is the energy supply."

Research data from USDA at Beltsville shows that ureaforms are an incomparable source of energy for soil organisms. Massive applications at the rate of 20,000 lbs. to the acre continued to stimulate bacterial activity. This leads us to the inescapable conclusion that Residual Nitrogen in the soil will be best achieved with N materials that provide the longest,continuous source of food and energy for soil microbes.

True Residual N, even though stored in the soil in great excess of the immediate needs of plants, never releases N in excess of demand, nor does it suddenly release large excesses because of changes in growing conditions. When growing conditions are unfavorable for plants they also are unfavorable for bacteria and thus the Residual Nitrogen just sits there, not releasing, but waiting unchanged until growing conditions are once again favorable for plant growth. Briefly, as you well know, favorable growing conditions include air, warmth, moisture, proper pH range, good soil. Change any factor in this complex system and adjustments take place automatically. This dynamic system provides the best way of maintaining control of the nutrient needs of grass. Simply keep the soil microbes adequately supplied with their growth needs and they will furnish nutrients to plants "on demand." At the same time the microbes help to create more favorable physical soil conditions through aggregation.

To understand how a manufactured nitrogen material can provide Residual Nitrogen in the soil, we should take a look at how a synthetic organic (like ureaform) is made. Soluble urea is reacted with formaldehyde solution under precisely-controlled conditions. The resulting product is Ureaform. It is a mixture of molecules of varying size and complexity. Technically, these molecules are called polymers (many molecules). Solubility of these molecules ranges all the way from completely soluble to completely insoluble. This is basically the secret of controlled availability, Reserve, or Residual Nitrogen. In the soil the microbes, even as you and I, will take the line of least resistance and attack the smallest molecules first, the easiest ones to assimilate. In 3 weeks they will have utilized, and passed on to the grass, about 15% of the Nitrogen in the material. After the small molecules are gone, the only source of food and energy are the more complex molecules. These are more difficult to "chew up", but, the bugs keep right on working. It may take them a year or more to digest the most difficult, but, in the end, they convert about 95% of a good ureaform to a useful Nitrogen for the grass. This is an extremely high efficiency curve. Meanwhile, there is virtually no loss through leaching or volatilization.

Speaking for the Nitrogen Industry let me set the record straight on a phase of Residual Nitrogen. No one ever need fear a Reserve of ureaform Nitrogen in the soil. Unlike some less stable forms of Nitrogen, an accumulation of the less soluble portions of ureaforms is totally incapable of sudden explosive release. I've worked with ureaforms since 1945, probably longer than anyone here, and I have yet to see this happen. Turfgrass superintendents have today a most wonderful opportunity to utilize fully the advancements of a century of fertilizer technology. Residual Nitrogen can be stored in many turf soils for the manifold benefits to be derived from this sytem.

Readily-available nitrogen is at hand from several natural organic and inorganic sources to provide quick effect, to supplement periods when Residual Nitrogen temporarily may be deficient, and for the other benefits to be derived from these sources, particularly the natural organics. Each material has its place; each must be used in accordance with its qualities and characteristics.

In summary - Residual Nitrogen from properly-made ureaforms is an established fact. This type of nitrogen is in wide use with absolute safety and with pleasing, long-lasting results. The slides showed examples of storing 8 pounds of actual N and 20 lbs. of N in turf soils with peffect safety and with rapid development of seedling grass. Color slides showed that residual nitrogen from ureaforms still feeds grass 2, 3 and 4 years after the final application. Actual field results, recorded with the camera, lent substance to the foregoing remarks.

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MAINTAINING NUTRIENT BALANCE

W. H. Daniel, Turfgrass Specialist
Purdue University

Papers prepared by Dr. Grau, Barber and Nelson on N, P, K respectively give you much background. May I summarize and suggest a course of action.

First, I believe in a Philosophy of Adequacy. Keep within the rootzone where active roots are growing, ample supplies of all nutrients - save Nitrogen. Then, adjust nitrogen to produce the growth wanted. For example, one turf manager said - "If the greens don't respond to nitrogen I know they are short of potassium. Thus, most apply fertilizer by season and need. Records help immensely even though weather may change and vary by one month - cold spring, warm spring, etc.

