PROCEEDINGS

of

1959 TURF CONFERENCE

Sponsored by the

and

PURDUE UNIVERSITY

LAFAYETTE, INDIANA

March 2 to 4, 1959

PROCEEDINGS OF THE
1959
MIDWEST REGIONAL TURF CONFERENCE

The 38 articles included in these Proceedings are condensations of talks by speakers before sections and divisions of the 1959 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 1956 and 1958 Proceedings are available at price below.

A copy of these Proceedings were mailed to:

1. The 537 attending the 1959 Midwest Regional Turf Conference.
2. One person of each Member Organization in the Midwest Regional Turf Foundation not attending 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	277
Turf materials & supplies	115
Sod & Landscape Service	63
Parks (most have golf courses)	12
Industrial Grounds	15
School Grounds	8
Cemeteries	11
Non-profit & Universities	36
Total	537

Distribution by States

Indiana	133
Illinois	173
Ohio	100
Michigan	40
Wisconsin	32
Kentucky	18
Missouri	18
Outside Midwest	23
Total	537

Attendance by area represented by the 13 Golf Course Supts. Ass'n.

Midwest	132
Indiana	80
Northern Ohio	32
Cincinnati	30
Miami Valley	18
Central Ohio	20
Mississippi Valley	22
Wisconsin	32
Michiana	29
Kentuckiana	27
Central Illinois	32
Michigan	26
Western Michigan	7
Outside Midwest	23
Purdue	27
Total	537

TABLE OF CONTENTS

STUDENT TRAINING AND DEVELOPMENT

Raymond P. Freeborg, Senior, Turf Management
Purdue University

A student in Turf Management has two areas of development at Purdue University. One is the academic training which includes required course work. The other is the practical training in establishing and maintaining the turf plots at Purdue and in the field during the summer months.

Academic training involves a four year program. At its conclusion a degree of Bachelor of Science in Agriculture is awarded to the student. In earning this degree he must meet a minimum requirement of 136 credit hours. To meet this requirement he must take an average of 17 credit hours each semester, or 34 credit hours each school year. These credit hours are made up of individual courses, each valued at from three to four credit hours.

Here we have a list of the suggested courses relating to Turf Management offered at Purdue University. Those marked "R" are required courses and must be taken by the student in the turf option. The unmarked courses are electives. A student may select approximately one-third of them, whichever are of most interest, to complete his requirements.

Turf Management Courses

Agricultural Engineering

Elementary Drawing for Forestry Students
Farm Structures
Agricultural Tractors & their power Units
R Drainage, Irrigation & Erosion Control
Farm Tractors andEngines
R Agricultural Lectures

Agronomy

Crop Production
Grain & Forage Crops
R Soils
R Soil Fertility
R Genetics
Agricultural Meteorology
Soil & Plant Analysis
R Soils and Crops Seminar
R Turf Management
Field Crops Breeding
R Crop Ecology
R Soil Physics
Soil Classification & Survey
Intermediate Soil Science
Special Problems

Art & Design

Basic Design
Basic Drawing

Bacteriology

R Bacteriology

Biochemistry

R Agricultural Chemistry
Plant & Animal Biochemistry

Entomology

Introductory Entomology
R Fundamentals of Applied Entomology
Theory & practice of Economic Entmol.
Insecticides Formulations & Appliances

Geology

Physical Geology
Historical Geology

Government

Introduction to Government
Elements of Democracy
International Relations

History

Early Civilization
The United States & Its Place in World Affairs
History of Indiana

Horticulture

Introduction to Hort. Science
Floriculture
Landscape appreciation
Nursery Management
Greenhouse Management
Plant Protection

Industrial Management

Industrial Sales
Small Business Management

Mathematics

R Algebra
R Trigonometry
Analytic Geometry, Differential Calculus
Analytic Geometry, Integral "

Botany & Plant Pathology
R Introductory Plant Pathology
R Weeds and Weed Control

Chemistry
R General Chemistry (two semesters)
Introduction to Qualitative Analysis
Introductory Quantitative Analysis
R Organic Chemistry

Economics
R Principles of Economics
Introduction to Accounting & Cost Accounting
Personal Finance
Legal Background for Business
Business Law
Insurance Principles
Land Economics

English
R English Composition I
R English Composition II
Introduction to Literature
Agricultural Writing
Business Writing

Military Science
R Two years for able-bodied non-veterans

Physics
R Outline of Physics for Ag.students

Plant Science
R Introduction to Plant Life
Agric.Application of Plant Science
R Introductory Plant Physiology
Taxonomy of Seed Plants
R Ornamental Plants
Introduction to Plant Anatomy
R Intermediate Plant Physiology

Psychology
Elementary Psychology
Psychology of Sales & Advertising

Sociology
Introductory Sociology
Urban Sociology
Marriage & Family Relationships

Speech
R Principles of Speech
Business & Professional Interview

Zoology
R Biology of Animals

There remains the practical training of a student in Turf Management. This area of student training is divided into two groups. The first is a summer training program.

Each student is expected to work at least one summer, and preferably two, in some activity related to Turf Management and maintenance in order to acquire experience, an understanding of the practical problems involved, and a practical ability to solve these problems.

The second area of practical training is found here at Purdue. This requires that a student work with Dr. Daniel on the Turf Research Program as student labor. The student aids in maintaining the experimental plots at the Agronomy Farm, the experimental putting green and in the greenhouse. In this work a student is gaining experience in turf research, a background in the grasses and their maintenance, plus responsibilities for some of the research program.

To further develop a student's background and to assure him of definite responsibilities, a student, with his counselor's approval, may take a special problem in Turf Management where he conducts specific research. Some of the work done as a special problem includes a project in development of turf research program as a combined summer field project and special problem. Other special problems include work on effects of oxygen on bentgrass roots by John West, Zoysia breeding by Dick Trevarthan, golf course construction by Dick Dobis and arsenic toxicity to varieties of grass seeds.

The academic training, the practical training, including summer field work and work on the research program, thus aids in preparing a student for future service to a community. He has spent four years learning why a job is done, including two years learning how to do many of these jobs. With this background a student is prepared to increase his knowledge by working with and learning from the men who have a wealth of practical experience.

PURDUE UNDERGRADUATE TURF TRAINING

Norman Goetze, Dept. of Agronomy, Purdue University

A steadily increasing number of students are seeking university training in Turf Management. Purdue's program is but one of several currently active in the country. This presentation will describe the training such a program provides.

Students majoring in Turf Management are associated with the Agronomy Departments, which is one of the twelve departments of the School of Agriculture. Of the 1300 undergraduates in Agriculture at Purdue, 130 are Agronomy students. Of these, 14 are currently taking Turf Management. In terms of total agricultural enrollment, the number of turf majors is rather low. When compared with other individual full four-year university programs, the number is relatively large.

Students entering the program as Freshmen usually have had some background in turf work and have come here at the recommendation of their superiors or associates. About half of our students enter the program as Sophomores or Juniors after they have been motivated into turf by contacts here on the campus. The first two years of study primarily involve background university training in Humanities, Science and Agriculture.

During Junior and Senior years the students take, in addition to turf, courses in Plant Physiology, Soil Physics, Crop Ecology, Genetics, Entomology, Plant Pathology, Weed Control, Agricultural Engineering, and Plant Taxonomy. Depending upon their interests they may elect courses in Personnel Management, Small Business Management, Psychology, Irrigation, Seed Technology, Climatology, Design, Geology, Nursery Management, Plant Protection and Economics. During the Senior year each student also completes at least one special research problem involving library, greenhouse, or field research on some turf problem. The student is expected to work rather closely with Dr. Daniel, or other staff members, to gain an appreciation of the research attitude.

At some time during their University enrollment the students are expected to gain practical experiences in turf maintenance by either summer employment in turf areas, or by working on the University turf research plots.

Since this program has a wide range of flexibility, we are able to give the student more nearly what he needs. The key to success of the program is the individual counselling of the student and assisting him in self-analysis. Once the student really finds himself, he is able to make his own decisions.

Graduates of the program eventually fill a variety of positions in the turf field. To date the majority of the graduates have become associated with turf product sales or turfmaintenance. Some have also advanced to further graduate training. Regardless of what position they fill, it is hoped they appreciate as much of the "why" as the "how."

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BUILDING GREENS TECHNICALLY

Leon Howard & Associates
P.O. Box 1245, College Station, Tex.

A desirable putting green soil is one with the CHEMICAL and PHYSICAL properties which will PROMOTE the growth of turf and RETAIN a good playing surface. The chemical properties are readily controlled with fertilizers and amendments, but the physical properties are not easily altered once the green has been constructed. Also, if the physical properties are undesirable, then the chemical properties are not as easily controlled as where the physical properties are ideal.

Player traffic and the use of high speed maintenance equipment subject the soil to constant packing. Also, the fact that golfers demand that the greens be kept moist enough to hold a golf shot serves to intensify the compaction problem. Compaction is an orientation and consolidation of the individual soil particles in such a manner that there is an increase in weight per unit volume and decreases are brought about in porosity and permeability.

If a clay soil is compacted, at the proper moisture content, it becomes very dense, while a sand, no matter what the moisture content, remains largely unaffected by compaction. From a physical standpoint, then, it would be desirable to have a soil composed of sandy non-compactable materials. However, for optimum growth, under ordinary conditions and a normal environment, plants require nutrients and moisture and that these things are provided by properties ordinarily attributed to clay and organic matter. The question, then for which we seek an answer is, "what sand-clay-organic matter RATIO will give us the desirable physical and chemical properties which will maintain maximum growth of turf under conditions where compaction is prevalent"?

Many variables are involved in answering this question. However, there are several factors which affect the response of a soil mixture which should be useful in evaluating the sand and clay materials for use in an optimum soil mixture.

The first factor to be considered is the TYPE OF CLAY mineral found in the soil. In most of our agricultural soils one of three clay mineral types may predominate. These are montmorillonite, kaolinite, and illite. There are such wide differences in the water holding capacity, swelling and plasticity levels between kaolinitic and montmorillonitic types of clay minerals that a knowledge of and determination of the type of clay mineral present is a pre-requisite to arriving at a suitable sand-soil mixture.

The second factor which should receive close attention is the TEXTURE OF THE SAND to be used. Sands available for green construction vary widely in texture (fineness and shape) and the water and air relations of the sand-soil mixture will be strongly influenced by the texture of the sand used.

In seeking an answer to this question as to what sand-soil-peat mixture will perform satisfactorily, we want a set of laboratory measurements with which to evaluate any sand-soil-organic matter mixture and determine its relative value as a putting green soil. In order to obtain such a set of laboratory measurements, a study was undertaken at Texas A & M in 1956. The work was supported by a fellowship grant from the U.S.G.A., Green Section. For this study an experimental green was built by what is considered

the best principles of putting green construction. These can be enumerated as follows:

1. Contour the subgrade just as the finished surface will be contoured. This subgrade or base should be 14 to 16 inches below the level of the putting surface.

2. Lay tile in a suitable pattern on the sub-grade in trenches deep enough to accommodate the tile. Water should not have to move more than 10 feet laterally to reach a tile.

3. Place a layer of gravel (1/4 to 1/2 inches in diameter) over the tile, and over the entire sub-grade. This gravel layer should be about 4 inches deep, but may be deeper over the tile itself.

4. It is not absolutely necessary, but is desirable, to place a layer of coarse sand about 1 to 2 inches in depth over the gravel. This sand provides a zone of intermediate texture which will prevent the migration of top soil mixture into the gravel layer.

5. After mixing, a suitable top soil mixture off the green site, place a 10 to 14 inch layer over the sand over gravel. Within the cup setting area of the green a minimum of 10 inches of loose soil mixture should be assured to provide adequate cup setting depth above the sand-gravel layer.

6. The new green should be sterilized with a suitable sterilant such as Methyl bromide, or Vapam to minimize competition from weeds.

7. Soil amendments, such as fertilizer and lime, should be added to the new green and worked into the surface. The rates at which those materials are added will vary with the area and the grass to be used.

8. After final grading and smoothing, the green is ready to be planted or stolonized. Care should be taken to insure that top-dressing is identical with the soil used in constructing the green, and be sure that top-dressing has also been sterilized.

In building the experimental green used in the study at Texas A & M, 4 soils and 3 sands were used in different ratios to give a total of 45 soil mixtures. These soil mixtures were placed in 30" x 30" plots with each mixture being replicated 3 times to give a total of 135 plots. The shoulders of the green were rounded off so that the finished green was about 40' x 60' in size.

To evaluate the response of the various soil mixtures, measurements were made on the experimental green and these were correlated with measurements made on the various soil mixtures in the laboratory. Measurements made on the plots of the experimental green included weight of clippings removed, and oxygen diffusion rates within the soil mixtures, visual ratings of turf density, vigor and color.

Laboratory measurements were made on cores of the various soil mixtures which had been compacted to a state similar to the soils under natural conditions. These measurements included capillary and non-capillary porosity, total porosity, permeability and bulk density. It was found that the capillary and non-capillary porosity and permeability measurements correlated very well with the clipping and visual rating data.

It was found that the response of any given soil mixture to actual playing conditions can be predicted by employing the techniques developed in this study and evaulating the results obtained for capillary and non-capillary porosity and permeability.

This, then, is one way to find the answer to the question proposed earlier, "what mixture should be used?" Only by taking the various components into the laboratory and making a careful study of them we can determine what ratio of sand-soil-organic matter will perform best in the finished green and thus take the guesswork out of putting green construction.

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COMMENTS - ON SOIL MIXTURES

Assembled by Editor to supplement previous Article

John S. McCoy, Supt. of Cincinnati Country Club, quote from letter of March 6, 1959 -

"Certainly one of the most discussed subjects was the soil mixture question brought out by Mr. Howard's talk and by others. I don't know whether I am ready to go along with him 100 percent. After we rebuilt our #8 green last year with a sandy base, we used a 7 - 3 - 2 mixture of sand soil and peat for topdressing. We were planning to (did not however) rebuild our #16 green last fall and sent samples of same sand, soil and peat to Mr. Howard for structural analysis. He recommended an 8 - 1 - 1 mixture. In the greenhouse this winter, we have the two soil mixtures with very thin plugs of C-7 and C-52 bent in them. The roots are going down in our 7-3-2 mix, but not in the 8-1-1 mix. I want to put in small plots of these mixes outside this spring and stolon them to see what they do."

Bob Dunning, Agronomist in Oklahoma. Recent writing include these sentences.

"It was thought a soil should contain a minimum of fine sands, be low in silt, and the clay content should be between 5 to 10%. Later -- during the forties the peat content was reduced to 15% by volume and the finished mixtures would be over 80% sand.

A description of Muskogee No. 820 sand (which has been used in Oklahoma -

Screen Size (Opening equal to 1 inch)	Retained on %	Passing through %
# 8	0	100
10	29	71
16	82	18
20	94	6
30	98	2

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BASIC CONSTRUCTION WITH HEAVY EQUIPMENT

M. Gruening, Supt., Midwest Country Club
Hinsdale, Illinois

One might call this a progress report on how we are trying to make Midwest a golf course. When I took over the job, the golf course needed a lot of work. It was built about 30 years ago with little thought given to things such as rotation of holes for successive pars, yardage, sand traps, green and tee design, blind shots and ease of maintenance.

My boss, Joh Polakovic, and I, decided we would try to rebuild Midwest Golf Course. Not only to rebuild the golf course, but also add another 9 holes to make it 36. We first decided to acquire the services of a golf course architect and chose R. B. Harris. He gave us an overall plan and a complete revision of the old course. This included plans for grading and dimensions for each green. Then we could see it on paper and believe me this makes a difference. We could plan a program and gradually have a golf course. I should add we needed a plan whereby the present golf course could remain in play without too much interference.

I am sure of one thing, in all due respect to my boss, who incidentally, I think is a good one. If I would have said to him before we had an architect, "John, let's take 15 ft. off the hill in the middle of No. 7 red fairway," he would have said, "Marv, you're crazy." But, a golf course architecht can suggest such on a half dozen places on the golf course and the boss will go along with him. In other words, whether it be the club owner, or chairman of the green committee, they will say, "Well, this fellow is a golf course architect; he must know what he's talking about."

In order to build a modern golf course you have to have dirt. You might tear up some turf on the golf course, but it is still the cheapest thing to do. Sure, dirt can be hauled into your course from the outside. But, fill dirt is costly unless a contractor is working very close and is looking for somewhere to get rid of it. We did have an occasion to get fill dirt once, but as a rule it doesn't amount to much when it comes to bringing a green or tee to grade. It takes a lot more dirt because traps are put farther from greens, and more thought is given to air circulation and water draining. Tees are also designed and built larger because of the great amount of play courses are getting.

After finding fill the next job was to get the dirt to new proposed green. With the program ahead of us, we decided it would be impossible every time we wanted to change a hole, green or tee, to call in machines and trucks. This was to be a five year or more plan. I think you men know contractors charge plenty just moving their equipment on golf courses, let alone doing any work with them. And to be very honest, we could not afford paying 15 to $ 20.00 per hour for a machine. So, we decided to buy our own T D 9 International crawler tractor with hydraulic lift and 1-1/4 yard bucket. We then could use the machine any time we needed it. If I had men free we could just go to work. We now have about 2500 hours on this machine.

The next thing we bought was two 2-1/2 ton trucks.

We first started a green that was going behind the present green that was in play. In other words, we did not bother the golfers. Whenever possible we stripped the sod off the area where the new green was going. It made the dirt much easier to handle later on the new green. If the sod was

good we always moved it to the previous green that we had just finished for trims around traps on banks, etc. We then scraped off all topsoil in the area and pushed it to the side. In all our work we tried to pick our fill dirt as close as possible to the green we were constructing to avoid hauling too far and making roads across complete golf course. I might add the biggest job is getting started, for as you men know, it can actually be real fun to see a new green take shape.

Now this equipment for one green or one area at a time was fine. The second year into our construction we found in order to change one hole we had to rebuild 4 other holes. This created a problem. The work could not be started until late in October in order to keep the golf course in one piece for the players as long as possible. As you can guess, 5 new holes could not be built with one tractor and 2 trucks by the following spring without temporary green for a long time.

We then got in touch with a company that did a lot of earth moving. With a not too great a distance to haul dirt, we decided on a 24 yard carryall, which was pulled by a D-8. Also, we needed a D-8 with a bulldozer blade one that could push dirt, and also push the carryall when needed in loading.

With these two machines we threw up the 5 greens and 3 tees in a short time. All we were interested in was to get these areas roughed in, the fill brought up to grade and then the black dirt put on top of the area. The fine detailed work could be done with our own machinery. Maybe we were lucky, but we made it. All I had to do the following spring was to sod the putting surfaces for we sodded the banks that fall. The dirt was taken off a hill in one of the fairways to give us dirt and also eliminate a blind shot. We did sod about 3 acres of fairway. By May 15 we had all but one of the greens in play.

But we were not through yet. Around the middle of November of that year, we decided to complete 9 new holes. We knew the weather would not hold out too long, but we wanted to move as much dirt as possible before winter,and take advantage of the greens and tees settling until the following spring. Included was a one-half acre lake to build.

I think one of the real important things we did that summer before was to plow up the complete area. It make the topsoil very nice to handle. This is the equipment that we had brought out. One 24 yard carryall loader to haul dirt for short distances, two D-8 bulldozers, one was used to push carryall, three D-6 loaders and 1 D-7 scraper. Also, for 5 days we had five 6 wheeler trucks which can haul about 10 yards of dirt.

Again the first job we did was to scrape all the topsoil wherever a green or tee was going to be located, or where a hill was to be removed. We had dirt piled all over 45 acres. We were fortunate the dirt was dry. We then proceded to get our fill dirt on greens and tees. With this kind of equipment the golf course took shape in a hurry. Within 3 weeks the golf course was completely roughed in. By that I mean the fill dirt was brought to grade and black dirt was back on all the areas and a lake dug. Work started December 3 and we finished December 19.

So you can see nowadays with the kind of machinery available, a job can be done in a comparatively short time. The important thing is to make sure you choose the right equipment for the job. Decide where your dirt is going and where it can be taken. Trucks can be used on long hauls, and when they are used start with only two and add more if needed. Big scrapers can

be used for short hauls - they move slower, but can carry a log of dirt. For a happy medium between the two distances small 8 to 15 yard Tournapuls can be used. These machines are mojnted on rubber tires, so do a lot less damage to your course, and are much faster. As soon as dirt is thrown up, get rid of the large machines. They can waste a lot of money trying to do fine grading.

If possible, when you are contemplating doing some work with big equipment, ask the contractor for an operator that knows what a golf course looks like. It helps. If you can get an operator to know what he is doing and what the green is to look like when he gets through, that's half the battle. Use plenty of grade stakes. A lot of extra work is done and dirt moved for nothing sometimes, just because an operator got lost between grade stakes. These men are used to building driveways, parking lots, diging holes for basements, etc. They are usually grading to level ground - when it comes to contours and grades it can be very difficult for them. I don't imagine there are too many fellows here who are going home after this talk and start rebuilding their courses. But, if I have given you an idea of what we have done and we are still doing at Midwest, I am grateful.