Nitrogen - Before each application determine:

1. The response wanted (quick, lots, fast, slow, gradual, reserve)
2. The supply already in the tissue
3. Currently available in the rootzone.
4. Reserve in the rootzone, which may become available
5. Soil temperature and moisture supply

Only then can the wise use of a preferred form, rate and procedure be achieved. Many excellent blends, coatings, natural, organic, synthetic are available.

General rates and ranges suggested annually as lbs/1,000 sq.ft. are:

	Greens	Irrigated fairways and lawns	Average lawns
Nitrogen	6 -10	3 - 6	2 - 4
Phosphorus	1 - 3	1 - 2	0 - 1
Potassium	2 - 5	1 - 3	1 - 2

Phosphorus - Barber pointed out that 1/10 lb. of actual P in the soil solution of an acre is near normal. Also, that by diffusion 95% of P used is gradually absorbed by roots. This explains in part why added P shows readily in plant response when needed. Also, why a fibrous rooted perennial may do well even with low phosphorus supply. In fact, when P has been applied to a turf area three times a subsequent deficiency is almost unexpected. In summary, keep enough, no need for big applications, but maintain adequacy with light annual applications.

Potassium - Nelson reviewed and illustrated Potassium needs. Again, plan an adequate reserve supply, but it requires more. Golf course superintendents having soil testing done have found they can increase K from low to medium in one year by extra applications. Also, they can drop one level (from high to medium) in one season. Thus, twice annually, or monthly applications are recommended for K on greens.

Fortunately we have some excellent turf fertilizers in many forms and formulations. Their ample and wise use in repeated applications to maintain a background of Adequacy involves both technology and tedium.

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NOTES FROM SOD GROWERS DISCUSSION

March 5, 1963

Approximate attendance by states: Ohio 12, Michigan 5, Indiana 2, Illinois 22, Wisconsin 5, Missouri 3, Nebraska 1. Richard Craig presided.

M. P. Britton of the University of Illinois reported the approximate thirty attending the G.C.S.A. meeting in San Diego were largely from California and Northwest area. Major interest and discussion was on certification of sod:

a. What states are contemplating sod certification? California and New Jersey are taking steps.
b. How practical and feasible is certification? Probably limited to purity of strain and noxious weeds.
c. Agreed to hold another meeting in Philadelphia in 1964.

Britton reported growers were concerned that seed provided be quite pure and free of unwanted weeds. Ben Warren reported on New Jersey meeting (of sod growers) and felt they were considering a program giving some protection against uncertified. Also, he stated that most certifying programs had been with vegetative increase - as stolons of Bermuda, bent, Zoysia. Britton mentioned that certification is basically trueness to type and absence of noxious weeds with disease, a variable changing expression, which is not easy to certify. Warren said California sod growers were required to sterilize soil for certification. Jim Latham pointed out Georgia was successful, while Florida with a more restrictive program has poor cooperation.

Daniel asked group what species of grasses, weeds, insects or diseases should be of concern in certification of sods in Midwest. Golden nematodes, Japanese beetles, white fringe beetle, and recently the cereal leaf beetle into northern Indiana and southern Michigan may be problems. All USDA and state nursery restrictions should be of concern.

Daniel passed out copies of uniform turf evaluation program to those attending (additional copies are available upon request). This attempts to work with both private and public turf selections. It is similar to corn, sorghum and alfalfa test program.

Ontario sod growers have 5 categories of sod, but sell only better three. The specific classification is left to individual grower. Either grower, or placer, may claim designation felt justified.

Daniel reviewed Evansville bentgrass release (5 growers - Warrens, Links, Godwin, Chester Hybrids, Boggs, in 1963 are growing stolons under certification) and limited testing. About 20 locations have test plots. First stolons available in fall of 1963.

Midwest zoysia release consummates 10 year selecting program. Out in 28 locations by 1963. Distribution to be through Agricultural Alumni Sod Improvement Association, Hy. 52, N.W., West Lafayette, Indiana. Limited supplies for midsummer distribution in 1963 by priority.

Richard Craig - as possibility of vegetative bluegrass - some sod growers would be interested. May be route for dwarf varieties. Warren, Latham and Britton pointed out all new varieties should be adequately tested under use intended before release. These brief notes assembled by Lobenstein and Daniel.

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