In conclusion, I might say when we first started on our remodeling program, the golfers would make the comment, "why did you remove that green Marv - it was alright." Now, the comment from people on the golf course is, "when are you going to do that green down on 7?" Naturally, some of the holes we haven't changed as yet just look out of place.

I'm not going to tell you that everyone who comes on the golf course is glad to see a pile of dirt on a couple of holes on the course. But, as a rule, most people went along with us, especially after seeing exactly what we were striving to do - give them a better golf course to play on. And again I say, the biggest job of all is getting started. I know in all my work there is a "Man" above who gave us an awful lot of help.

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USING A GOLF COURSE

Earl Yesberger, Owner, North Olmsted Golf Course,
North Olmsted, Ohio

Using a Golf Course is a loose and varying subject. Bill Daniel has left it up to my discretion as to what phases to discuss. I am not talking as an authority, but will endeavor to pick out a few of the major items that I consider earlier mistakes and tell why and what I am doing to correct these so-called mistakes on the golf course that I designed, constructed and now operate as a public golf course.

My background started, like so many other fellows, as a caddy, then on up through course laborer to Superintendent. If I may, I would like to quote several short proverbs that are food for thought, and my talk hinges on them.

1st. "The men who try to do something and fail are infinitely better than those who try to do nothing and succeed."

2nd. "I respect the man who knows distinctly what he wishes. The greater part of all mischief in the world arises from the fact that men do not sufficiently understand their own aims. They have undertaken to build a tower, and spend no more labor on the foundation than would be necessary to erect a hut."

3rd. "Failures come to all persons who strive to do something. They are the mark of the man who tries. Few persons without scars have ever been in battle. Our greatest glory lies, not in never failing, but in rising every time we fall."

4th. "It is not certain that a man can make opportunities for himself. But he can put himself into such shape that when opportunities come, he will be ready to take advantage of them."

In the building of my own golf course I made many mistakes - due to not having the professional knowledge in every phase of building - and there are many, such as: (1) golf architect, (2) Agronomy, (3) builder's knowledge, (4) drainage, (5) irrigation, (6) turf, (7) landscape, etc. It is practically impossible for any man to have the professional ability and knowledge of every phase of producing a fine golf course, thus the professional knowledge and services of these men should be considered in the building or redesigning of a golf course - a penny spent wisely saves dollars.

At the time of the building of my golf course about all I had was determination. I would like to list the many mistakes and costly problems that are incurred over a period of time due to lack of capital, knowledge, and not enough foresight at the time of construction to handle the great increase in present day play.

(1) Starting with the greens - they were constructed too small
(disadvantage) - turf does not have time to properly recover from heavy play in cupping areas, and too small a target for public play.
(correction) - costly job of rebuilding, or the frequent aerification and topdressing heavy on collars and approaches, seeding and cutting the green out as far as possible where desirable.

(2) Too much contour and slope to front of green-
(disadvantage) - slows up play by excessive putting, moisture content always higher in front of green than back, heavy or frequent precipitation causes water logged condition on apron.
(correction) - cutting greens higher in heavy playing season to slow ball up; frequent aerifying and installation of a fairly shallow drainage system from putting surface on out through apron.

(3) Improper soil texture in topsoil on greens when constructed -
(disadvantage) - they do not hold a ball well, unless consistently moist on top, ball marks show readily, and green putts very fast when top starts to dry out. Compaction and the loosing of the deeper root system in later part of July and August, the requirement of longer periods of watering with a very small sprinkler nozzle so as not to flood, and have a minimum of run-off.
(correction) - several years ago I installed a time clock in my pump house, used for turning my pump on and off. It has two cycles of on and off. For example, if I am going to water for 2 hours, I will set the clock to come on for 1 hour at desired time, then off

for 2 or 3 hours - then back on for the remaining 1 hour - watering with this method is very effective. I do not force the air out of the soil with heavy continuous application of water, and the greens are not soggy, they are firm for the early morning play. I have a snap valve in front of green and sod-cup in center of green.

I really shouldn't have said improper soil texture, because my belief is that superintendents from the time the first golf greens are constructed have debated on what is the ideal percentages of ingredients that constitute a lasting effective,physically constructed soil to maintain good turf on and withstand machinery and traffic of golfers. For the correction of the condition of my greens, of which the soil is a clay loam, I am and have been aerifying periodically and topdressing with a mixture that consists of about 60 to 70% of a combination of 2 textured sands, half medium sharp and half a medium coarse sharp sand - 10% humus, 25% clay loam.

(4) - Not enough ventilation in the vincinity of the putting green area due to trees
(disadvantages) - interference to golfers, a costly leaf problem, and slowing of play in the fall. Maintenance problems of shade, root cutting, tile lines, and after every storm, limb picking up and extra maintenance to keep good turf under trees.
(correction) - during construction I was an avid tree lover, just couldn't cut those beautiful stately elms around greens and even left a number of them throughout the fairways, which up to date, have been very costly and unsightly since most of them are in the process of being wiped out by the Dutch elm disease. I have thinned out and trimmed all trees high around green areas for ventilation and find it a great improvement and reduction in fungus attacks. Matured trees are beautiful, but if they are in the wrong location as far as good architecture and play is concerned, definitely make away with them.

I would like to make a recommendation to any person or persons interested or contemplating the construction of a golf course - - Don't get over-anxious to hurry up the construction! Rough in green, tees, cut and fills, roughs and fairways. Then install all irrigation lines and drainage system. Let complete roughed in golf course weather over one winter to settle, then complete the fine grading and continue to work all soil lightly all summer to keep weed-free until time of planting in early fall. It will pay greater dividends in the future operation.

Top Dressing Soil

Why do we have to spend costly time, labor and inconvenience of hand preparing our topdressing mixture? You all know that mixing of a shovel of this and a shovel of that, or whatever proportions you desire to mix, then stored under cover, practically bone dry and very little, if any, bacteria action taking place. Then when applied to a green it immediately separates back to the original materials used before the mixing. You have,no doubt, all witnessed this - humus and peat floating; sand, loam or clay separated after a good rain or watering.

My belief, and I have been doing it for the past several years, is by proportioning the mixture by truckloads of ingredients in a designated area where it can be easily tilled periodically by tractor. By knowing your existing soil texture and structure, by using the shaker bottle method, you can match the topdressing material by this method of adding more or less of ingredients used in the mixture.

You can professionally condition the soil chemically, by the addition of desired chemicals, such as, herbicides or sterilants, insecticides, lead arsenate and lime if needed. It is also possible to add small amounts of plant nutrients. My belief is, old mother nature does wonders in conditioning a soil out in the open with all of her organisms working hand in hand with climatic conditions, much more so than the soil under cover, and it will not separate as readily when applied to the green as topdressing.

I would like to comment on professionalism and encouraging an understudy. You must convey to your employes that they are a part of a business operation and that their job is vital to its operation. You need to impress upon your employes the word Professionalism. Without Professionalism today a superintendent is fast going to fall along the wayside.

In the days gone past, if an employe acquired too much knowledge, the Greenskeeper, as we called him, would fire this aggressive fellow because he thought this fellow was going to jeopardize his job. Today the feeling isn't that way. There is a great shortage of trained and qualified young men in the superintendent field and its allies. Today a professional man is given the title of Superintendent, and he is to watch over a golf course, not a greenkeeper working on it.

In encouraging an understudy - I have employed two young fellows the past several years. Both are enrolled at Penn State College taking the two year Turf Course this fall. I have encouraged and helped them whenever I could with the knowledge I have gained through schooling and practical experience. My advice to them was - the sooner they received a college education or technical training, plus their practical background working for me - they then would have qualifications to apply for a superintendent's position. The demand is getting greater each year for these young fellows with practical experience and professional schooling. The boys were home between terms and I certainly enjoyed conversing with them. They were pulling their technical terms on me, which I hate to admit - but it took me back about 20 or 25 years when I was going to the Turf School at Massachusetts State College.

Public Play Operation of Golf Course

I built the course with the thought in mind of keeping it as compact and efficient as possible, both from the maintenance viewpoint and accommodating play. The yardage is 2700 yards, par 34, and there is a nice clientele for this type of course. I have approximately 12 ladies' organizations playing on week-day mornings - Monday, Tuesday and Thursday. They number from 20 to 40 players in each group. I usually allow leages in the evenings only on Monday and Friday (men) because I feel the golf courses are getting like bowling alleys - no open play in the evenings because of leagues. I try to accommodate open play on Tuesday, Wednesday and Thursday evenings, and a great many of these people play the course several times a week and weekends, while most of the men leagues play only league night as they live a greater distance from the course. One thing I notice with men's leagues - they always seem to buy merchandise wholesale some place at a price you can't touch, where the regular player patronizes the Pro-shop much more.

The Club House is a very small building, but operates efficiently from the standpoint of location to No. 1 tee and No. 9 green. One person can operate the whole Club House from behind one counter due to the compactness of fixtures. I have a close speaking mike and a P.A. system from Club House to patio at No. 1 tee. Each player must register as he purchases a ticket and is then called onto the tee in foursomes, or foursomes make up through introductions.

Our No. 1 tee is visible through the window, so the person behind the counter or cash register can see when to introduce and send next group off the tee. The P.A. system has paid for itself many times.

In closing, I would like to quote another proverb - "If I supply you with a thought you may remember it and you may not. But, if I can make you think a thought for yourself, I have indeed added to your stature."

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WHY I SELDOM TOPDRESS GREENS

Wm. E. Lyons, Supt., Firestone C. C.
Akron, Ohio

Several years ago at one of our MRT Conferences, Dr. Fred Grau quoted the old Chinese proverb - "Profit from the mistakes of others - you will not live long enough to make them all yourself." Some of us are like the man whose wife asked him what the minister's topic was on Sunday morning. "Sin" replied the short-spoken husband. "What did he say about it," she asked. "He's agin' it", replied the husband.

We, like the minister, should all be agin' topdressing greens when we do not have the right materials at hand to do the job. Many times I have not topdressed greens only because we have not had the right materials.

In the early spring of 1942, before I was a GCS, I recall seeing greens that had been literally smothered with cultivated peat humus the previous fall. This material is commonly called muck by farmers. Unfortunately, I inherited this situation in 1945. It has haunted us ever since. There are no roots thru this layer of muck, except thru the holes put there by aerifying and turferating.

We have not been topdressing consistently because management has seen us do without it so long that we cannot get it back into our budget. Our aim has been to give our employees golf at the lowest possible cost and still have a course that management can be proud of. Another reason is that we have exhausted our topdressing supply and would have to purchase same. In brying it is difficult to get the right materials, or the same materials year after year.

If topdressing is done only in early spring and fall, then we cover the layer of summer mat. This forms an organic layer when it becomes decomposed. At the Canterbury Club, Cleveland, Ohio, the topdressing program has been excellent. The same materials have been used for the past 30 years. On another nearby course, over 30 years ago a 1/4" layer of trap sand was spread. It is now too deep for present day aerifiers to perforate, and it is causing trouble.

Penn State has made a very worthwhile contribution to our knowledge of thatch control. The plots we evaluated best were those that had been vertical mowed regularly, aerified 3 times a year, plus 3 topdressings per year. In his comments about this experiment, Professor H. B. Musser stated that certain strains of bents thatch more than others. He suggested rebuilding

those kinds of greens and use one of the newer proven strains of bent. Many clubs are now doing this.

Professor J. A. DeFrance at Rhode Island has done a long term study on the use of lime as an aid in thatch control. His work definitely shows that greens irrigation practices leaches the active calcium and magnesium from the surface area and in most places needs replacing annually. It is a standard practice in Rhode Island, Pennsylvania and Eastern Ohio to apply 25 lbs./1,000 sq.ft. of superfine dolomite lime in the late fall or early spring.

Keep in mind that the beneficial cellulose decomposing bacteria numbers are highest at pH 6.5. In fact 100 times higher than at pH 6.0. (See table 21. "Soil and the Microbe" by Wakesman and Starkey). The higher the amount of cellulose in the thatch, the greater the number of fungi when the pH is below 6.5.

J. L. Holmes of the USGA, Green Section, states that a golf green is built as an artificial medium in which bentgrass will grow well if properly managed. Current USGA specifications call for a good subgrade; 4" tile to outlet; blanket of gravel; topped with a blanket of sand; then a 10" layer of a mixture of 85% No. 1 concrete sand, plus 7-1/2% silt loam soil, plus 7-1/2% humus. How do your greens compare to this?

The point I wish to make is that we are not going to cure basic structural faults with a lot of expensive guesswork topdressing. We are going to have to show our clubs the facts and then get them interested enough to change a problem green or two at a time to get our courses up to par. Even though we have mechanized the job of preparing topdressing, we still have a cost of about $ 25.00 per cu.yd. laid down on the greens. Many of the experts agree that the materials we have all been using in the past contain too many "fines." These only lead to more soil compaction - the enemy of bentgrass roots.

Mr. Paul Truckenbrod, owner of Sunnybrook Golf Course, Kent, Ohio, was among the first in our acquaintance to recognize that too many "fines" in the soil are the major cause of soil compaction. Paul looked for the most uniform gritty material free from "fines." He found it 40 miles from home in an 8 - 16 (mesh per inch) silica sand. It is as uniform as buckshot. He has been using this material for the past 7 years and has improved the physical structure of the soil in his heavy soiled greens.

Larry Wolfe, Rosement Country Club, Akron, Ohio aerifies 4 times, vertical mows the plugs, then adds 1/2 yard of 8 - 16 sand and works this into the holes by brushing for about 45 minutes.

In conclusion may I make these suggestions:

1. Reduce the need for topdressing by daily mowing 3/16 to 1/4". Vertical mow once a week.

2. If thatch control is still a problem, then plan the topdressing program to use materials free from fines.

3. Select materials that will be just as available 10 years from now so that a consistent program can be adhered to.

4. Avoid mushroom bed soils. They make develop a serious "fairy ring" problem.

5. Sterilize topdressing to reduce weed seed contamination.

6. Rebuild problem greens rather than trying to topdress your troubles away.

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WHY AND HOW I TOPDRESS

John McCoy, Supt., Cincinnati Country Club
Cincinnati, Ohio

To topdress or not to topdress often depends on individual circumstances. Under my present conditions I prefer to topdress. My greens are old, most are of mixed seeded bent origin. The soil is heavy, layered, with internal draining only poor to fair. Putting surfaces of the greens average 4,000 sq.ft. My objective is to keep a smooth, dense putting surface, disease-free, uniform in color and density throughout the season and at the same time modify somewhat the present soil.

Our course is never closed. The putting surface may be impaired thru winter play, play when greens are soft following thawing, or just from continual use. When topdressing is applied, it is worked into the surface, filling the voids and smoothing the turf. It covers the undecayed vegetable material present in the lower part of the turf layer, and aids in its decomposition by introducing new soil organisms into the top soil layer. This breakdown keeps thatch from forming which is helped by topdressing. To me topdressing aids in control of diseases and may offset some of the ill effects from fungicide and insecticide materials used. With my topdressing program I use considerable less of these materials than when I topdressed only once or twice a season. Topdressing worked into the surface and deeper thru aerification methods has changed the surface soil in our greens, assisting in deeper and quicker water penetration, better movement of air into the soil and hence better and deeper root development.

It is our aim to topdress at least six times per season. The first dressing in March or early April, and thereafter about every four weeks. To maintain this schedule we prepare our material in advance so that the dressings can be applied in one day, Monday usually. Our operations are mechanized to a considerable extent.

Soil used is the best we can secure and is treated with nitrogenous material, such as sewage sludge (200#/cu.yd.), or cyanamid (13#/cu.yd.) to destroy weed seeds. This is allowed to stand several months (overwinter) before use, until all reaction is complete. For our sand and peat treatment is not necessary at present. Sand comes from our local pits, is medium in texture and quite high in calcium. We use ground sterilized peat. The materials are mixed with a Royer shredder and screened through a six msh per inch screen before application. There is no material to be removed from the green after applying.

The topdressing material is applied with a mechanical spreader, such as the Root spreader, using 0.5 to .75 cu.yd. per green, the amount depending on the time of year, temperature and condition of turf. (I might

say we expect to try a power driven spreader this spring.) This topdressing is worked into the surface by a power driven brush of our own assembly, brushing in two directions. This is a flat brush, not a rotary brush. The brush used has flat wire bristles approximately five inches long, the brush is four inches in depth or thickness and is four feet in length. This is attached to an Overgreen tractor with a depth wheel in the rear to prevent too much down pressure on the bristles as the nearer the bristles stand straight up, the better the job of brushing. No hand matting is done. Following the brushing, the greens are cut without using a basket and immediately hand watered.

In our first spring dressing we usually add lead arsenate and may add other materials, such as chlordane, muriate of potash, sewage sludge, or ureaform fertilizer. The last dressing in the fall also carries lead arsenate. The nitrogen in the topdressing is organically bound, so slowly available. During the summer months sewage sludge or ureaform fertilizer may be applied with a rotary seedcaster or spreader ahead of the topdressing, the brushing aiding in working these materials down into the tight turf.

Some superintendents say they cannot afford to topdress because of the high cost of labor. I do not believe the cost of topdressing is proportionately as high now as it was in past years when more hand labor was used in its application.

With our one day application of topdressing to our putting surfaces, there is little inconvenience to players. Since reverting to regular topdressings our greens have been easier to maintain, they keep a good putting surface, air and water penetration is improved, root growth is deeper, we have no thatch problem and there is very little wilting in hot and humid weather. And most important of all, the players are very happy with the putting surfaces.

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TURF DEVELOPMENTS

Ralph E. Engel, Associate Research Specialist in
Turfgrass Management, Rutgers University,
New Brunswick, New Jersey

The dynamic growth in turfgrass usage has been one of the striking features of the present day turfgrass field. In New Jersey, we completed a survey of turfgrass installations in 1955, which helped us realize that turf was one of our largest fields of agricultural endeavor. A short time later, California reported even greater unit costs than we obtained. At the present, we are checking the different turfgrass commodities with regard to areas and expenditures. It appears the totals for area, the annual maintenance costs and the installation costs have increased measurably since the survey. Yes, the vast growth in turfgrass demands and acreage of our metropolitan areas is a changing agricultural pattern.

The next great opportunity for change in the turfgrass field lies with research which will greatly change technical procedures. The formal experimentor will play the major role, but the professional turfgrass superintendent will continue to play an important part.

While the biggest changes in turfgrass management lie ahead, we would probably amaze ourselves if we would consider the changes that have been made since World War II. A complete knowledge of our commodity involves answers to many questions. Some of those we have obtained with our current activity in New Jersey follow:

Poa annua Control -- In 1952, we asked ourselves if any of the new herbicides could be used to combat annual bluegrass. We used all the chemicals of promise that we could obtain at that time, in both spring and fall treatments. We decided that endothal, maleic hydrazide, and sodium arsenite offered promise as spring treatments. As a result, we started large scale plots on a fairway at Canoe Brook (Jack Ormand's course). We concluded that endothal applied at a rate of 1/2 lb. per acre to a mixed turf in early spring successfully reduced annual bluegrass, eliminated clover and increased the bentgrass content. While our experience with endothal at other seasons was more limited,we were of the opinion that treatment at periods other than early spring were inadvisable. Also, use of a selective herbicide for annual bluegrass control is appropriate only when enough bentgrass is present to fill in for the plants elminated.

Creeping Bentgrass -- Creeping bentgrasses are frequently observed giving a fine performance at 1/2 or 3/4 inch turf. Yet, they are not commonly recognized for this use. How fast do they develop trouble when mowed at these cutting heights? Five colonial bentgrasses and four creeping bentgrasses were grown at levels of 2 and 4 pounds of nitrogen per 1,000 sq.ft. per year. Clippings were not removed. After five years the creeping bentgrasses had consistently better quality and were more aggressive in eliminating the weeds.

I do not recommend that New Jersey turf growers make a standard practice of selecting creeping over colonial bentgrass for 1/2 and 3/4 inch turf. However, where close-cutting, irrigation, adequate fertilization, cultivation and intensive maintenance can be practiced, the use of creeping bentgrass is appropriate.

Nitrogen Carriers -- Good turf can be grown with proper use of most carriers. Yet, it is known that great differences in precise use and behavior occurs. On occasions, an activated sewage sludge has shown authoritative indications of doing something more for the grass than merely provide nitrogen stimulation. Our own fungicide trials of some years past showed consistently less large brownpatch under a pattern of light steady fertilization with this type of carrier. Other reports of reduced disease incidence have been given. This feeling has been carried by a number of superintendents. We developed a study to determine the way some of the nitrogen carriers may influence disease.

The evenness of available nitrogen supply from a fertilizer will greatly affect the general health of the grass plant. Our results show that the insoluble carriers can give more even stimulation during the warmer periods of growing season. There is greater feasting and famine with the soluble as compared with an insoluble carrier.

Dollarspot ratings made on turf fertilized with several nitrogen carriers showed the activated sewage fertilizer treated plots developed less dollarspot. The results for the 1957 season were similar. Unfortunately significant quantities of other diseases did not occur during the two-year period of this test.

The relative growth stimulation of the several nitrogen carriers can be expressed by the clipping weights and color. The insoluble carriers, activated sewage sludge and ureaform, gave similar growth when useas as a repeat application basis. A tankage product gave less, but very steady growth similation. The season's total of ureaform applied in a single application compared with the same quantity in repeated application gave a surge of growth at the start and less growth at the close of the season. Besides nitrogen, other factors (temperature and moisture) affect the growth. In color ratings the performance of a given quantity of ureaform in a single application is not equal that of repeated application.

One of the results of nitrogen fertilization is the carry-over effect from one season to the next. Current tests showed some advantage in carry-over for the insoluble carriers. Ureaform in repeated applications and activated sewage sludge ranked first and second respectively. The single application of ureaform was no better than the repeat applications of ammonium nitrate.

Pre-emergence Crabgrass Control - Several chemicals are receiving attention for pre-emergence crabgrass control, but when is the proper time for applying these materials? Three tests were established in the winter 1957-58 to study this problem. Test 1 was on a mixed turf which is cut to 1/2 inch. Test 2 was 1/4 inch turf, and Test 3 was on fairway turf. Chlordane at 40, 60 and 80 lbs. per acre on granular clay, lead arsenate at 871 lbs. per acre, and an arsenical complex at 1350 lbs. per acre were used on all three tests. Chlordane at 40 lbs. on an organic carrier, and chlordane on vermiculite were also included in part of the series.

The results from applying chlordane preparations and the arsenate preparations at different seasons follows:

1. Chlordane gave best crabgrass control when applied during the period of mid-March to mid-April.

2. The lowering of the rate of chlordane from 80 to 60 and 40 lbs. per acre increased the need for specificity in the date of treatment.

3. Chlordane applied at 80 lbs. per acre gave the best and most consistent crabgrass control of the test treatments.

4. Chlordane on granular attaclay and vermiculite gave similar results at 60 lbs. per acre

5. The arsenical treatments generally gave their best crabgrass control with winter application. The crabgrass control produced by lead arsenate and the arsenical complex were unsatisfactory except for the latter when used on the first two dates of Test 2.

The pre-emergence crabgrass control that has been shown to date is convincing that good results can be obtained. However, we are not making a general recommendation for their use in New Jersey in 1959. We wish to obtain a better picture of the degree of success that can be obtained from their use and to know more answers pertaining to their use. We do not say turf growers should not use them, but we suggest they consider their pre-emergence efforts as trial work.

Lime and Phosphorus Penetration of Turf Sod -- Turf growers of New Jersey have great confidence in proper liming. My impression is that other growers are equally appreciative of good liming. On occasion we may ask ourselves, what do we accomplish by this respected practice? One value of lime treatments is improved drought resistance. This may lead us to ask about the mechanics involved in the slow penetration of lime. Note the lime has encouraged a rather steady increase in pH at the surface through the period of this test. In contrast note that liming had little or no effect on the pH at the 6 to 9 inch level during the first six years. These results show that considerable lime must be used over a period of time to produce the desired results. It is of interest to note that the limed series shows at 23 percent increase in growth in1958 over the unlimed.

We have been asked why the fertilizer should be mixed with the soil at the time of construction. The movement of phosphorus through the soil of established turf is very slow. Note that phosphorus movement into the 2 -4 inch layer did not change much until the sixth year. Incorporation of phosphorus fertilizer through the depth of tillage has the effect of developing a deeper soil at an earlier date.

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LOOKING EASTWARD WITH TURFGRASSES

Alvin G. Law, Agronomy Dept., State College of Washington[1]
Pullman, Washington

It is a privilege to attend and participate in your Turf Conference. You realize, of course, that the M.R.T.F. has established the pattern for Turf Associations all over the United States and Canada. That hardworking, outstanding group of traveling turf specialists, Noer, Grau, Wilson, Watson, Mascaro, et. al., that you have had an important hand in developing to their present proficiency, have indeed been successful missionaries. Most of you will remember O.J.'s barrel full of turf management principles, or Dr. Sharvelle's well earned title of "Super Duper Blight Buster" for his work with those "Tyrants of the Turf and Gremlins of the Green."

Your total turf program, sponsored jointly with Purdue University, is looked upon with respect and admiration by turf people throughout the United States. In my own area, the Pacific Northwest, we are dependent on the fundamental principles Dr. Daniel and his group are developing in the fields of disease and weed control, fertilizer use and soil management. Most of our turf research is supported in part by grants from the Northwest Turf Association. Cooperation of the Green Section of the U. S.Golf Association is also acknowledged. I would report briefly on some of this research.

Disease Control Research

Dr. C. J. Gould is doing extensive work with fairy ring, fusarium patch and red thread. We are blessed with extensive and intensive infestations of fairy ring fungus on the Pacific slope with lesser amounts on inland turf.[2] We have tried to fight this fungus disease in two ways -- suppress it, or try to eradicate it. Dr. Gould has tested many compounds, but only phenyl mercury acetate (PMA) has suppressed mushroom production

in at least a partially satisfactory fashion. PMA should be used at the rate recommended by the manufacturer in 10 gallons of water per 25 square feet. Applications should be repeated once per month until the mushrooms no longer appear.

The elimination of fairy ring is a costly and time-consuming procedure for us. The rings may be dug out to a depth of one foot, or as deep as the white mold appears in the soil and two feet beyond any diseased turf. The proper use of methyl bromide fumigation has resulted in elimination of the fairy ring for at least two growing seasons. This funigamt is poisonous and directions for its use should be followed closely. The general procedure Dr. Gould has used follows:

1. Treat in late spring or early fall when soil is moist and soil temperature is 60° F., or above.

2. Mow turf on the area short, punch holes two inches deep and two inches apart throughout the area.

3. Place gas-proof tarp, or plastic sheet over the area, extending 2 feet beyond the diseased turf. Raise tarp above area and seal edges in a shallow trench.

4. Release two lbs. of methyl bromide per 100 sq.ft. (use odorized form) through tubing into evaporating pans under the tarp.

5. Leave tarp in place 48 hours, then remove and let turf aerate 2 - 5 days before seeding.

Perhaps fusarium patch and snow mold have been the most serious diseases on turf in this Northwest area. Fusarium patch is responsible for over 90% of the spotting on golf greens on the Pacific slope during the fall and spring. It is least common in the summer. Snow mold may run rampant on greens east of the Cascades during the fall and spring months. It becomes even more severe if a mild winter occurs. Both types can be controlled by phenyl mercuric acetate (PMAS), or by mercuric chloride compounds. We use 1/2 to 3/4 ounce of PMAS every two or three weeks during the times of year when the disease may be serious. In preliminary resistance studies, Penncross and a selection of Seaside have shown the greatest resistance with Colonial and Highland bent most susceptible. Intermediate types included Congressional, Cohansey, Pennlu and R. I. Colonial No. 5.

Weed Control Research

Pearlwort and chickweed have received some attention as they are widespread in our area. Neburon has given best results in initial trials at rates of 4 - 6 lbs. of formulation carrying 50% active ingredient per acre. 50/59 mixtures of 2,4-D and 2,4,5-T will give fair control when used with a wetting agent, but not on greens.

Crabgrass is not serious with us except in two localized areas. DSMA used as described by Daniel in the 1958 Proceedings of the Midwest Conference has been successful when we have correct soil moisture and time of application. Annual bluegrass has been variously described as our best turfgrass and worst weed. It grows in association with bentgrass. Goss found no difference this past season in tolerance to lead arsenate between Poa annua and Agrostis tenuis. His rates varied from 5 to 80 lbs. of lead

arsenate per 1,000 sq.ft. mixed with the upper two inches of soil. We regularly use Karmex formulations, Endothal and CIPC to control annual bluegrass and other grassy seedlings in our field grass seed fields on the Pacific slope. Continued research will likely define rates of one or more of these safe to use on turf plantings.

Turfgrass Seed Production

Seed production of turfgrasses has become an important part of the agriculture of the Northwest. Table 1 shows the total production of turfgrasses in the Pacific Northwest. In Washington, turfgrasses made up 50 percent of our total grass seed production in 1958. We expect this industry will become more important.

One of the reasons for this feeling is illustrated in Table 2. These yields represent averages for a number of experiments. It is not uncommon to find yields in excess of 800 lbs. per acre for creeping red fescue.

Table 1. Turf Seed Production in the Pacific Northwest[3]

Year	Acreage 1,000 acres	Yield lbs.	Production 1,000,000 lbs.
		Merion	
1955	6.4	140	.8
1956	8.9	170	1.5
1957	11.7	190	2.3
1958	10.4	150	1.6
		Chewing Fescue	
1947-56 Av.	16.	270	4.4
1957	20.	390	7.8
1958	21.	280	5.8
		Red Fescue	
1947-56 Av.	6.5	310	2.1
1957	7.0	450	3.2
1958	9.5	320	3.0
		Bentgrass	
1947-56 Av.	17.	160	2.8
1957	28.	290	8.1
1958	26.	240	6.2

Table 2. Seed Yields of selected turfgrasses (average of several experiments and three years) Washington

Variety	Yield lbs. per acre
Olds. creeping red fescue	720
Pennlawn red fescue	620
Delta bluegrass	460
Merion bluegrass	270
Bentgrass (Astoria)	230

Basic to successful seed production is proper climatic conditions. Winter rainfall, dry harvest season, ample irrigation water, and adequate frost-free season are all factors contributing to high yields. The increasing number of growers, through study and experience, have become experts at seed production. They have made seed production their primary farm enterprise. The final link in this particular chain is the seed processor. The Northwest is blessed with a number of progressive processor-wholesale houses who are up to the minute on marketing, production and quality factors. The Agronomy Department at Washington State College initiated a seed technology course for students interested in learning the details of production, harvesting and processing of seed.

Possibly our greatest selling point for turf seeds is the emphasis on quality seed of varieties that are in demand. The certification program followed in Washington with its field and seed inspection requirements and its generation limitations is the best procedure yet devised to insure genetic and variety purity. A single example of how it works to protect consumer and producer alike will illustrate my point.

Pennlawn creeping red fescue was developed by Professor Musser at Pennsylvania State University. He bred into the variety quality factors, disease tolerance factors, and adaptation factors that make it superior to other fescues for specific uses. Ten pounds of Breeder seed (generation 1) was sent to the Northwest. Our Crop Improvement Association working with a leading processor selected a grower who planted 10 acres with the Breeder seed. This grower produced an average of 400 pounds of Foundation and (Generation 2) per acre each year. Thus, there was available 4,000 pounds of Foundation seed for redistribution to certified seed growers for planting to produce the certified generation (Generation 3.) This was sufficient seed to plant a thousand acres.

The certified seed is used only for turf planting and the bulk of it was made available to the consuming area where the variety was developed. Such a procedure illustrates two points: First, a relatively small amount of Breeder seed of a variety is needed. Second, a variety can be increased rapidly in an area favorable to seed production without losing its particular characteristics if it is grown under certification regulations.

Turfgrass seed growers must be good farmers. They must have clean fields. They usually plant the grass in rows and practice cultivation. They use dinitro and 2,4-D spray for broadleaved weeds and may use grass killers for the seedling grasses and annual grasses. They apply 60 - 120 pounds per acre each year of nitrogen to their fields, plus varying amounts of other fertilizers and amendments. They must be willing to do rogueing and even hand hoeing to remove off-types and inseparable weeds. They must follow rigid schedules for control of wireworms, timothy mite, sodwebworms and lesser insects. The result of these practices is high quality seed of varieites needed by the consumer.

Harvesting presents two problems -- high moisture content and seed shatter. Field combining has become the dominant harvesting method. To avoid serious shatter loss, most field are cut while the seed is too high in moisture. Various drying devices are used. The seed may be run through a scalper in the cleaning line. It may be spread on platforms and allowed to cure. Perhaps the most successful curing method is one devised by the Jacklin Seed Company. It consists of a large concrete platform in which electric cables have been embedded. Seed spread on

this platform will dry in a matter of hours and can be stored safely until it can be processed in an orderly manner.

We feel the eastern states are looking to us for high quality seed of the varieties adapted to the eastern area. We will continue to improve our production and processing procedure to supply this demand at a reasonable price.

[1]Paper presented at the 1959 Turf Conference of the Midwest Regional Turf Foundation, Purdue University, 1959.
[2]Washington Agricultural Experiment Station Circular No. 330, 1958.
[3]U.S.D.A. A.M.S. Annual Summary 1954-58.

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MICRO-CLIMATE AND BENTGRASS ROOTS

James B. Beard, Graduate Student, Purdue University

It has been known for some time that such factors as temperature, moisture, cutting treatment and light affect plant growth. However, the degree to which each of these factors influence bentgrass root growth under natural putting green conditions has not been ascertained. Controlled climate conditions showed the rate of root growth to not be significantly different in the 60° to 80° F. temperature range. But, above 80° F. the rate of root growth was reduced significantly. In terms of total root yield, based on organic matter content, it was found that as temperature increased the amount of roots was decreased. Results also indicated a sharp reduction in rate of root growth and in total amount of roots due to defoliation of the top growth. Thus, we can see that under close cut putting green conditions, we are exerting a great stress on the root system. Thus, any other factors detrimental to the root system will be more pronounced. In this case temperature proved to be very detrimental.

In order to further study the inter-relationships between the environmental factors and their influence on the plant, extensive studies were initiated on the Purdue experimental putting green in the spring of 1958. Soil temperatures were measured at depths of 1/2", 1-1/2", 3", 6", 12", 18" and in the turf mat. Also, air temperatures were measured at heights of 1", 12", and 36" above the ground. The 12" and 36" heights had an aluminum sun shade which eliminated any heating effect from the direct rays of the sun. The 1" height was unshaded and received the direct heating effect of the sun's rays similar to the grass leaves. Temperature measurements were taken with silver soldered, 22 gauge, 1938 copper-constantan thermocouples.

The thermocouple leads terminated in the junction box where they were connected to a 26 pair, stranded copper cable which was suspended across the street and into the Horticulture Building where the 60 point Speedomax potentiometer recorder was located. This instrument recorded each individual temperature 3 times an hour, or 72 times a day continuous throughout the summer period. All data was printed on moving charts.

Soil moisture was measured 3 times daily at depths of 1", 2", 3" and 6" below ground, using plaster coated nylon moisture blocks. It was found that the moisture level was maintained at or near field capacity throughout the summer period. Light was measured within terms of total units per day with a light integrator. All of the above measurements were replicated two times.

The plant responses measured included root number and root color which were measured twice weekly. Root color was measured by use of root observation boxes which were built into the putting green. They were 18" deep and had a slanting glass face which allowed observation of root growth in an undisturbed state. Ratings were taken of root color at depths of 5", 10", and 15" in terms of four categories: white, slightly brown, light brown and brown. White roots were active and functioning, while brown roots were shriveled and inactive. Core samples were also taken and counts of the number of roots were made at depths of 2", 5", 10" and 15" in the ground.

Top measurements were made by Edward Jordan, who was cooperating in this study. The tops were harvested three times weekly and yield determinations made on a dry weight basis. Determinations were also made of the N, P, K, reducing sugar, and fructose contents of the shoots.

Results

The data from all 38 variables was entered on IBM punch cards and a statistical analysis was made using the datatron, an electronic computer. Multiple linear correlation and regression determinations were made to determine the relationship between the various plant and environmental factors measured.

The first analysis was run with the root number at the two inch depth in the ground as the dependent variable. It was found that 85 percent of the variation in root number could be accounted for by just seven environmental factors. (Table 1.)

Table 1. The percent of variation in Root number that can be accounted for with 7 dependent factors.

Independent variable	%
Light	10
+ Soil temperature at 6" depth	48
+ Soil moixture at 2"	50
+ Air temperature at 36"	56
All 7 variables	85

The factor selected out first was light, but its predictive value was only 10%. However, when the variable temperature at 6" below ground was added, the ability to predict the variation in root numbers increased to 48%. This value above is over one-half of the accounted for variation and brings out the importance of temperature. The additive effect of soil moisture was very low. The air temperature at 36" proved fourth in its imprtance.

Seven other regression analysis,similar to the one just described,

were run except that the dependent variable was changed in each case. In all of these analyses, temperature was the predominant environmental factor that could be used with the most consistancy in accounting for the variation in root growth. Light did contribute a high R^2 value in two of the analyses. However, due to the type of measurements made, it is not known whether the light variable indicates the amount of energy available for photosynthesis, or whether it is just another function of temperature. In all cases, soil moisture made very little contribution to the R^2 value.

These microclimate studies indicate that temperature is the major environmental factor influencing bentgrass root growth under putting green conditions. This supports the results obtained in the controlled climate chambers. It was observed that most root initiation and growth occurred in the spring. These new roots elongate, develop and eventually mature after which the roots shrivel,brown and die. The controlled climate data suggests that the rate at which these roots reach maturity is more rapid at high temperatures.

Thus, during the hot summer period the rate of root develo ment is increased and the roots naturally reach maturity, brown and die. From observations to date, this is a natural occurrence and nothing can be done to maintain these existing roots throughout the entire summer. The problem seems to be in the initiation of new roots from the tops. New root initiation occurred naturally in the cool spring period and twice, June 27 and July 20, when sharp drops in the temperature occurred. Aside these two items, little root initiation occurred during the summer period. This suggests that temperature is the environmental factor controlling natural root initiation, or that it is a pre-requisite condition under which natural root initiation may occur. If this is the situation, it means that new management practices must be developed which will result in root initiation during the summer months.

These investigations are by no means complete and many new ideas and interesting avenues of research are suggested by these results. As already mentioned, a means should be found to cause the initiation of new roots. Possible ways to do this may include root pruning, or the application of some auxin or plant hormone.

The relative humidity aspects of the environment should be investigated. Relative humidty controls the rate of evaporation and transpiration from the surface, and these phenonema may have a great cooling effect on the plant. This idea is again closely related to temperature. If this would be the case, then wind movement over greens should be encouraged by the removal of surrounding trees and obstruction, and also would suggest the importance of the proper contour and facing of the putting green.

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LEAF RESPONSES OF BENTGRASSES

Edward E. Jordan, Graduate Student
Purdue University

This article is directed to the effects of temperature upon the growth and carbohydrate levels found in bentgrass leaf tissue. Most people understand the advantages of a sound fertility, moisture, fungicide and weed control program in maintaining excellent turf. This is an attempt to better understand the internal functions of a plant.

A definitely inverse relationship exists between growth and carbohydrate levels in plant tissue. Anything which we do to increase growth will decrease the level of carbohydrates found in plant tissue. In turn, anything which we do to decrease growth will increase the level of carbohydrates in the tissue.

Temperature is an important factor in contributing to both growth rate and carbohydrate or sugar concentrations. It directly and indirectly affects these three systems:

1. The growth mechanisms or enzyme systems which create new tissue function.

2. The systems which furnish the fuel or energy for growth and affects the systems which produce the simple carbohydrate raw materials from which the complex materials for growth are built.

3. It affects the uptake of nutrient salts which combine with the simple carbohydrates to form such things as protein, which will later be built into new tissue.

Two experimental methods were used to study these relationships. Grass was grown under equal levels of nutrients, moisture and light, but at various levels of temperature. In the second method grass was grown under natural varying conditions , and as many natural factors and effects as possible were measured.

Under controlled conditions, bentgrass was grown at a cool temperature of 60° F., an intermediate of 70° F., and a high temperature of 80° F. Top growth and sugar levels were measured and compared for seven weeks. At all temperatures the daily growth changes in rate and sugar levels showed a strong inverse relationship. And more important yet, was the effect of temperature upon this relationship. Total growth was best at 70° F., and was accompanied by the lowest level of sugars found because most of the sugars were being used in the growth process. At the higher and lower temperature, 80° F. and 60° F., poorer growth occurred, and this was accompanied by higher sugar concentrations. This indicated that the higher and lower temperatures were inhibiting the growth mechanism which stopped the utilization of sugars, allowing them to accumulate in the tissue.

The second approach to determining the effect of temperature was done under varying natural conditions. Thirty-eight different natural factors and plant responses were measured during the summer. From these 16 factors, 9 plant responses and 7 environmental factors were selected for a mathematical comparison. These calculations enabled all factors

to be observed and compared at one time, and the relative importance of each to be measured.

The importance of the fifteen factors upon yield was studied first. In Table I the results of these calculations indicate the amount of variations in yield which was observed by measuring one or groups of variables.

Table I. The amount of yield which can be predicted by studying 15 independent variables.

	%
Reducing sugars only the effect is	24
plus % light brown roots 5"	38
plus fructose	43
plus maximum temperature at 1/2"	48
plus moisture at 1"	52
All 15 factors	73

It indicates how important the factor is in relationship to yield or growth of new tissue.

A second study was run to show the importance of the 15 factors upon fructose production; since fructose is the major sugar found in bentgrasses. Table II shows the results of these calculations and indicates the amount of variations in sugar which could be predicted by studying one or a combination of these factors.

Table II - The amount of fructose which can be predicted by studying 15 independent variables.

Five most important factors:	%
Maximum temperature only the effect is	42 - 42
plus moisture at 1" combined is	16 - 58
plus yield	6 - 64
plus light	5 - 69
plus % white roots at 5"	2 - 71
All 15 factors	89

Notice temperatures appear in the first five selected factors when studying either yield or sugars. Also, notice fructose appears as a predicting factor for yield, and yield appears as a predicting factor for fructose. This indicates a strong inter-relationship between sugars and growth.

By better understanding these relationships inside grass plants, one will be in a better position to grow and manage turf successfully.

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HIGHWAY SODDING TESTS AND RESULTS

Ben Warren, Warren's Turf Nursery, Palos Park, Ill.
Dale Habenicht, H & E Sod Nursery, Tinley Park, Ill.

Permission was obtained from the State of Illinois in July 1958 to establish an experimental area to determine the proper thickness and the correct amount of water at which sod is best transplanted on roadside embankments.

By the middle of July, the Sod Growers Association of Illinois obtained an area of about 18,000 sq.ft. on the south embankment of the Congress Expressway, just east of Cicero Avenue. This section had been sodded in 1956 and by July 1958 it consisted of 90% weeds and only 10% grass. The entire area was sprayed with 2,4-D to kill the weeds. The black dirt from the original planting was pushed to the upper half with a bulldozer, leaving a blue clay on the lower half. Final grading was done by hand, but the soil was too compacted to give a very smooth surface.

The area was divided into twenty-two test plots, plus two demonstration areas. Fifteen of the test plots were included in the thickness test. Five thicknesses were tested, each being repeated three times at random. Three different amounts of water were tested on regular 3/4" nursery grown bluegrass sod. A special fertility test, consisting of 4 plots in which Thrive and another commercial 12-6-6 was included. However, no significant data was gotten from it. The rest of the space was made into two demonstration areas, using regular nursery grown Kentucky bluegrass.

Before sodding, the entire area was fertilized. Starting August 12, the Kentucky bluegrass sod was brought from three different nurseries. Each test plot was 12' wide and 40' long. The thicknesses were: 1/2", 3/4", 1" and 1-1/2" - Kentucky bluegrass and 2" field sod. However, the field sod was 50% quack grass and the appearance was better than normal.

The sod was laid according to State specifications. The majority of the test areas had a 2 to 1 slope which did not require staking. Only at the far east end was the slope much steeper which made staking necessary.

The sod was watered according to State specifications: saturated at the time of laying, plus five waterings of 1 - 4 gallons per sq.yd. over a two week period. The 1/2", 3/4" and 1" required four gallons per sq. yd. for saturation. The 1-1/2" and 2" sod needed over 5 gallons water to be saturated. The watering was all done by hand. A 1,000 gal. tank was put on the back of a truck and the water was brought from a nearby fire station.

During the first two weeks there were two days with temperatures above 90 degrees and 7 more days with temperatures above 80 degrees. There were also two rain showers amounting to 3/4" of water each, or the equivalent of four waterings.

Each yard of sod received two additional waterings besides rains. However, the State specifications for water seemed inadequate, and it was questionable if any of the thicknesses were rooted well enough to

withstand a severe drought at end of watering requirements. In the water test though, the plot receiving 2.1 gal. per sq.yd. each time was rooted well enough to withstand any further adverse conditions.

Four evaluations were made of the experiment at periods of two week intervals. The 1/2" sod made the poorest showing. The hot weather made the 1/2" sod burn unusually severe, even though it was watered.

The 3/4" sod made a good appearance, except that it could have used a little more water. But, in the demonstration areas, it looked very good. The 1" sod showed up just fair. The 1-1/2" sod looked slightly better than average. In appearance, the 2" field sod looked much better than expected, but that was because of the quackgrass. This could hardly be called typical field sod.

In root development, the 3/4" sod showed new bluegrass roots much quicker than any other thickness. In ten days, the 3/4" bluegrass sod had numerous white feeder roots beginning to take hold.The 1/2" cut bluegrass was retarded enough that new root development was about as fast as the 1" sod. The 1" sod was much slower in rooting than the 3/4" sod.

The quack roots offered some advantage to the 2" field sod, but the true bluegrass roots were not evident in ten days. At the end of the four weeks, all the plots were established well enough to survive, with the 3/4" sod appearing superior.

Summary

1. Sod may successfully be transplanted at any thickness.
2. 3/4" sod roots-in faster than thick cut sod.
3. State specifications regarding the amount of moisture were inadequate to establish sod.
4. Sodding with 3/4" sod in hot weather requires about 16 gals. of water per square yard during the first two weeks.
5. Thicker cut sod, 1-1/2" to 2", requires 10% more water.
6. Good sod, cut at the proper thickness, doesn't need black dirt as a base.
7. The general appearance of nursery sod is far superior to pasture or field sod.

Editor's note: As a result of this test, the specifications for sodding highways have been modified to permit, with approval, the use of 3/4" nursery sod in sodding. (See article page 34.)

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TURF SERVICE FOR CLUB MEMBERS

Taylor Boyd, Supt., Camargo Club,
Indian Hill,Ohio

This particular phase of turf maintenance has many interesting and educational sidelights. When we are very busy it can be a pain in the neck. When we need work to keep a good crew year round, it is nice -- and it is profitable at all times. Our first year in 1947, our income was only $ 1,100.00.

At Camargo in our operations we sold $ 13,400.00 of labor, $ 10,200.00 supplies, and $ 7,600.00 equipment rental for fiscal year 1958. It cost the Club 8388 hours of labor (or 1/4 of all hours) to earn these amounts. We are able to reduce our direct golf course maintenance costs about $ 10,000.00 per year through labor utilization.

The Club handles all billing for all categories of charges. This method eliminates the chance that the homeowner thinks he is being overcharged. And also, more important, the Directors of theClub know I'm not selling their labor or supplies, nor getting their money. I, of course, get paid for the extra work involved in producing this outside income. The member is the real winner in this shake because he gets the services of men with many years of training and experience, plus the best possible machines for his particular job.

We do about any kind of work that a homeowner would want done, whether it be turf or shrubs work. We cut and plant trees, fertilize and seed new and old lawns, cut lawns, apply insecticides, herbicides, and fungicides. We patch blacktop or gravel drives. We install tile lines, or regrade a lawn that has poor surface drainage. We plow snow and salt ice in the wintertime. In fact, to repeat, we do about anything there is to be done around the home but baby sit - the right baby and we'll do that!

We have some school lawns, plus football and baseball fields, that we do all the work on. Our mower and tractor repair shop is equipped to do about anything that needs to be done to the homeowner's equipment. We make it a hard and fast rule to never rent equipment without an operator.

Because of the fact that theClub is a non-profit organization, we make no firm bids on work to be done. This, we believe, keeps us out of the trouble the contractor has in similar work. We have, over the years, learned a lot about this business.

1. It helps the superintendent.
2. It helps the homeowner.
3. It helps the Club

We have what I call a sort of bible we go by, and I give you that now.

Comments on Home Lawn Maintenance

The average American lawn has, in recent years, become quite a major problem. Not too long ago the lawn was maybe mowed, but never fertilized, and had more dandelion, plantain and crabgrass than good grass. Nothing was done to correct it either. Now it has become a MUST to have a well groomed lawn.

Topsoil

Good topsoil is a must if a good turf is to be maintained. The perfect soil would be, by volume, 50% fine sharp sand, 20% humus, and 30% good clay loam soil. This is to be mixed off the site and applied to a 6 inch depth. This is expensive, so it is rarely done, but if you have a terrace or an area that is used extensively, such a soil would be worthwhile. Try it some place - it works!!

Vermiculite is not a good thing in an area that is to be in turf and have traffic on it. This material compresses under traffic - it is

good in flower beds as a soil conditioner.

Topdressing

Sometimes it becomes necessary to topdress a lawn or terrace area. If you do topdress, use a soil or soil mixture that is compatible with the old soil. Never topdress with pure sand, humus, vermiculite, or other material radically different in structure from old soil. Topdressing, incidentally, is good because it stimulates root growth and encourages new plants from rhizomes.

Drainage

There are two kinds: surface and tile. Surface drainage is a must. If you get a lawn job that doesn't have surface drainage, correct it, or use ample tile laid 14 - 16 ft. apart, at 24" depths.

When a lawn is heavily terraced, some tile may be necessary to prevent seepage in certain areas, such as the base of slopes. A tile installed to stop a seepage condition should be 3 or 4 ft., deep, covered to within 8 inches of the top with 1" or finer washed gravel to catch all free water running through the soil. Tile does not take out too much water. It takes only the free water, and as this takes place, air with oxygen can be taken into the soil for the turf. Never have two openings in a tile line - this destroys its purpose.

Seed

For a new lawn, use nothing but the best, and stick to bluegrass, Astoria bent, or fescue -- stay away from ryegrass, timothy and redtop. There are few times and conditions when rye and redtop have a place. This happens when some homeowner wants grass in June,or July,or August, and wanted it yesterday! I would, when this happens, write a letter to the owner, telling him what to expect and how to correct the trouble. Soaking the seed before planting cuts germination time by 30%.

For reseeding, try to always reseed with same grass that is the predominant grass in the lawn. Certainly for reseeding there is no place for ryegrass, redtop or timothy, or clover for that matter. If you have been caring for a lawn, most of the time you have goofed if reseeding is necessary. Proper fertilizer, mowing, watering and insecticide will in most instances keep a lawn in such condition that reseeding is unnecessary.

Reseeding time is early fall or late winter - never late spring.

Mowing

Do it at regular intervals. If mowing at 1", cut when grass is 2" high. If cutting 2", cut when grass reaches 4". Don't raise and lower the mower - mow when grass is dry, except in prolonged dry times when mowing can damage grass. Have a sharp mower and keep it that way.

Merion and Delta bluegrass and Astoria bentgrass should be mowed at 1" - all other grasses cut at 2" for good results. Merion, Delta and bent require a reel-type mower. Other grasses do better with rotary type mower.

	Nutrient needs per year/1,000 sq.ft.		
	N	P_2O_5	K_2O
Most grasses	3 - 6	1 - 3	1 - 2
Merion	10	3	3
Bent	10	3	3
Zoysia	10	10	10
Bermuda	18	3	3

Grass can't tell what name is on the bag, so use any good fertilizer that is economical. Organic feeding is necessary under most conditions at least once a year. It can be used entirely and supplemented with phosphorus and potash.

One of the fescues and/or Poa trivialis are the grasses used for shade. Certain maple trees prohibit the growth of grass, so plant something else. Sometimes light, monthly feeding helps.

Warm season grasses have their place - be sure you know what their place is. By all means, tell the homeowner what to expect. These grasses react differently from our cool season grasses. So, if you aren't satisfied, learn about them before you use them on a lawn. Zoysia is doing a good job in its place.

Poa annua is a pest, to say the least. Best known cure is the judicial use of lead arsenate, or calcium arsenate along with a good feeding program. Watering has a tendency to promote Poa. Heavy feeding in late summer and early fall helps eradicate Poa by helping good grasses recover.

If you have Muhlenbergia "you've had it!!" No known cure, but sodium arsenate 3 oz. per 1,000 ft.in solution applied about August 15, then fertilize about September 10. Amino triazole will do the trick, but experiment with this material yourself. It is a tricky product, but does a good job. Takes a long time before reseeding can be done.

Insecticides

Grubs do a lot of damage that is blamed on other things. Arsenate of lead is expensive, but will control the grubs, plus give some good effects on Poa annua and crabgrass. There is one other product that acts as an insecticide and herbicide - chlordane - dry wettable 50% active powder at 1-1/2 lbs. per 1,000 does a good job. Sufficient lead or chlordane applied in late March works as a very good insecticide and control for Poa and crabgrass.

Herbicides

Any of the 2,4-D compounds may be applied when the ground is moist and the grass growing. It can kill bent, and even bluegrass, if applied in hot, dry weather. It will also kill good grasses if the soil is saturated with the solution, so use a low pressure mist. Don't forget this material will damage or kill oaks, roses and many other plants - SO BE CAREFUL!

There is a new form of 2,4-D, a stick of the material to drag behind a mower. When you use 2,4-D, fertilize so the good grasses will fill the voids. There are many new herbicides on the market.

Crabgrass

It is a pain in the neck to everyone. The arsenicals will, with a good feeding and watering program, control it - at least sometimes. A loose soil will help - aerification helps to get a loose soil. Keep the watering down. Fertilize late fall and early spring. Reseed in fall where you've had crabgrass.

You can kill completely with 3 oz.sodium arsenate solution on August and reseed September 10 - 20 and come up with a clean lawn. Use plenty of complete fertilizer with the seed.D.S.M.A. is a good control after the plant has started. Use carefully, however, in extremely high temperatures.

Watering

This one thing causes the commercial lawn man loads of trouble. The homeowner insists on doing some watering, and when he does you've had it! When it's necessary, really water, and then quit - certainly here in the Midwest daily watering on a lawn can be murder to grass, but good for crabgrass. Most sprinklers can run 2 hours in one setting. Some judgment has to be used. The water should be applied in a mist, or very fine particles.

Honesty and Know-How

These two things are the beginning and the end result of a good lawn man. I hate to say this, but many of our customers come to us because someone lacked one or both of the above named things. Lack of knowledge is correctable and the correct answers can be found, but to be dishonest with the lawn-owning client is unforgivable. He is at your mercy. He usually knows nothing for sure, has read just enough to be thoroughly confused, so he calls you. Will he get "yientzed?"

Before we go any further, I have been in the grass racket for nearly 40 years and I don't have all the answers and admit it. I make mistakes and admit it. I forget to do things and admit it. When I get stuck I call Noer, Daniel, Ferguson, or Wilson for help - sometimes they can't help. The point is this: No one knows the "Grass Story" completely.

I asked a doctor member of our Club whether he could be sure all his patients would live. He said, "no, they would all die eventually." The same is true of grass. Some will die - tell the homeowner so - tell him you are no miracle man. He will like you for it. Usually the first attack of any trouble is small or light. Get on the ball and stop it where it starts.

To close, I would like to say that it is my firm belief that any man willing to spend his time and money to attend these Turf Conferences is certainly most likely to do a competent, honest job. What you learn here from hearing my paper is improved by the question it brings out and the bull sessions that take place.

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SPECIFICATIONS FOR HIGHWAY SODDING

Ben Warren, Warren's Tury Nursery
Palos Park, Illinois

Bringing about a change in outdated highway specifications is not an easy job, but, our efforts along these lines in sodding specifications in Illinois highway work have finally met with some success. For some years, and until 1957, individual firms worked separately with little success. The formation of an association of sod growers, the engagement of a man acquainted with the ways of politicians in the State Capitol, and the backing of numerous letters of opinion from scientific and practical men made the combination,which led to some success in 1958.

Late in 1957, after submission of numerous opinions from experts and with the urging of our political friend, the Highway Department announced that a grant might be made to the U. of Illinois for a study of highway planting and landscaping. Handling of sod was to be included in this study. As this grant did not materialize by May of 1958, the Sod Growers Association decided to undertake some test and demonstration plots at its expense. Our representative presented such a plan to the higher eschelons at Springfield, and after several meetings with the local officials, a program began to evolve. Several more meetings were required to select a site and adopt a program. A final O.K. was obtained in July of 1958, and work was begun in early August. Dale Habenicht reports an outline of the work done and some conclusions that were apparent from this work.

A final appraisal of the plots was made by State, County and City officials in late October, and shortly after a meeting of Sod Growers representatives with these officials was arranged. At this meeting a rough draft of new specifications was agreed upon. It is our understanding that those specifications will be used for all sodding in Northern Illinois this coming year.

Two major changes concern water and thickness -

Thickness: 1 inch thick - to be measured between two flat surfaces placed on top and bottom of sod and moderately compressed.

Water: 16 gallons per yard, applied as follows: Saturation (about 4 gallons) within 30 minutes after laying, the balance to be applied in 5 applications in the 2 weeks following laying.

It was also agreed that at least one contract in1958 would call for nursery grown Kentucky bluegrass. Other requirements were discussed concerning covering of loads when transported long distances. A standard of purity when specifying a given strain, and means by which a field man could determine acceptability of sod as to age or strength for handling purposes.

The final form that these specifications will take in print has not been available, but verbal assurances have been obtained that they will be along these lines. Nursery grown sod is still on probation with highway people, but with the very satisfactory progress made last year, I feel that the future is much brighter for improved grass on the expressways.

PHYSIOLOGY OF GRASSES IN RELATION TO TURFGRASS MANAGEMENT

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Plant physiology may be defined as the study of the growth processes and functions of the various parts of the living plant. Environment - both soil and climatic - exerts a marked influence on physiological processes, such as photosynthesis, transpiration, respiration, absorption of water, uptake of nutrients and growth. Likewise, environment - both soil and climatic - influences to a large extent management practices. In fact, turgrass management may be partially defined as the practices required to adjust, compensate, or manipulate environment to assure adequate growth of turfgrass.

This discussion will deal primarily with the influence environment exerts on the physiological functions of the roots and shoots of turfgrasses, and the relationship these bear to turfgrass management practices.

Environmental soil factors which exert a major influence on the physiological proceses are aeration, moisture and temperature. Each influences the other, and they control growth; hence, are important in turfgrass management.

Aeration

Aeration, as spoken of in connection with soils, is an interchange between atmosphere and soil air. This is necessary to supply the oxygen needed by plant roots and soil organisms, and to remove carbon dioxide from soil air. It is generally accepted that changes in such physical properties as pore size and distribution, bulk density, and aggregate stability result in changes in soil aeration.

Factors which influence or affect an interchange of soil and atmospheric air are:

1. Diffusion - the spreading of gases. It is less in compacted than non-compacted soils.
2. Changes in pressure and temperature produce a change each week.
3. Removal of water - as the water moves out of large pores, air moves in. Removal of water by roots produces the same effect, only more slowly and to a lesser extent.
4. Except irsofar as they affect biological activity in the soil, tillage practices have not shown any clearly defined effect on the composition of soil air.

Composition of soil air

The only two gases of primary concern in this discussion are carbon dioxide and oxygen, although the percentages vary.

Air	Nitrogen %	Oxygen %	Carbon dioxide %
Atmospheric	78	20 - 21	.03
Soil	78	19 - 20	.65 - 1

Soil air fluctuates more than atmospheric air. Oxygen content is decreased when nitrates are high, or when soils are waterlogged. Marked reductions have been shown to occur following irrigation and rainfall, although if a soil is well drained, this is only temporary. Carbon dioxide may go over 5% under waterlogged conditions, and, if a large supply of readily decomposable organic matter is present along with adequate nutrients, the CO_2 may go to 10%. This is one of the reasons why heavily thatched green, as well as greens constructed with excessive amounts of peat or other organic materials, produce unsatisfactory growth.

Soil air exhibits marked seasonal variations. The oxygen content in heavy soils is generally low in the early spring and increases as the season advances. Less variation is reported in sandy soils, or in soils of light texture. Carbon dioxide content reaches a maximum in the summer when soil temperatures and moisture conditions are favorable for biological activity,

Effect of Aeration on growth and function. Roots growing in well aerated (adequate oxygen) soils are long, light colored and well supplied with root hairs. Roots growing in poorly aerated (low oxygen) soils are short, thick, dark and have few root hairs.

Absorption of ions by roots is one of the most important physiological functions of living plants. It represents the connecting link between the soil and plant growth. Reduction of water uptake occurs only at relatively high carbon dioxide concentrations, and even then its effect is reduced by presence of oxygen; hence, carbon dioxide is of minor significance in water economy, except in those cases where roots are growing in waterlogged soils in the presence of large amounts of readily decomposable organic matter. In the absence of adequate oxygen, anaerobic reactions predominate and reduce managanese and iron availability.

Germination of seed is reduced by low concentration of oxygen dioxide and often occurs in soils having poor structure or excessive water content.

Aeration and Temperature on Root Growth and Function. Root growth at various levels of oxygen is strongly influenced by temperature. Experiments have shown that at 3% oxygen and at 64 and 86° F. root growth is inhibited; whereas, at 10% oxygen, root growth is normal at 64, but reduced at 86°. This indicates that at the higher temperature, 10% oxygen is deficient. Further work has shown that at oxygen concentrations:

1. Of less than one percent, roots lose weight
2. From 5 to 10% required growth of existing root tips.
3. Greater than 12% are required for root initiation.

Within the temperature limits for root growth (Cannon), the greater the temperature of the soil, the higher must be the concentration of oxygen in the soil atmosphere for normal root growth.

Soil Temperature

The activity of soil nicrō flora is dependent entirely on soil temperature. Maintenance of an adequate carbohydrate supply and the absorption of water and nutrients, all essential for growth, are affected by temperature.

Effect on Carbohydrates: Carbohydrates required at the growing points must be translocated from leaves where they are produced by photosynthesis. High temperatures favor rapid translocation and accelerated respiratory activity, while low temperatures retard. Hence, low temperature favors an accumulation of photosynthetic products (carbohydrates), while high ones may cause a serious depletion and restrict growth.

Effect on Absoprtion: Within limits, the rate at which water and nutrients are absorbed increases as temperatures rise. The viscosity of water is twice as great and protoplasm is several times as great, at 32 as at 77°. An increase in the viscosity results in a slower movement from the soil to the root. Likewise, an increase in the viscosity of protoplasm retards water movement within the roots.

The effect of temperature on transpiration is direct, i.e., when temperatures increase, transpiration increases, and when temperatures decline, transpiration is reduced. Low soil temperatures reduce water absorption, while high atmospheric temperatures increase transpiration. Under such conditions, wilting becomes a possibility. Wilting always occurs whenever transpiration exceeds water absorption.

Summer growth is largely dependent on photosynthesis, whereas early spring growth comes largely at the expense of stored food.

Effect on Species. There is a marked difference in the response of different grasses to temperature. For example, Brown has shown that water absorption by bermudagrass was sufficiently retarded at 50° to cause wilting, but that Kentucky bluegrass was unaffected at this temperature. This indicates a basic difference in the reaction of protoplasm to this temperature. Soil temperatures of 59 - 58° appear optimum for Kentucky bluegrass, and above 80° is unfavorable. Bermudagrass, on the other hand, continues to grow with rising temperatures up to 100° (the highest temperature studied).

Factors Affecting Changes. Irrigation is quite effective in reducing soil temperatures. In Arizona, Dr. Bill Martin has shown that following irrigation soil temperature was lowered 4 - 10 degrees at 1 inch and 1 to 4 degrees at 3 inches. Other significant factors are:

1. Evaporation - the cooling effects brought about by evaporation from irrigated areas (such as greens) adjacent to non-irrigated areas are well known.

2. Shade - Brown (Missouri) in a study comparing summer temperatures at a depth of one-half inch under a bare soil and a Kentucky bluegrass sod, found that the daily maxima were as much as 10 degrees higher, and minima were as much as 5 degrees lower for the bare soil than for bluegrass sod.

3. Mulch - an organic mulch will absorb heat and insulate the soil.

4. Dark materials absorb heat - the use of dark materials, such as lamp black, sewage sludge and topdressing to speed the melting of ice on greens takes advantage of the heat absorbing properties of these materials. This is also one reason why bentgrass greens should not be topdressed during summer months.

5. Location and position - In general, southwest slopes are the warmest. Whenever possible, turf areas (such as greens) should be faced toward the sun (southward) in the colder climes and away from the sun (northward) in the warmer latitudes. Also, cool air settles in valleys during the night, and high wind-swept hills are more subject to excessive transpiration. Exposure to wind and provisions for adequate air drainage are of importance.

Transpiration

There is a constant stream of water passing in through the roots and being transpired by the leaves. From 300 to 500 lbs. of water are required for every one pound of dry matter produced by the plant. Many plants transpire an amount of water equal to their weight every 24 hours.

The actual amount of water required by plants is, therefore, far in excess of the amount retained by the plant and is influenced by these conditions:

1. High temperature increases and low temperature retards transpiration.
2. Air movement increases transpiration from the plant. The movement of the plant itself aids in circulation of water within it and so increases transpiration.
3. Low humidity increases transpiration.
4. Low fertility increases total transpired per unit of growth. Fertile soils are more efficient in turf growth.
5. Transpiration is greater in bright sunshine.
6. The more moisture contained in a soil, the greater is the transpiration rate.

Plant growth and transpiration phenomena require large quantities of water most of which is transpired. As we understand this, we adjust our management practices to alleviate undesired transpiration whenever possible.

Water practices that are based directly on transpiration phenomena are "syringing" of golf greens during hot, windy summer days, and the watering of turf areas during winter or early spring when atmospheric temperatures are considerably higher than soil temperatures. In both cases, transpiration exceeds water absorption. This results in wilting or dessication. On high areas not covered by snow and exposed to drying winds during winter and spring months, winter kill is often observed. The plant roots are relatively inactive and cannot take up sufficient water to offset transpiration; hence, wilting -- and often death - occurs.

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ON THE MOWING OF GRASS

J. R. Watson, Jr., Toro Manufacturing Corp.

Photosynthesis (photo-light; synthesis - putting together) is the process of converting, in the presence of sunlight, carbon dioxide and water into simple sugar (glucose). This process is the most important

on earth since the simple sugars are the basis of all organic compounds in life activities.

Trapping sunlight necessary for photosynthesis is only one of the functions of grass leaves, and carbon dioxide and water are only two of the elements or materials necessary for proper growth. Nitrogen is an integral part of proteins, iron an essential in chlorophyll production, phosphorus is involved in the transfer of energy, and potassium is necessary for translocation of sugar and other physiological processes. The role of these and other essential elements, as well as other leaf functions, should not be minimized.

Grass cutting is the major operation (50% of labor) in the maintenance of turfgrass. Good mowing practices contribute to a well groomed appearance, and also greatly influences its health, vigor and density. Adapted grass, proper fertilization, aeration and judicious watering will also affect the ultimate quality of turf. An understanding of the basic growth habits and characteristics of grass is essential for the development of proper mowing techniques.

Growth Habits and Characteristics

Grasses may be classified into three general groups. Bunch type grasses, such as ryegrass and chewings fescue, produce new shoots which grow inside the sheaths of the previous stem growth. Stoloniferous grasses, such as bentgrass, spread by runners or stolons which develop from shoots that push through the sheath and run along the surface of the ground, rooting at the nodes (joints). Kentucky bluegrass, a rhizomatous type of grass, develops shoots at the underground nodes. Some grasses, such as bermudagrass and Zoysia, spread by both rhizomes and stolons. This is one reason why bermudagrass is so difficult to control and keep out of flower beds, gravel walks, etc. There are also intermediate types with decumbent stems which root at the nodes, such as crabgrass, nimblewill and some fescues.

The grass leaf is adapted for intercepting a maximum of sun rays which are essential for photosynthesis. The long flattened grass blades provide a maximum of exposure with a minimum amount of protoplasm. A reduction in leaf area reduces the plant's capacity to carry on photosynthetic activity. This is a vital consideration in determining the frequency and height of cut.

The ability of grasses to withstand frequent and relatively close cutting is related to certain peculiarities of the grass family. Grasses exhibit basal growth, as opposed to terminal growth found in most other plants. Basal growth means simply that growth initiates at the base rather than at the tip of the blade or stem. From a practical standpoint, this means that normal and frequent mowing does not cut off the growing areas of the grass leaf.

Height of Cut

Creeping type plants, such as bentgrass and bermudagrass, when properly fertilized and watered, are able to produce adequate leaf surface at very low heights of cut (3/16th inch). Buffalograss, although a creeper, cannot produce sufficient leaf mass at low heights because too few basal buds exist and, therefore, cannot withstand low clipping. For this same reason, Kentucky bluegrass and fescue must be cut relatively

high (1 - 1½ inches).

Frequency of Cut

Infrequent clipping allows the grass to elongate to such a degree that any subsequent clipping removes an excessive amount of leaf surface. At no time should clipping remove over one-third of the total leaf surface. Severe cutting is a physiological shock to the plant which depletes root reserves. In addition, the accumulation of excessive clippings may smother the grass and provide excellent conditions for disease organisms and insects.

Stage of Growth

Young, tender growth is generally more soft and succulent, has a higher moisture and less fiber content than mature grass. Tender young grass must be cut with a sharp, well adjusted mower to avoid mechanical damage and must be cut frequently, Regular cutting at the medium, preferred height will encourage dense cover, lateral spreading and better competition against weeds.

Selection of the Mower

Good mowers are characterized by high maneuverability, easy adjustment, durability and adequate horsepower for the size and usage expected. In addition, the ready availability of parts and service is important.

Four basic types of mowers are available - reel, rotary, sickle bar and vertical. Choice of a given type will be governed by the particular duties the unit will be expected to perform. Each type has certain advantages and limitations.

Reel type mowers are always recommended for the cutting of formal and semi-formal turf areas, including golf greens, tees, fairways and well kept lawns. Reel type gang mowers are also the most efficient and economical for mowing large open areas, such as airfields and parks. The cutting action of the reel is like that of a pair of scissors.Reels when sharp and properly adjusted, give a clean, even cut which cannot be equalled by any other type of mower.

Reel type mowers require relatively smooth ground upon which to operate, and they will not cut tall, rank growing weeds. In addition, the cost of maintenance is somewhat higher than other type of mowers.

Rotary mowers are best suited to rough conditions and to areas where control of grass, rather than appearance, is the predominant consideration. In addition to controlling the grass, rotaries may be used to grind up leaves, cut tall, stemmy weeds, and for trimming. The rotary cuts by impact similar to the cutting action of a scythe. For this reason, a sharp, properly balanced blade is necessary to avoid ragged tearing of the grass blade and to prolong engine life. Cutting with a dull blade generally results in a graying and subsequent browning of the leaf tip. When selecting a rotary mower, particular attention should be given to the safety features, the type of blade and method of blade amounting, ease of adjustment and the horsepower of the unit. Power requirements - the highest of any type of mower - along with poor quality of cut, are the major limitations of rotary mowers. The cost of maintenance is low, although the cost of engine maintenance may be much higher

than on reel units, particularly if the unit is underpowered.

Sickle bar mowers have no place under normal turfgrass conditions. They may be used to advantage in rank, weedy growth where only an occasional mowing is required. Sickle bars are extensively used by highway departments to cut highway berms where foreign objects such as cans, bottles and other debris often interfere with reel or rotary operation. They have a very high cost of maintenance and relatively slow ground speed and consequently are an expensive method of mowing.

Vertical mowers are made with fixed blades, or with free swinging blades (hammerknife). They cut by impact similar to the rotary mower, except that the blades travel in a vertical plane rather than a horizontal plane. Hammerknife mowers can be used on rough terrain more satisfactorily than rotary mowers because the wheelbase is shorter and scalping is lessened. They are also excellent for clearing light brush and undergrowth. They have a very high cost of maintenance.

Vertical mowers having fixed blades are used primarily for controlling thatch and grain on golf greens and other highly specialized turf areas.

It is essential that all types be kept sharp and in good operating condition Dull, improperly adjusted equipment not only destroys the aesthetic value of the area, but also bruises the leaf tips, increases moisture loss and provides ready access to disease and insects.

Washboard effect. Turfgrass areas sometime develop a series of wave-like ridges running at right angles to the direction of mowing. This may be reduced or remedied by regularly changing the direction of mowing (diagonal or right angles). Alternate directions of cut will partially control runners of creeping grasses and aid in the prevention of grain and thatch. Many times seedbed preparation does not remove previous rows or ridges prior to seeding, so unevenness develops. Such a situation may be reduced in severity by intense aeration (5 times over in 1 day) followed by repeated dragging, which removes most of the soil cores from the high areas and deposits them in the low areas.

Wet Conditions. Mowing wet grass shouldbe avoided as much as possible, although available labor and time often make it impractical to do so. Dry grass cuts more easily, does not ball up and clog the mower, and gives a much finer appearing lawn. Timing tests show that mowing dry grass requires less time than mowing wet grass.

Uneven Terrain. Mowers are not built for grading purposes. Turf areas containing high areas which are continually scalped should be regraded in order that they may be cut properly and to reduce the wear and damge to mowing equipment.

Inadequate insect control can become a serious mowing problem. Areas heavily infested with earthworms or ants will have many soil mounds caused by their activity which will result in a poor appearing area and will cause damage to mowing units. Mounds of earth thrown up by gophers and other soil burrowing animals will have the same result.

Improper Operation. Uneven cutting often occurs due to bobbing caused by mowing at excessive speeds, or by equipment not built correctly for the grass it is cutting. This often occurs where the grass is extremely heavy, or dense, and the mower, because of insufficient weight

and/or cutting ability bobs up as the mower hits heavy grass.

On specialized areas, such as putting greens, bowling greens, lawn tennis courts, etc., improper handling of the mower on turns will result in turf damage through bruising and wearing of the grass. Reducing motor speeds and making wider sweeping turns may reduce damage.

Terraces and banks. Terraces and banks offer a difficult mowing problem. Scalping generally will occur if the bank or terrace is mowed across the slope. Up and down mowing generally is the most satisfactory method of cutting these areas. The inherent physiological anotomical and morphological characteristics of a given grass will determine the height and frequency of mowing that will give the most satisfactory performance. Mowing is more than removing excess leaves - it is a maintenance practice which affects the appearance and longevity of turf.

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MECHANICAL AND CHEMICAL CONTROL OF GRASSES IN FAIRWAYS

Robert Williams, Supt., Bob O'Link Golf Club
Highland Park, Illinois

This report is based upon our practical experience with the fairways at The Beverly Country Club in the Chicago district over a period of 12 years from 1947 through 1958. The fairways consist of 40 acres of area, range from clay to sandy loam soil, and have a grass mixture of approximately 60% bent and 40% Poa annua. The height of cut was 5/8" in 1958. The irrigation system is of the center line hoseless type of a capacity which enabled us to water the entire course in approximately 7 hours, with a flow of about 1200 gpm.

The membership of the Club wanted a closely cut turf for maximum playability without excessive thatch and puffiness. They also wanted a turf that was fairly uniform and free of foreign grasses and weeds. From the superintendent's point of view, I wanted to produce a type of turf best suited to the membership's desires and with the added features of having a turf that would give the minimum amount of trouble and damage under trying weather conditions and heavy play. It was also necessary to attempt to keep the turf growing at a fairly consistent rate with comparatively little damage from disease organisms. To accomplish these objectives which, incidentally have been quite successful under our conditions, we employed the following Mechanical Controls:

Mowing: The fairways have been mowed three to four times per week with two, seven gang pull units, accomplishing the job in about 3 hours. The mowing is usually done before the heat of the day and sometimes we drag the dew off of the fairways so as to get an earlier start on mowing and still keep ahead of the play. The direction of mowing is reversed each time with the hookup of the mowers being changed as well so as not to form wheel marks from traveling in the same tracks.

Seeding: Our fairway turf had a good percentage of bent established at the time that I started working at Beverly in 1947. From that

time on we completely reseeded all of the fairways once and spot seeded periodically in special areas. We also used a soil and seed mixture in the fairway divots about twice a year. The seed used was Highland, Astoria and Seaside bents and in the case of the divots a liberal supply of ryegrass was added. The overall seeding was done with an alfalfa seed drill. I might add here that the bentgrass in the fairways today is creeping types.

Aerification: Our aerification procedures have varied from none at all in 1947 up to monthly treatments by 1956. Since then we have used spring and fall treatments. We have also run the gamut of types of machines, from the open tine aerifier, the hollow tube, the rotary hoe, the spiker, the straight disc and finally the thatch spoon type. My conclusion on aerification is that its greatest use is as an aid to moisture control and penetration. For this reason, I have favored a shallow core or plug removal process which will allow rainfall or irrigation water to penetrate through the turf mat and into the soil. Undoubtedly, the benefit of soil brought to the surface in the process has been helpful in keeping thatch to a practical level. I believe that after a period of years of aerification, the carry-over benefits reduce the necessity of it.

Irrigation: Perhaps this item is about the most important of all merchanical controls for the production of close-cut bent fairways. Good grass is most favored by a regular supply of moisture in the soil. If too much moisture we drown the grass; too little and it soon wilts and dies. One theory on watering of grass has been to give it a good deep soaking and spread the intervals to several days, with the idea of encouraging deep root growth that will withstand drouth. The other theory is to start out the season with uniform moisture provided by natures normal spring weather and attempt to keep a uniform degree of moisture in the soil by adding, as required, that moisture that is taken up by the plant or lost through daily evaporation. Personally I have favored the latter theory for fairway turf inasmuch as Poa annua is still quite plentiful in our fairways and needs moisture in the upper inch of soil. As long as we have Poa annua I believe that the superintendent must have fingertip control of soil moisture if he is expected to produce close cut fairway turf.

To do this at Beverly, we increased our irrigation facility to provide 1200 GPM of irrigated water to the course. This meant that we, in any one night, could water all of the fairway areas, as well as tees and greens. The old theory of watering fairways every third night left a great deal to be desired when a hot, windy day came along and dried out the surface of the soil with the result of the Poa going out over night. With this added capacity for irrigation, and the ability to turn it on or off like a shower bath, we found that we did not use more water over the season, but used it more judiciously,with more frequent applications for shorter periods of time. This last year our average fairway sprinkler setting would run about 20 to 30 minutes.

Drainage: Here is another mechanical factor that is all important in the control of fairway turfgrass. Both surface and sub-surface drainage must be within the limits of tolerance of the grass plants or we find a problem. At Beverly we did have drainage problems which affected the entire course, and it was necessary to install a complete system of some 25,000 feet of tile with 75 manholes and another 35 surface drains in order to avoid unplayable golfing conditions and loss of turf from excessive moisture in the soil and standing water in low spots. This was

a costly item accomplished in 1948 at a cost of some $ 60,000.00 and considerable interruption to golf during one season.

Tree Root Pruning: This factor is also one of the mechanical controls that must not be forgotten in the development of close cut fairway turf. We have used the Haines Pruner for a number of years and we recently purchased a small self-propelled trencher for this purpose. If the adjacent trees are allowed to dessicate a fairway area, it is sometimes nearly impossible to get the soil to once again accept moisture. Where tree roots have been cut during the season, there is sometimes an immediate response by the turf over a period of hours. Having covered the Mechanical Factors of Control of Fairway Grasses, let us now consider the Chemical Controls for better turf on these areas.

Fertilizer: All important as a chemical control, fertilizer must be used to its greatest advantage. Here again, we must stay within the range of tolerance. Too much is worse than not enough, and mighty costly too. It has been our objective to attempt to keep an even growth of the turf throughout the season without developing a lushness with excessive clippings, or allowing starvation with attendant disease attacks and lack of firmness to hold up the ball. At the same time, we have tried to reduce the quantities of phosphate fertilizer in keeping with our program of impeding the Poa annua through the use of arsenicals. To accomplish all of this in a fertilizer program, we tried a number of different approaches and ended up with a schedule last year that seemed to give us just about what we wanted. The total amojnts of fertilizer nutrients applied were:

Nitrogen	157 lbs. per A.
Phosphorus	8 " " "
Potash	60 " " "

The total amounts of fertilizer material used were: Nugreen - 6½ tons, Potash - 2 tons, Milorganite - 4 tons. Total of 12½ tons. The cost of the fairway fertilizer was less than $ 1200.00 for 6 applications.

Date	Rate/acre on 40 acres	
March	100 lbs. Nugreen	100 lbs. Potash
May	50 " "	
July	50 " "	
August	50 " "	
September	200 " Milorganite	
September	75 " Nugreen	

Two of the fairways were treated through the season with Milorganite at the rate of 200 lbs. per acre in addition, and appeared to have a better stand of turf, and the least damage from weather, traffic and disease. Also, on fertilizer, we have added lime from time to time to keep the pH range in line.

Fungicide: For the past several years we have been working with fairway fungicides at Beverly. First on a limited scale and the past two years on full scale. We applied a 10% phenol mercury at the rate of 1 quart per acre in 75 gallons of water. Three applications were made on July 5, July 16 and August 1. We tried to time these applications to get the most effect against dollarspot, and at the same time to keep control over crabgrass. Apparently we were successful in both. Other years we have used as many as 5 applications. This lighter dosage seems to do the trick and bring the cost within practical limitations. The cost,

incidentally, amounts to approximately $ 120.00 per application for 40 acres. This is reasonable in comparison to the damage that disease can do. At the end of this past season, we also started using 1 oz. of iron sulphate per 1,000 sq.ft. with the mercury with beneficial results.

Herbicide: Our herbicide program on fairways has been through the use of phenol mercury as previously stated, sodium arsenite, 2,4-D and 2,4,5-T. The sodium arsenite has been applied spring and late fall in rates of about 1 to 3 lbs. per acre in 75 gals. of water. This treatment apparently impedes the Poa and stimulates the bent. The 2,4-D and 2,4,5-T treatments were used for clover and broadleaf control some years back. With our present program we have not used these materials now for about four years except for a few localized areas. We do have a small amount of clover present,but I have not felt that it was enough to warrant risking possible damage to the bents with the broadleaf treatments.

Insecticides: We have been using insecticide treatment on the fairways now for several years. We use chlordane at the rate of 8 lbs. of technical material per acre, once each year. We try to time this application with normal insect infestation in late May or early June. We have had no insect nor angle worm problems since adopting this procedure. The cost for this application is close to $ 400.00 per year for materials.

To summarize this subject, I like to think of the superintendent as a sort of puppeteer who has a string attached to each of these factors which lead to fairway turf management. The better he learns how to control them and use them, the better reaction he will get from the turf. Re-enumerating the Merchanical controls, we spoke of Mowing, Irrigation, Drainage, Aerification, Seeding and Tree Root Pruning. The chemical controls were: Fertilizer, Fungicide, Herbicide and Insecticide.

A good deal of our work with fairways has come out of the research work being done here at Purdue University under Dr. Daniel, and from comparing notes with other superintendents. This Interchange of Information has been worth a great deal to all of us, and I have been happy to have had this opportunity to report to you on the techniques that we have developed at Beverly over the years.

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FUNGICIDE HERBICIDE USE ON FAIRWAYS

Carl Bretzlaff, Supt., Meridian Hills C. C.
Indianapolis, Indiana

During the past years we were faced with an increasing crabgrass problem which, if let go, might require complete renovation of the fairways. During the fall of 1957 we decided to set up a program for the Spring and Summer of 1958. After conferring with the technical people, our goal was set and the program devised. This program was submitted and explained in detail to the Board. The details were simple and easy, but had to be followed religiously. The program was this:

Starting in early May and repeated each week, we applied 1 fl. oz. of 10% phenyl mercury acetate (or PMAS) per 1,000 sq.ft., or 40 oz. per acre in 80 gal. water per acre. The weather in 1958 was cool with plenty of moisture. We expected crabgrass germination during mid-May, but it continued cool, which delayed it. Nevertheless, the program was set so we applied the prevention applications. Now, as we look back, the first two or three treatments could have been eliminated. But, we continued every week until late August. This program prevented crabgrass germination as well as leafspot disease infestation.

A total of 30 acres were treated twelve weeks in 1958. With some of the equipment used, we had a one man operation. Equipment included a tractor, a sprayer with a 300 gal. tank and a 20 g/m pump with the sprayer control at the side of the tractor operator's seat. The sprayer had 300 lbs. pressure and fed through an 8' boom with 3 No. 9540 Tee-Jet nozzles, which gave a broad-fan, and covers a 30 ft. strip. Expect some disappointments when you plan on weekly applications. For example, if you set up for Monday then rain, strong winds, even golf tournaments will interfere. However, in 1958 we only missed two spray periods during the twelve week period.

The conclusion arrived at is this: Crabgrass, weeds and some of the disease can be prevented in fairway turf by setting up a program and following it. Application should start with the product used just before crabgrass germination is expected and continued at weekly intervals. In this manner you won't see crabgrass plant, nor loss of grass by disease.

If we are going to close cut bluegrass and bentgrass in fairways in Indianapolis, we must keep out crabgrass, clover and Poa annua, and we must protect bluegrass and bent from disease. Our treated fairways are much better than a year ago. We still have Poa, but are using arsenicals for its reduction. In 1959 we expect to expand the spray program to include all fairway and tee areas, about 55 acres. We will use fewer applications - with two week interval between early and late ones - but weekly sprays, once seedling crabgrass emerges, until it is controlled.

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MECHANICAL RENOVATION OF GRASSES

W. H. Daniel, Turf Specialist
Purdue University.

As more disease and wear resistant grasses are provided with ample nutrition and good management, more living and dead tissue can accumulate at the surface. The dead mass or layer of plant clippings, old leaves and stems can reduce air and water infiltration, but more important new leaves need room for growth. How shall we provide this space?

Thatch may be reduced by:

1. Avoiding - its accumulation
   a. slow growth
   b. limited feeding
   c. plant failure

2. Decay - generally continuous
   a. bacterial feeding
   b. fungi feeding
   c. decomposition
   d. earthworm ingestion

3. Dilution - by soil materials
   a. topdressing
   b. aerifying - plugs
   c. earthworm casts
   d. freezing and thawing
   e. use of area

4. Removal - annually or at intervals
   a. hand-raking - may damage thin area
   b. Delmonte raking - used on bentgrass
   c. Verti-cutting - cuts off older growth
   d. thin-cutting
   e. sweeping or catching clippings
   f. burning of dormant stubble

Where bentgrass or nimblewill patches are in bluegrass lawns, the removal and thinning may greatly improve uniformity of turf area. In early spring the old growth may be thinned out. In late summer crabgrass competition can be reduced so bluegrass has more room. In dense bluegrass, removal of old growth permits new vigor in fall shoots of bluegrass.

It is interesting that, on the market in 1959, several companies have catchers available for their rotary mowers. The availability of easily applied fertilizers make the return of clippings less vital as a little fertilizer can replace the nutrients.

The best management of lawn grasses, even bluegrass, can now follow the lead of putting greens in renovation, and twice a year thinning and removal of excess. With less dead material present, the new leaves produced will have room to grow nearer the ground, yet give a greener appearance.

The availability of machines and blades for thinning and grooming, as well as catchers on mowers (even rotaries) make another improvement in lawn maintenance practical.

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WARM SEASON GRASSES

E. J. Sears, Supt., Paxton Park G. C.
Paducah, Kentucky

All ditches are now in good condition with no water holes. This year we plan to place a 14" tile 12" below grade with grated openings even 100 ft. This will bleed the ditch and keep it dry so good turf can be developed.

All ditch areas afer fertilized twice a year. All fairways are fertilized in the fall with 500 lbs. of 12-12-12. Thirty tons of limestone were applied in 1935. On fairways we use a 3 gang fairway aerifier with 1" spoons, both spring and fall. We only aerify when the soil is in such condition that we can get the spoons down 3". This makes it very hard to pull. We use two, dual wheel four wheel drive jeeps as our tractor won't do the job.

Paxton Park is a 25 year old, eighteen hole Municipal Golf Course operated by a three member golf commission. It is only supported by green fees and a $ 50.00 membership. The maintenance of ditches crossing fairways is always a major problem. In the last five years all water holes, some were 4 ft. deep, have been filled and brought to grade. All ditches have been widened and graded flat in the bottom to slow down the runoff. All these areas were sodded with U-3 Bermuda.

Since my greens are Bermuda, I will discuss modern practices in development of fairways as it applies to me. I have been obsessed with the idea of developing good fairways on our golf course. As examples of excellent fairways, I cite Memphis C.C., Chickasaw C.C., and Colonial C.C. all in the city of Memphis. These fairways have been my targets for excellence and I have followed their program of maintenance carefully.

In the last three years play on our golf course has more than doubled. It has become more apparent that a perfect fairway is the best solution for speeding up play. An appeal to all superintendents to speed up their fairways was made at the Chicago convention by Chick Evans.

Aerification has had a major role in the development of our fairway turf. The deep one inch holes make it possible for the soil to store up sufficient water to carry through long dry periods in the summer. This has developed a root system so deep and a turf so tight that zero weather causes no freezing and heaving. There is no inconvenience to play after a thaw.

A 300 gal. bean spray with a 21 ft. boom is used for applying sodium arsenate on the fairways. After 5 years regular use of machine and material, we now have an arsenic residual built up in the soil to the point where we have a very little Poa annua and crabgrass problem. This program has developed the Bermuda turf on the fairways to the extent that the player now seldom ever has a bad lie. This is point one for speeding up play. And point two was - eliminating all areas where balls could be lost. The grading out of all ditches developing rough areas, has in no way detracted from the character of the course.

Golf carts on our course are only restricted in the early spring. They do no damage to good Bermuda turf during the growing season. Carts are not funneled through certain areas. They follow a straight line from shot to ball. The ditches do not require a detour. The only requirement is that carts stay off greens, aprons and tees.

Cultural practices in the mowing of fairways at Paxton Park has played its part in the development of a tight turf. One man working full-time with a seven unit mower does the entire mowing job. All greens, aprons and all areas between sand trap and green are mowed with this unit. There is no other mowing required. All tees are mowed with this unit. The golf course is mowed at fairway cut from fence to fence.

There are no roughs except at tournament time. There is no whirlwind mowing required.

In 1953 we planted a nursery using Bay Shore Genetift hybrid Bermuda. We have consistently increased this area until today we have 5 acres which is mowed regularly once each week. We have U-3, 328, Tifton 57, Bay Shore and Uganda Bermudas, Meyer and Emerald zoysias and Merion and Kentucky bluegrass. All tees have been extended, terraced and sodded with U-3 from this nursery.

Eighteen of our greens have been converted to Genetift Bermuda, using two inch plugs. These greens are true to strain and there has been no closed periods on them, no loss of play. Greens are fertilized with a 10 ft. Gandy spreader pulled with a dual wheel jeep equipped with 8" tires. Sodium arsenate chlordane solution is sprayed on the greens twice each year with the Bean Boom rig which is equipped with Aircraft B-29 14" tires. Eighteen greens are fertilized in two hours, sprayed in one and one-half hours. Organic fertilizer at 20 lb. rate is applied every two weeks. Two applications, spring and fall, of inorganic at a 30 lbs. rate is standard practice. These greens received a total of 18 lbs. of nitrogen per 1,000 ft. during the 1958 season.

One hundred yards of hardwood sawdust ten years old has been used as topdressing in the last three years. Result - greens hold shots better, water requirement is cut in half, and greens hold color better in July and August. Greens are mowed every day until September 1. Mowers are then raised and clippings left on. On October 15 cups are moved to secondary rye winter greens

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WARM SEASON GRASSES

Donald Likes, Supt., Hyde Park Country Club
Cincinnati, Ohio

Would you like to have a near foolproof grass? A grass that would take care of itself and need very little attention?

Let me tell you about a grass I have been growing at my Club for the past eight years. It has provided for several thousand happy rounds of golf. It is a warm season grass. It grows vigorously in the hot weather - it makes a dense turf. It chokes out other grasses and weeds. It is relatively disease resistant. It responds wonderfully to fertilizer treatments. It reseeds itself. The scientific name for this grass is Digitaria sanguinalis - more commonly known as crabgrass. I have probably grown more and better crabgrass than anyone in the Midwest.

I don't advocate the planting of crabgrass. The point I'm trying to make is this: crabgrass is a warm-season grass and it does make a fairly good turf for a large part of the golf season. Fortunately, we have other warm season grasses that are much better than crabgrass. For example, U-3 Bermuda is much finer in texture. It makes some a winter turf and with a normal spring it will green up and make turf before crabgrass does.

In 1951, my first summer at the Hyde Park Country Club in Cincinnati, I tore up one-half of No. 1 tee and started sprigging in U-3 Bermuda in rows about 1 ft. apart. I wouldn't have the guts to do that now. Here it was the middle of June and this tee was next to the Club House, a very conspicuous place. The club members had never seen anything like it. They thought I was planting some kind of a vegetable garden on their No. 1 tee. That was the middle of June. By August 1, 6 weeks later, we had solid U-3 Bermuda sod and we were playing on it. Since that time this has been a very satisfactory tee. Nightcrawlers have given us some trouble. After the U-3 goes dormant in the fall, these earthworms will do a pretty good job of fall plowing, especially during a wet period. This leaves Bermuda turf in bad conditions for winter survival. Where this is the case, we try to use enough insecticide to discourage nightcrawler action.

After the success we had with this first Bermuda tee, approval was granted to plant several U-3 tees the next year. Our No. 5 was planted solid with stolons on June 5. We were using it the 4th of July. Incidentally, where we have Bermuda tees we also have another tee with a cool season grass that is used when the Bermuda is dormant. Most of these cool season tees are in partial shade and contain a high percentage of Poa annua. Our experience with U-3 in partial shade, or even close to shade, has been bad. For example, our back tee on No. 7 has trees on both the north and south side. However, the sun has a fairly good shot at it all day. We had a good U-3 turf established, but lost 95% the following winter. This has been the same story on other tees that were planted in slightly shaded areas.

At the present we have several good Bermuda tees that have given sztisfactory service for 8 years. However, unless we change our thinking, we will not plant any more Bermuda. It has been somewhat disappointing the last two years. However, our main reason is that there is a better grass; namely, Meyer zoysia. It greens up about April 1 regardless of the weather. It is at least one month ahead of Bermuda. It makes a much better dormant turf than U-3. It is more winter-hardy than U-3.

In 1951 we received two small chunks of Meyer zoysia sod from Purdue. This was kept around for 3 or 4 years and at various intervals was propagated into larger areas. By 1954 we had approximately 1,000 sq.ft. of Meyer sod. In the fall of 1954 about one-half acre was planted to Meyer zoysia plugs. This field made sod by 1956. The bulk of the Zoysia nursery was sold to large estates. About one-third of the field was stripped in late 1957. This area had to be replanted in June 1958. The remaining two-thirds of the field was stripped in early summer 1958. This area came back to Zoysia without being replanted.

I am sorry to say I haven't used much Zoysia on the golf course. We have Meyer zoysia on a portion of our No. 7 apron where it is impossible to hold a cool season grass. This has held up well for a year and a half and at the present time has not grown into the green enough to be concerned about it. Last summer we plugged our No. 8 tee with 4" plugs on about 1 ft. centers. Likewise, we plugged about 1 acre of our No. 5 fairway with 3" Zoysia plugs. We have cautioned our members not to expect any quick results from these Zoysia plugs. But, we are confident that if givenenough time, Meyer zoysia will make an excellent turf.

In conclusion, I would like to say this: Meyer zoysia is a great grass. There will be more of it used in the future. It has been over publicized and the public has expected too much of it. They have become disappointed and rejected it. This bad publicity has set its progress back perhaps 10 years. It you don't already have a nursery of this grass, get one started. There is a place for this grass in your future turf program.

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SURVIVAL OF BERMUDA AND ZOYSIA

Ernie Schneider, Supt., Big Spring Golf Club,
Louisville, Kentucky

Last year I talked about the place that Bermuda and Zoysia have on the fairways, tees and aprons of the greens. We had a very severe winter in '57 - '58. The frost was 23 inches deep with no snow cover. The ground was heaved badly - the worst I've seen. The ground did not thaw out until the middle of March and we had a very late freeze after that.

In the high and well-drained areas, the Bermuda survived, but recovery was slow. In the poorly drained area, there was about a 90% loss in Bermuda, except for the coarse type.

The greening-up of the Bermudas in the nursery this past year was a little different than before. They were all late, but in this order: T-47, Gene Tift, Uganda, Texas 94, Tifgreen, U-3, T-35A, Tiflawn, Tiffine and Sunturf was last. By August 1 all had recovered. Some of the common, medium to coarse patches on the golf course were also late in greening-up. A few patches of the old commons that had been there for years froze out 100%.

In my extimation it is foolish to plant Bermuda in poorly drained areas, or in places which would flood for any period of time. U-3, T35A, Sunturf, Gene Tift were 100% loss in poorly drained areas, yet the coarse Bermudas survived. I lost most of my Bermuda tees - they were not mulched.

Uganda has done well for me both in my nursery and also under play. It requires high rates of nitrogen and cutting at least three times a week. I had lost my No. 1 tee which was U-3, so I sodded about half of it with Uganda. Uganda is not as tough as the other Bermuda - it bruises easily, but the recovery is good.

My collars and aprons around greens that were Bermuda had very little winter-kill. They received 30% Milorganite the middle of October when I fertilized my greens. The tees were last fertilized about the first of September. The only good turf I had left on my tees was Zoysia - and we have some in nearly every tee. It was green by April 12 despite the late freeze.

My original plot of Meyer zoysia, a spot about 8' x 8', was planted

where an old sand green had been. It has been removed twice, in '51 and '52. This plot has not received any fertilizer and has grown 16 ft. beyond the original planting. It is weed-free in the summer, but does get winter weeds in it. I had some small plots of Zoysia in the fairways, which receive only regular mowing. There's no crabgrass in it and no build-up of thatch to date. These plots have been in since '52. Zoysia will grow on any type soil - there was one area of Zoysia and Bermuda planted side by side in '53. The Bermuda has never made turf, but the Zoysia has been removed and used as sod. From that it would seem that Bermuda requires better soil.

About May '53 Bill Daniel and I planted twelve 2" Zoysia plugs in a fairway where Bermuda predominated. When the Bermuda froze out, I found that some of these Zoysia plugs had grown to five feet across. I should have spent more time plugging Zoysia than Bermuda for it has proven our best warm season grass.

These observations were all made at the Evansville Country Club, Evansville, Indiana. I am now with Big Spring Golf Club in Louisville, Kentucky. This spring we are going to put in 20 acres of U-3 Bermuda fairways. Also will put in a large nursery of Bermudas and Zoysia.

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THE GENUS OF BLUEGRASS

Itura Shiotani, Graduate Student
Purdue University

The genus Poa, meaning all bluegrasses, consists of perhaps 400 species and they are classified into about 20 genera. This is one of the largest genus in gramineae (grasses). We followed mainly Hitchcock and Roshen's classification. Little cytataxonomial study has been done on bluegrasses and we have limited knowledge on the nature of the species formation in Poa. We should consider the geographical distribution and polyploidy relationship of some Poa species.

We took a census of the Poa species. Two dark areas indicate the highest density. We found two separate centres in the world. One is the region including North India - Sikkim-Nepal region and a part of East Siberia. The other is the Rocky Mountain region in Western North America.

Table I. Frequencies of the Poa species in major areas.

Number of species	Location
78	No. Am. & Canada
106	Russia
44	Europe
34	Australia

Some species of Poa are characterized by wide variation in the chromosome numbers, namely, a series of polyploidy and aneuploidy within a species. In Poa the occurrence of aneuploids seemed to be related

to high level of polyploydy, but apomixis is not always associated with high polyploidy, because some lower polyploid species also exhibit apomixis.

Table 2. Some Chromosome ranges in Poa

	Range	Average
Pratensis	2 x - 18 x	10 x
Irrigata	12 x - 21 x	16 x
Compressa	5 x - 8 x	6 x
Alpina	2 x - 6 x	4 x

Although there is not any relationship between size of distribution area in polyploidy, as a convenience we classified them for the criteria, cosmopolitan, subcosmopolitan and endemic species.

Table 3. Relation of distribution and polyploidy in Poa pratensis

Species	Group	Cosmopolitan	Subcosmopolitan	Endemic	Total
Pratensis	Arctiea	2	7	33	42
Compressa	Stepposa	1	5	6	12

In the distribution of lower polyploid species, some diploid species are concentrated in Europe, but some are also scattered all over the north temperate region. Several tetraploid species in South America may be related to P. trivialis.

Last year one species P. autumnalis was reported as a diploid. Viellander obtained 2 plants of P. pratensis which had 2 n = 15 and 18. He observed they were similar to P. trivialis. These lower polyploid species, or their ancient relatives, should have some contribution in the species building of vast Poa complex which are represented by high polyploidy and aneuploidy.

Now we at Purdue are working on bluegrass breeding. Our interest is to introduce predominant characters of other species to the Kentucky bluegrasses. Our P. palustris are very resistant to leaf rust, puccinea poae - nemolaris, but this leaf rust is more or less common in P. pratensis and P. compressa. What internal factors or external factors, or combinations of some of them, which might control apomixis, is our current problem. This is my Ph.D. study under Dr. R. C. Pickett and W. H. Daniel at Purdue.

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ARSENICALS

Roger A. Brown, International Minerals & Chemical Corp.,
Skokie, Illinois

The word arsenic (As) comes from the Greek arsen, meaning "strong one". Arsenic trioxide, or white arsenic, is a byproduct of the smelting of non-ferrous ores and was first produced in the fifth century A.D. The largest producers of arsenic are the United States, Sweden, Mexico, Germany and Brazil.

The majority of arsenical compounds are colored pink to distinguish from edible flours or talcum powders. A simple test to determine whether a substance is arsenic or not is to put a small portion into an open flame, arsenic burns with a blue flame and gives off a disagreeable garlic-like odor.

Arsenic has long been known as a deadly poison. It only takes 1.5 grains to be fatal to a human being and between 30 and 60 grains for a cow or a horse. It was only natural then that this poison be combined with other chemicals to kill undesirable insects. Percentage-wise, the uses of United States' crude and refined arsenics are broken down as follows:

70% is used for pest control
15% for weed killers
3% for the manufacturer of glass
2% for wood preservation
1% for miscellaneous and medicinal purposes
9% for export

Lead arsenate ($PbHAsO_4$) was originally developed during the latter part of the 19th century in Massachusetts for the control of the Gypsy Moth. Calcium Arsenate $Ca_3(AsO_4)_2$ was developed around 1918, basically for the control of the cotton boll weevil. Prior to World War II, lead arsenate was the leading chemical for the control of turf chewing insects. When DDT was discovered, it took lead arsenate's place because of economy. Chlordane now leads the list as the most economical for turf insects.

Arsenic acid and lead arsenate have been used by golf course superintendents for years to control crabgrass and Poa annua. Arsenic acid has proven too dangerous for both man and plant and the increasing cost of lead arsenate has made its use on large areas questionable.

With the development of new pre and post-emergent chemicals it is hard to decide which is the best to use. Arsenical pre-emergent crabgrass killers have several advantages over the post-emergents:

1. Only one application is needed annually.
2. Toxicity to crabgrass persists for a long period.
3. Crabgrass is killed before it becomes unsightly or crowds out desirable grasses.
4. No dead crabgrass is left to mar the beauty of the turf.

Powdered calcium arsenate is the most effective and economical pre-emergent crabgrass killer on the market. It is not very desirable to handle and can be difficult to apply, which limits its useby the homeowner. The

pelleted and granular forms of pre-emergents are easier to use, but the cost is higher. Pelleted calcium arsenate costs about the same as powdered lead arsenate. However, the calcium arsenate will treat twice the area that the same amount of lead arsenate will, making it twice as economical as lead arsenate.

When you purchase pelleted or granular chemicals over the powder form, you are paying for convenience. When purchasing any chemical, read the label. Look at the ingredients - not the size of the package.

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USING ARSENICALS

Clarence Wolfrom, Supt., Maple Lane Golf Club,
Warren, Michigan

Our major emphasis has been on the use of sodium arsenite as an economical material in Poa annua reduction. The first thing to consider is the harm and damage that is caused by not using it properly. Some of the precautions we take are:

1. It's a poison and should not come in contact with the human body in any way.
2. Large quantities should not be used in the tile lines that empty into streams where cattle drink or fish live.
3. When used along fence lines to kill weeds or brush, make sure nothing drifts on the other side where cattle are grazing, or a farm crop is grown, or you may have a damage suit on your hands.
4. Clean the spray tank and all screen filters, hose and spray gun before spraying greens or shrubs. Particularly so after you have used a high percentage of the material.

Treating fairways for chickweed, angle worm, white grub and Poa annua with sodium arsenite.

Selective burning on fairways - repeated 3 times/season

Daytime Temperatures °F.	Sodium Arsenite lbs./acre	Comments
40 - 50	2	75 gals. water per acre
50 - 65	1.5	
65 - 75	1.0	
above 75	don't	

We try to get on three treatments between September 1 and May 1 - any time when the temperature is between 40 and 75 degrees. Be sure it is dry enough so the tractor and sprayer don't mark the turf, and there is no wind to drift the material on trees, shrubs, or greens. With this treatment we have eliminated the white grub damage entirely on the fairways and reduced worm casts. This has stopped Poa annua to a point where it is not taking over our fairways, and slowly but surely we are gaining on this unwanted grass.

We have found the best way to kill chickweed in our fairways is by spiking first. This will bruise the leaves and make them bleed so the sodium arsenite can get through the fuzz on the leaves and do a better job of killing the plant. We have had very good results in November with this treatment. A lot of new plants come up in the fall and are good size by November. The weather is colder and we are able to use the 2 lb. rate.

Treating Greens for Poa annua, chickweed, angleworm and white grub.

Daytime temperatures °F	Sodium arsenite ounces/1,000 sq.ft.	Comments
40 - 50	.75	5 gals water
50 - 65	.5	per 1,000
60 - 70	.33	
above 70	don't	

We water the green the night before so it will have enough water to last 40 hours. This gives the sodium arsenite time to kill the Poa annua seed before it is washed down in the soil to inhibit the roots. In applying this treatment every precaution should be taken not to burn the turf. One mistake may kill a lot of turf and you wish you had never heard of sodium arsenite.

A few things to watch that may cause damage:

Fill the spray tank 1/4 full of water, dissolve the dry sodium arsenite in a pail of water before putting it in tank. This will eliminate any chance of the material getting into the outlet of the tank and cannot be reached by the agitators. Spray in a sand trap for one minute before starting on a green. Hold the spray gun high and keep it moving.

River banks, Roadsides, fence lines and tile lines

We use 10 lbs. sodium arsenite in 150 gallons of water and wet the foliage. This will burn the weeds and grass down to the ground, but not kill the roots, and save a lot of hand mowing. We haven't used a scythe on our course since we started this treatment in 1947. The treated area will be brown for a while, but will soon turn green again.

We use the above mixture to kill roots in tile lines before they are completely stopped up. If the sodium arsenite can get through, it will stop root growth only temporarily at best. The best time to get good results with this treatment is when the roots first come in. Again this should never be used in tile that drains into a stream where cattle drink or fish live.

Sterilizing soil

Use 6 lbs. sodium arsenite in 25 gallons of water per 1,000 sq.ft. of green or nursery to be turfed. We go over the area with our spray boom and follow with the spring-tooth harrow. Repeat this operation 12 to 15 times, or until all the material is used up.

In summary, make sure your men using sodium arsenite know the full danger and damage it can do if misused. Also the good results if used properly. Never use when temperature is above 75 degrees, or when soil is dry. We think it is a good material if handled properly.

ARSENICALS FOR PRE-EMERGENCE CRABGRASS CONTROL

Frank C. Burns, Ferteleze Lawn Culture
Detroit 19, Michigan

In the Spring of 1958 we decided to see if arsenicals could be applied as a large scale operation with any degree of success. We chose calcium arsenate for lower cost and higher arsenic content. We applied five ton of calcium arsenate to approximately 750,000 sq.ft. of lawn. These lawns ranged in size from 3000 sq.ft. to one acre - the majority were over 20,000 sq.ft.

We began applying calcium arsenate on the 14th of March. We had an open and early spring and it took about two weeks to complete this operation. This was entirely too long due to the difficulty of applying calcium arsenate in large quantities.

We used a force feed power driven spreader (Lawn Beauty), but any attempt to fill the hopper over one-fourth full resulted in bridging. Also, we had to skirt the spreader, for with the extremely fine texture of calcium arsenate, any wind created a drift. This made it difficult to tell when bridging had occured, and application must be uniform to get maximum results.

Now something in favor of calcium arsenate. It was applied under very adverse conditions. After all applications were finished, the calcium arsenate laid on the ground from one to three weeks, waiting for precipitation to wash it in.

The results were excellent - to good - to fair - to poor. Again, we cannot balem it all on calcium arsenate. Crabgrass germinated in May on lawns that we had not treated, and there was very little in treated lawns. Some of the smaller lawns that had been watered properly had complete control. However, near the last of Mayd we applied a soluble fertilizer (10-20-30), plus Nitro-form at one pound per 1,000 sq.ft. We did not think this amount of phosphorus would over-ride the arsenic. However, in June, many customers stated they were now getting some crabgrass germination -- in most cases spotty. Whether this was from not having a uniform application, or it was released by the phosphorus, I do not know. However, I suggest a minimum of phosphorus on calcium arsenate.

In our search for a method of applying a more uniform application of calcium arsenate, we decided on the use of Flat (Lake Shore) Sand as a carrier. Due to the fine texture and bulk of 15 lbs. calcium arsenate, it needs 30 lbs. Flat Sand. This proportion feeds ideally through the spreader with uniformity and no bridging. Some may be interested in mixing sand, corn gluten, Milorganite with arsenic. The pelleted and granular forms are on the market in 1959 also.

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POA ANNUA AND CRABGRASS CONTROL WITH CALCIUM ARSENATE

Eules Skaggs, Supt., Moraine Country Club
Dayton, Ohio

Fairways

Poa annua over several years has become a serious problem with us in our fairways, green and tees. Our Board requests that we mow our fairways at a one-half inch height, so consequently the fescues and bluegrasses have completely left us and we are converting over to bents.

Two years ago we had a serious problem with our No. 1 fairway. The Poa annua completely died so that it was practically bare. In two weeks the fairway was filled with soft and hard crabgrass. This being a serious problem, I took my worries to Dr. Bill Daniel. After he loooked the situation over, he recommended that we should give calcium arsenate a try. So, we aerified the fairway in eight directions, to open up thatch and prepare seedbed. We used water as a carrier and spraying the fairway in two directions to get a good coverage with the calcium arsenate. Rate of application was 20 lbs. per 1,000 sq.ft. each time over.

This being a new chemical in the golf course work, we made a mistake in applying 40 lbs. of 85% Ca Ars to the 1,000 sq.ft., which was just double the total rate that we should have used. When we applied this heavy rate, the mature soft crabgrass died, and turned black within three days. We seeded bluegrass and bentgrasses at the time of application. The arsenic toxicity was so great that, after the seed had germinated,and grew to about 2" high, many of the seedlings died.

To over-ride this toxicity, we applied 350 lbs. of 20% super-phosphate to the acre. Then we seeded in early spring and got a wonderful stand of grass. Later crabgrass germinated and got to the two leaf stage, then died because of arsenic toxicity. The crabgrass problem has been licked in this fairway. On our No. 7 fairway last September we aerified several times, then sprayed 85% calcium arsenate. One month later we aerified two more times, this giving a nice seed bed. We then seeded - the results so far seem to be good.

Tees

We sprayed our tees,where Poa annua is a problem, in September. The rate of application was 20 lbs. per 1,000 sq.ft. Before the winter the Poa annua was rotten and had no live white roots. One can see the bent that is in the tees looks good.

I think that when calcium arsenate is applied, one should wait one month before any seeding is done. Just before coming to this Turf Conference, we seeded our tees with 2 lbs. per 1,000 sq.ft. of Penncross bent. Because the Poa annua has thinned out so much, the bent has room to grow.

Greens

We applied 16 lbs. per 1,000 sq.ft. divided into three applications, in the spring, 6 lbs. one month later, 6 lbs., and in early fall, before the Poa annua starts growth, another 4 lbs. completes the job. To keep the toxicity built up,we should use about one-fourth this amount each year. Our greens still are spotted with Poa annua, but it is weak, yellow

and sick, this giving the bent a chance to progress. Each application was applied in two directions for even coverage. One should use calcium arsente with caution because if you take all the Poa annua out at once there would be big bare spots.

On greens we may have to use more calcium arsenate over a period of time to get good results. If the pH or phorphorus is high, you will have to use more calcium arsenate We have irrigation in our fairways, tees and greens so we watered the chemical in right after spraying so that it would not have that white-wash effect.

Lawns

We sprayed a 1 acre lawn with 16 lbs./1,000 sq.ft. calcium arsenate for the control of soft crabgrass. Calcium arsenate killed the mature crabgrass within 3 - 5 days, although this was not expected. Calcium arsenate is somewhat toxic to the desirable grasses. They are discolored to a degree, but have a wonderful recovery. We can now buy calcium arsenate in granular form which is easily applied with a spreader. To me this chemical has several promises.

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ARSENICALS AND THEIR USES

James W. Brandt, Supt., Danville C. C.
Danville, Illinois

The use of arsenicals on the golf course falls into two categories. They may be used as insecticides, or they may be used in the control of weedy grasses, such as Poa annua and crabgrass.

The use of arsenicals for insecticides again fall into two broad basic classifications. The classifications are: (1) use as a control for leaf feeding insections; (2) use for soil borne or root feeding insects such as grubs. If grubs or other root feeding insects are your only problem, their control may be more effective and far more economical with chlorinated hydrocarbons, such as chlordane, or some of the newer organic phosphate insecticdes. For leaf feeding insects I still like to use light, repeated applications of arsenate of lead.

When I became a golf course superintendent about nine years ago, the trend was not to use the arsenicals as an insecticide. This was due chiefly to the economic factor. However, some of the older and wiser superintendents believed that arsenate of lead served some useful purpose other than just being an insecticide. They noted that Poa annua seemed to be more of a problem than it had been when arsenate of lead was widely used. This brings us to the second major use of the arsenicals, and that is their use in the control of weedy grasses.

For weedy grass control arsenicals again must be divided into those that offer either pre-emergence or post-emergence control.

The post-emergence treatments are placed, either by spraying or dusting, on the plant leaf, and it is absorbed by the leaf. Materials used in this fashion include di-sodium methyl arsonate and ammonium methyl arsonate. The advantages are:

1. Ease of application
2. Lower initial cost
3. Only needs to be used after you are sure you have infestation

The disadvantages are:

1. Repeated applications may be necessary to control
2. Some materials have a tendency to weaken desirable grasses
3. Rainfall or irrigations may wash material off leaves before it is absorbed.
4. Most materials must be applied in May, June or July (your busy months) when labor is at a premium.

Pre-emergence treatments are placed on or in the soil before seeds germinate.. Advantages are:

1. May be applied during dormant season of grass when labor is not at a premium.
2. Subsequent rainfalls do not hinder effectiveness
3. Have residual value, once toxic levels are reached the treatments become less expensive to maintain that desired level.

The disadvantages are:

1. High initial cost
2. Most materials difficult to handle. Pelletizing almost doubles cost of the materials.

Much work has been done here at Purdue with the arsenicals as pre-emergence materials for the control of crabgrass and Poa annua. The following rates have been pretty well accepted as standards. For crabgrass control 12 lbs. of calcium arsenate per 1,000 sq.ft., or 24 lbs. lead arsenate per 1,000 sq.ft. For the control of Poa annua, these amounts are increased 50%.

I really believe that Dr. Daniel asked me to talk on arsenicals as he knew that I had a crabgrass problem on my fairways. I was impressed with the use of calcium arsenate after viewing the results of theField Days in 1957, and I decided to put out 2 acres of plots on my fairways. And, if the results were good, I would sell such a program to the golfing membership of the Club for fairways.

Calcium arsenate, 85%, was put on at the rate of 450 lbs. per acre with a farm type spreader in March of 1958. I had a definite plan to sell the control program to the membership. Fairway mowers were set up to 1-1/4 inches. This immediately brought a howl from the players. I informed them that I was cutting at this height to try and control crabgrass. Player demands for a lower cut increased according to plan. By May 25, when I was sure that we would have a good crabgrass crop and that the control program would work, met with the golfer's committee. I agreed to set the mowers to 7/8 inches if they would go to bat for me if the control program was successful.

Around Labor Day, when crabgrass was at its finest, I placed signs on the control plots. The following slides show that crabgrass control was excellent. Along with this we fertilized the bluegrass. In January of this year, these slides were shown to the Board of Directors. Funds were allocated for a control program for all the fairways at the Danville Country Club.

It is my firm belief that crabgrass can be controlled. This year will be a very interesting one. Next year I hope to report that we were not bothered with crabgrass.

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ARSENIC TOXICITY TO WEEDY GRASSES

W. H. Daniel, Turf Specialist
Purdue University

May I call your attention to three words. The first is performance. None of us are interested in a product of importance to lawnowners, regardless of cost, that does not give satisfactory performance. We will get variable performance, over the wide range, but a chemical should do the job technically.

The second word is convenience. Pelleted, granulated - dust-free, non-staining to the clothes, not toxic to the user, easy to apply, doesn't burn turf, doesn't cake in the bag - all of these make products useful to a wider group of users. Usually the more conveience built into a product, the more it costs. For example, convenience in package sizes. There is a lot of difference in buying a 1 lb. bag at a garden center with all the convenience this offers in availability, than in attempting 50 - 100 lb. purchase, when little is needed.

When you get past performance and convenience there is a third word -economy. Only when performance and convenience is good, does the novice become interested in "economy." It is a big word, it is an important one, but only in this order - performance, convenience, economy. You may pay an awful lot for the 89¢ can for which the chemical costs very little, but you figure up the convenience, availability and economics that goes into making of the product available on the shelf where you are shopping.

Let me review two or three items. We have been combating Poa annua, a weedy grass. We know that it can be affected by arsenicals, when you have a toxic concentration of available arsenic in the rootzone. Where is the rootzone? At the top edge of the ground for a young seedling, so we talk about getting toxicity at the surface. Poa annua is a more shallow rooting crop than some turfs so it will pick up arsenic and react to arsenic toxicity.

We talk about killing crabgrass. We know in a grass seed there is enough phosphorus to get a little plant started. But, in most seeds the phosphorus is only enough to get the seedling up to the two leaf stage before the plant has to get its phosphorus through its roots. In

weedy grass control we try to prevent the seedling from getting past the seedling stage by having arsenicals at toxic concentration on the soil surface.

There are three situations, particularly at the novice level, where pre-emergence may be wanted. The first if where you have a good turf cover. There the primary purpose is to inhibit weeds, Poa annua, foxtail, etc.

Second situation. Turf is sparse and thin. It has spots of crabgrass - it is kind of sick looking. How can one prevent the infestation of weeds? In either of these situations you can use arsenics, chlordane, or some of the weed killing materials. (On some bluegrasses you can use Neburon 2 - 4 lbs./acre of active). They may be used on the good turf satisfactorily - they will work on sparse turf satisfactorily.

Third situation. The poor guy who has read the newspaper ads and hopes to keep out crabgrass, but if he keeps out crabgrass then his lawn cover is sparse, but his neighbor may have a luxuriant growth of crabgrass. Which would he like in July?

Then there are three sales conditions. First, the person interested in protecting the good turf he has. He can use protecting materials when the season starts.

The second type want crabgrass control, but they also are accustomed to fertilizing and the turf may well need fertilization. Then use both, but nitrogen is the preferred nutrient. A fellow in Huntington, Indiana said he had treated 100 lawns in 1958. He only had trouble on those lawns he treated with liquid fertilizer. Why? I would suppose when he put on the liquid fertilizer when the young crabgrass was coming up so it got more phorphorous availability than it had arsenic. The phosphorus over-rode the arsenic so the arsenic was not toxic.

Third type of sales. People want crabgrass control. They need the seed and the turf sure needs fertilization. What will you tell him? There is one thing for sure - If he buys arsenic, it will cost. The whole pre-emergence control is based on a little assumption that you can grow good turf and that is a rather sensible assumption, but not so simple when you consider the adversity and the difficulty involved in some turf locations.

I would hope this fellow would overseed as early as possible and get the seed started. He should use bluegrass as one of the components of the mixture. He should be on time with arsenic application. So, tell him to go ahead and plant grass seed, but use the arsenic only on a trial basis, but not on all the area.

What about new lawns? Most people want a ground cover above anything else, so leave out the arsenicals. Later on in season use a post-emergent material. Then next year use arsenicals or chlordane.

There are three types of understanding. Some, because of knowledge gained and through experience, now understand the principle and know what it takes. The question is to provide budget and labor to make control program active. Some of you are in that category.

There are those who are just now interested. This is their oppor-

tunity to test and try it in a limited way. It isn't a question of budget perhaps, but make test sites and show what good management is in 1959 on a trial area. Several of you will be in that group. For many arsenic is new in idea and practice, so, you will sit back and keep an eye open at your meetings, at the Fall Field Days so you can get acquainted. Then,next year you may try it. You will go directly into rapid use based on budget and time limitations.

We have three sales conditions, three turf situations and three levels of understanding of the user.

I am optimistic about pre-emergence chemicals for preventing weedy grass encroachment into turf areas. Certainly the recent progress indicates that industry will provide products and tremendous advances will continue to be made.

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FAIRWAY RENOVATION, HOW AND WHY

Gerald Dearie, Supt., Medinah C.C.,
Medinah, Illinois

The renovation of fairways requires a great deal of turf knowledge and know how, if it is to be effective. As in many other things, there are two thoughts - the short cut and the long pull. The short cut is the more drastic method of approach and involves the defoliaging or burning off the existing undesirable grass and weeds with chemicals, or plowing, then reseeding. The other, a more gentle approach, is the long pull with the know how through proper fertilizer, water, mower, insecticide and herbicide use. Often the long pull will be more acceptable to the golf clubs or parks. The short cut could apply more to the athletic fields and cemeteries. However, you can reach your goal through either method.

Just because you have gone through the practice of eliminating the undesirable grasses and weeds does not mean you have your problem solved. Youw answer will be in how well you will manage your new grass. Poor drainage, soil compaction, and soil fertility are other facts that cannot be overlooked in establishing desirable turf.

It is a common practice to plant a mixture of grass seeds on the fairways. One mixture could be 40% bluegrass, 20% fescue, 15% redtop, 15% ryegrass and 10% bent. It appears to me the planting of a mixture is a mistake. You cannot apply the know how to the individual species when used in a mixture, because your management practice on bluegrass may not apply to the bents, etc. You have to know the fertility of the soil and its requirements to grow the type of grass best suited for your particular location. It is possible to grow any desirable grass individually either on a hillside or in the lowlands with favorable management.

If you want bent fairways, plant bent seed only. The same thing applies to the fescue or the bluegrasses, or any grass. (When I say plant, I mean 100 to 150 lbs. of seed per acre).

Timing is the controlling factor in the planting of the seed, in getting the ground covered and reduce weed infestation. The old theory that it takes two years to establish bluegrass is not true today with our equipment and know how.

A renovation program has been in progress for a number of years at Medinah Country Club. In the spring of 1955, the 54 fairways consisted of 80% Poa annua, 10% bent and 10% foreign weeds. Thie renovation program has been followed out on the three courses. In this discussion, I will refer only to the Championship Course No. 3. This Course has 2 water holes, 1 short hole and 15 fairways which covers approximately 50 acres of heavy clay soil. Crabgrass in the previous years had been a terrible problem.

We started in April 1955 with an application of 350 lbs. of Arsenate of lead mixed with 600 lbs.of fertilizer per acre. Things looked fine until July 15, when following 16 consecutive days of 90° of above temperature and with 5 inches above normal rainfall, the Poa annua was gone, leaving dandelions, clover and a little crabgrass. However, the young crabgrass that was showing was so reduced you could see the application of arsenic was doing all we hoped it would in controlling the crabgrass.

On July 18 we sprayed the fairways, using 1 quart of 2,4-D and 1 qt. of 2,4,5-T mixed with 100 gal. of water per acre. This took care of the clover, dandelions and some of the young crabgrass. Five days later we started to spike the fairways with a 3-gang disc fairway spiker, spiking from three to five ways.

We then sowed 100 - 150 lbs. per acre of Highland bent seed on six fairways, then rolled and kept the ground moist. Within five days the seed was germinating. The weather was dry during this planting work, but we irrigated and by mid-August we had a good stand of grass. In September we applied 400 lbs. each of Milorganite and 5-10-5 per acre. In December we applied 2300 lbs. of ground limestone per acre.

In April of 1956 the fairways received 800 lbs. of Milorganite per acre. The results indicated progress was being made against Poa annua as well as broad-leafed weeds and crabgrass. Poa annua was more of a problem on the first six fairways. On July 15, with temperatures in the 90's, we stopped watering for as long as we dared - about 10 days - to retard Poa annua. The fairways began to look dry in spots. We then applied 100 lbs. urea, 45% nitrogen, per acre. We started to water and within a week the bent began to outgrow the Poa annua.

In August we set the mowers down below 1/2 inch. During this period of renovation work we continued to se the mowers down until we were cutting 1/4 inch in height. This helped show up the weak spots. Whenever turf began to show signs of thinning out, we would spike and seed, used approximately 800 lbs. of Highland bent seed on the 15 fairways. In September we applied 1,000 lbs. of Milorganite per acre. In October we raised the mowers to cut at 1/2 inch and are continuing this height. In late November 1956, we applied 1,800 lbs. of ground limestone per acre, completing our renovation program on No. 3 course, and the results are gratifying.

I would like to thank Al Radko, O. J. Noer, Bill Daniel and James Holmes for their help in completing this successful renovation program.

In the years of 1957 and 1958, Medinah Country Club's Annual Report stated that "Poa annua and crabgrass are no longer a problem at Medinah Country Club No. 3 Course."

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EXPERIENCES IN FAIRWAY RENOVATION, WHAT AND WHY!

Paul W. Neff, Supt., Scioto Country Club,
Columbus, Ohio

When I became Superintendent at Scioto Country Club in December 1957, I was told that one of the first orders of business was to start a fairway program that would produce a high quality turf and promptness would be appreciated.

The case history, as related to me, seemed typical. Nine years ago a watering system had been installed in better than average bluegrass and fescue fairways. With the golfer's insistence on closer cutting, the fescue quickly departed and the Kentucky blue gradually was eliminated by Poa annua, knotweed, chickweed, clover and crabgrass. The turf cover was possibly 90% Poa annua, with small patches of Kentucky bluegrass and bentgrasses.

The problem was simple. Remove the weeds and establish a dense close-out stand of bentgrass that would meet our golfers demands for championship turf. The solution, of course, was not quite as simple. It involved a lot of plain hard work, exact timing and a large quantity of materials. It further involved countless accusations of being a "dreamer" and "sticking" the Club with a costly program. Strangely, and also fortunately, almost all of the static came from outside the Club - other golfers and passesby who saw the fairway project from the adjoining streets. In fact, one chap came and took pictures to put in a news article, telling why it wouldn't work. Fortunately, he waited until success was obvious, so changed his story.

This may sound as if I am getting off the subject a little, but it just goes to show what I might have been involved in, among our own players, if everyone had not been informed what was going on and what to expect. Although our "scorched earth" renovation was new in the Columbus area, our program was not without precedent. I recalled O. J. Noer tell where this had been done with heavy rates of sodium arsenite. Carl Springer used it a few years ago at Congree Lake with outstanding results.

I talked to the Greens Committee about two methods, either killing all the fairway vegetation and reseed, with six weeks of bad golf, or increase what bent we had by favorable maintenance practices. Because the bentgrass present was not uniformly thin but in patches, this would have taken lots of reseeding and years of coaxing.

Charles Wilson of Milwaukee, and Jim Holmes of U.S.G.A. concurred with my observations and soon afterwards the Greens Committee approved a plan. I had given them a choice of doing the right or left half of each fairway, or the front or back nine the first year, and the balance the second year. They decided to do all eighteen and get it over with. The Board of Trustees approved the plan, and the members were notified by mail in March, before summer plans were made. All fairways would be treated by August 18, then seeding would be done September 2, weather permitting.

The fairways were sprayed with one pound of 2,4,5-T and 1/2 lb. of 2,4-D per acre in July to remove clover and broadleaf weeds. This was done early to prevent inhibition of seed germination. August 18, as per schedule, the fairways received the first application of sodium arsenite liquid concentrate at 35 lbs. per acre in 50 gals. of water. The kill was almost complete with recovery of an occasional spot of Kentucky blue, bentgrass and African Bermuda.

Three days later we started seedbed preparation. Lights had been put on one tractor that was to pull the aerifiers, and three shifts of men were used because going over all the fairways eight times was going to take a lot of time. Another tractor pulled a rotary hoe behind, which had a chain link drag to break up the cores. This tractor could keep up by going day shift only.

Milorganite was applied at 500 lbs. per acre on August 29. We aimed to put on more, but that was a wide open setting on our spreader and we never got over the ground again. By September 2, when we expected to start seeding, a "green haze" from a new crop of Poa annua was evident, especially where the ground had been stirred, so a second application of sodium arsenite at 20 lbs. per acre was put on that day. That took care of existing Poa annua.

On September 8, with 400 lbs. of 10-3-7 fertilizer ahead, seeding started. Rolling followed and irrigation commenced as soon as two or three fairways were completed. All watering was done during daylight hours to catch nozzle clogging, sprinkler stoppage, or flooding before washing could occur.

A bent seed mixture, 45% Astoria, 45% Highland and 10% Penncross was drilled lengthwise and crosswise at a total rate of 100 lbs. per acre. The heavy rate was justified to get the jump on the tremendous suply of Poa annua known to be in the soil. Watering continued until September 16 when light gentle rains came, about 1/4 to 1/2 inch daily, until we had received over 2" in five days. A wonderful help! Watering was then resumed at heavier rates and at less frequent intervals.

Mowing began four weeks after seeding and continued twice weekly until November 21 when growth became slow. Cutting height was at 3/4 inch. At five weeks after planting, the four inch drill spaces were solid bent in most places and voids were filling rapidly.

We have won a big battle, but the war is not over. We are using lead arsenate and calcium arsenate for pre-emergence control, and will continue some light sodium arsenite treatments if needed. Poa annua population during the fall months did not appear to run over one percent. Now, with the bent frozen and brown, it looks as if it might run two percent. When it blooms it will look like even more.

Our records show a labor cost of $ 942.00; sodium arsenite liquid concentrate $ 506.00; bentgrass seed $ 1,850.00. The fertilizer would have been used even without the above program, and part of the labor cost would have been using in mowing what we had.

In retrospect, I can say that the project was a lot of hard work, but also a lot of fun. I am satisfied that "scorched earth" renovation really worked for us, and, as of this date, think our greatest skeptics would agree. I received wonderful cooperation from the golfers and they are enthusiastic about the results.

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STERILIZATION OF LARGE AREAS

Eugene Johanningsmeier, Hiram F. Godwin & Son,
Detroit 19, Michigan

Let us first review the reason we felt Dowfuming on a large scale was necessary. Since bentgrass is cross-pollinated, it becomes mixed bent if seedheads form and mature. In the production of bentgrass stolons, it is essential to remove all seedheads as they are formed, before they become fertile, to maintain the purity of the selected strain.

Once seedheads have matured in an area, there are millions of seeds in the soil, making it impossible to use the area for stolons or pure strains of bent sod without first using some method of killing these seeds. We had one area that was seed-infested -- both bent and Poa annua seeds were present. To continue producing high quality stolons that are true to name, we decided to completely sterilize this soil rather than move our stolon production area.

There are several possibilities of cleaning up an area, one being keeping the soil fallow to give the seeds a chance to germinate and then be killed by cultivation and drying. There are several different chemicals that might be used to achieve the same goal. Vapam and VPM both require a water seal immediately after application, and for 2 - 4 days after application. The use of these chemicals would have necessitated an irrigation system to cover the entire area at one time. Two other materials that have been used for seedbed sterilization are calcium Cyanamid and N-dure F-85. Cyanamid has been used quite successfully for many years in the tobacco producing areas for seedbed sterilization. In its breakdown process, an intermediate compound (dicyanamide) is formed, which is extremely toxic, and does the sterilizing. When using Cyanamid or N-dure F-85, there is a waiting period of 1 - 3 weeks required before planting, due to the high concentration of nitrogen remaining in the soil.

Dowfume has been successfully used for several years on both small plots and areas as large as football stadiums. Many of you have read reports and listened to talks presented by John Davidson of the Dow Chemical Company concerning these uses. Mr. Davidson and Mr. Earl Lutz developed a hot water bath vaporizing technique of applying Dowfume

which was an improvement over the old method of using evaporating trays or pans. Literature pertaining to these methods and practices is available for your study. Recently the Dow Chemical Company developed a machine for laying the polyethylene necessary for covering the Dowfumed area. Through their co-operation it was possible for us to use this machine on our project. Without the use of the tarp layer it would have been virtually impossible to Dowfume large areas, due to the labor involved.

Hand-weeding stolons has been necessary throughout the growing season. We hope we have eliminated most of this hand work by sterilization. The tarp laying tractor had a vaporization tank mounted on the front, a 100# cylinder of Dowfume gas on the right, the 20# tank of stove gas in the center, and a hot water bath on the left. The stove gas is used to fire the multi-jet burner under the hot water bath. The Dowfume gas is piped through plastic to the rear of the tractor where it is metered, and then returns through plastic tubing to the hot water bath where it runs through 25 ft. of copper coil, which vaporizes the liquid entirely. The vapor then goes to the back of the tractor where a Tee fitting divides it so that it is exhausted through two plastic tubes that trail 8' back under the polyethlene cover being laid behind the machine. The meter and the valve that controls the rate of application has been calibrated for forward motion in M.P.H. and the width covered (square feet per unit of time).

To start, the polyethylene unrolls from the machine and is sealed across the end by hand with a shovel at the start of a roll. A general view of the back of the tractor would show the plastic roll, the press roller and the exhaust tubes. The slightly canted rubber press wheel pulls the polyethylene cover tight and the coulter covers the edge with soil to seal it. In joining of the end of one roll of cover and the beginning of another, simply by overlapping 2 ft. and hand cover all edges with soil to prevent leakage of the gas.

Most of the sterilizing was done during the first week of August, and approximately four weeks later it was planted. A man used a jet-stream of water to thoroughly wash the stolons that were taken from our foundation material to plant the sterilized area. Two weeks after planting, on October 1, no weeds or other grasses have germinated.

We sincerely hope that providing the finest stolons possible that everyone may have excellent putting greens. On question might be cost, so I will mention it before closing, approximately $ 1,000.00 per acre, but we expect it to save several hundred hours of labor.

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BETTER TURFGRASS IS THROUGH SOIL ANALYSIS AND CONTROLLED FERTILITY

O. J. Noer & C. G. Wilson, Milwaukee Sewage Commission
Milwaukee, Wisconsin

The Sewage Commission started testing soils in 1928. This was the year the "Acid Era of Turf Management" died with the grass on greens throughout the north. It was realized then that soils can become too acid for grass and lime came back into favor.

Since 1928 our Soils Laboratory has averaged testing almost 3000 samples each year. Almost all of these were from turf areas. Although the value of quick soil tests are being disputed by some, we believe them to be a useful tool, provided proper methods are used. Samples must be taken to an exact depth of 2 inches, be uniform in diameter and a composite of representative areas. In the laboratory, solvents of sufficient strength must be used and there must be a consistency of laboratory supervision. Finally, the soil test results should be interpreted by someone familiar with turf.

Sewage Commission soil tests are designed to determine possible need for lime, and to estimate the amount of water soluble and immediately available phosphorus, potassium, calcium and magnesium in the soil. Sometimes soluble salts are also determined. The results serve as an inventory of soil fertility levels. When used that way, soil tests are a useful guide in devising an effective fertilizer program.

Some laboratories test for organic matter and nitrogen. Plant tissue tests are more promising than soil tests for nitrogen because none of the existing soil methods are satisfactory for grassland areas. Need for nitrogen can be judged by the behavior of the grass. Poor color, thin turf, slow rate of growth, and the presence of weeds and clover are the customary signs.

Field testing with any one of several inexpensive test kits, which are quite accurate, is satisfactory for the purpose of judging lime requirements. The solutions should be reasonably fresh, or the results may be inaccurate due to the effect of the glass on the reagent. The pH will be too high unless the glassbottle used for the solution has been "weathered" by the manufacturer of the set. The indicator solution should remain in contact with the soil for a sufficient time to develop maximum color before it is matched with the color chart.

Soils which are more than moderately acid, that is below pH 5.7, definitely need lime and its use is justified without regard to any other factor. Lime may be beneficial when the soil is slighly acid, in the range of pH 5.7 to 6.2, particularly when Kentucky bluegrass predominates. When soils are sufficiently acid to need lime, it is desirable to determine the quantities of available calcium and magnesium. Some acid soils are so deficient in magnesium that plant growth is depressed as a consequence. Then a dolomitic type of limestone, containing not less than 25% magnesium, reported as the oxide, should be used.

When magnesium availability is less than 1,000 lbs. per acre by the Truog Method, a deficiency is likely and probable. Calcium is less important, but the available range should be 4,000 to 6,000 lbs./acre or more.

Much of the criticism about soil testing is justified because of poor sampling, or the use of a method which is not suited to specialized turf areas. The interpretation of the results is important also. What may be an adequate level of phosphorus and potassium for fairways, may not be enough for greens or lawns where clippings are removed.

The commonly used tests, such as Purdue, Truog, Morgan, Spurway, or Edwards, etc., differ essentially in the strength of the solvent used to extract the soil nutrients. In each a small amount of soil is extracted for a definite period of time. The solution dissolves all the water-soluble nutrients, plus the easily soluble ones, which are readily available to plants. Some kits use solvents which are too weak for turf areas. These may fail to distinguish between high and low levels of phosphorus and potash.

Soil samples were collected to a uniform depth of 3 inches from 3 fairways at Pickwick and Evanston Golf Club in Chicago. Phosphorus was determined by the Truog, Purdue and original Spurway method. Purdue and Spurway use designations very low, high, etc., and Trug reports pounds per acre with 75 lbs. being enough for fairways and lawns. The soils were dark colored silt loams in each instance.

Table 1. Phosphorus test results

Course	Sample	Truog	Purdue	Spurway	Comments
Pickwick	A	10 lbs.	V.L.	L.	All
	B	10 "	V.L.	V.L.	showed
	C	25 "		L.	low
Evanston	A	90 lbs.	H-	None	Spurway
Golf Club	B	90 "	H-	None	low
	C	100 "	H-	None	

Phosphorus was low with all methods at Pickwick and grass responded to its use. At Evanston the Truog and Purdue methods showed adequate supply - which was borne out in practice. Spurway method showed an acute deficiency. Similar results were obtained with potassium tests. As a result of these and other tests, which were submitted to Dr. Spurway by us, he prepared a stronger solvent and suggested using it on soils showing low results with the original solvent, which is essentially water.

For simplicity and convenience, most laboratories report results as Very High, High, Medium, Low or Very Low. Although these terms appeal to the layman, they are misleading as ordinarily applied. Fertility levels should be higher in greens than fairways because clippings are removed, and growth is maintained by more frequent and more generous watering.

By reporting the amounts as pounds per acre, it is possible to establish different levels for fairways and greens. Our laboratory uses this method for that reason. With the Truog method, fairway samples should contain 75 lbs. phosphorus and 175 lbs. potash per acre. The corresponding figures for greens are 200 to 300 lbs. for phosphorus, and 300 to 400 lbs. for potash.

Two samples taken at the same spot but to different depths will contain different amounts of available phosphorus and potash. The deeper

sample contains the least. To obtain consistent results and to show and follow trends, it is necessary to take samples to exactly the same depth at all times. It is why we standardized on 2 inches.

The amounts of phosphorus and potash decrease with depth on grassland areas because the soil is not disturbed after turf coverage is obtained. Both are fixed near the surface. Failure to appreciate this fact has been responsible for misleading results even with the better soil testing methods.

Samples were taken to 3 depths on a fertilizer plot at Blue Mound C.Cl. in Milwaukee. Available phosphorus was determined by the Truog method.

Table 2. Phosphate test - same location

Depth Inches	Pounds	Interpretation
0 - 1-1/2	65	adequate
0 - 3	35	inadequate
0 - 4	25	inadequate

Superphosphate was applied in spring and again in the fall on plots at Tuckaway Country Club in Milwaukee. One plot received 600 lbs., and the other 1,200 lbs. in total amounts of 20% grade superphosphate per acre. The original turf was exceedingly poor, but no noticeable improvement occurred as a result of phosphate or potash applications. However, heavy nitrogen feeding produced tremendous improvement.

Samples were tested by the Truog method. Results show that most of the phosphate was retained in the top two inches of soil.

Table 3. Phosphate fixation in soils

Depth	Check	Add Superphosphate/A	
		600 lbs.	1200 lbs.
in.	lbs.	lbs.	lbs.
0 - 1	70	100	140
1 - 2	40	65	80
2 - 3	25	45	55
0 - 2	55	82	110

Attention has been called to the fact that many greens are becoming low-grade phosphate mines. Ordinarily our laboratory does not show amounts above 800 lbs. per acre because it necessitates considerable extra work. In some instances the exact amount has been determined. They are exemplified by the following results from greens in Cincinnati at Joe Allen's two courses. Avon Fields is the older of the two courses.

Table 4. Available phosphorus in greens - 2" depth - Truog method

Green No.	Golf Course	
	California	Avon Fields
	lbs.	lbs.
1	1900	3300
5	2700	1250
9	2800	3900
13	2900	3800
17	2000	4000

Damage may result from a high concentration of soluble salts, usually chlorides and sulphates, but carbonates as well in spots where underground or other sources of water have a high content of chlorides and sulphates. Grasses have trouble absorbing water and nutrients, especially in hot weather when soluble salts are high. Failure of seed to germinate is one of the first signs.

At Southern Hills in Tulsa, Oklahoma tests showed the soil in the greens to be high in soluble salts, especially chlorides. The backwash from the water softener was blamed in part. It was discharged into the pond from which water was used for the greens. The backwash was diverted elsewhere. The difference in salt content after two years is shown in the following tests for chlorides:

Green No.	Soluble Chlorides	
	1949	1951
	lbs./A	lbs./A
2	4000	1500
7	4000	2000
9	4500	1500

Soil testing, when properly done, is a useful tool in turf production. Unfortunately, some methods are not satisfactory and at times even the best ones are not entirely trustworthy. Much progress has been made, and in the not too distant future even better methods will be evolved.

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PYTHIUM - A BASIC PROBLEM

James L. Holmes, Mid-Western Agronomist,
U.S.G.A., Green Section.

It has been known for quite a few years that Pythium sp. is pathogenic on most species of turfgrasses. However, it was not until Dr. D. Wells, Plant Pathologist at the Georgia Coastal Plain Experiment Station investigated the extent of damage by this fungus that its mode of action, extent of damage and area of prevalence was well understood. Since 1953 he has worked toward finding chemical controls for this virulent turf pathogen and mapping its life cycle.He has made some interesting discoveries and has arrived at some interesting conclusions.

The Pythium species which attack turfgrasses can occasionally be damaging when temperatures are in the 50's and 60's. However, it is usually not serious until temperatures are above 80° F. and free moisture as dew, rain or water-soaked turf is present. When this combination of heat, humidity and free moisture is present, Pythium can be, perhaps, the most completely destructive of any fungus which attacks turfgrass. I would like to re-emphasize that Pythium - water mold - usually require free moisture before it becomes a serious problem.

Visible symptoms of disease of the visable pathogenicity of Pythium include small spots which coalese to form large dead areas. This may

follow wet areas or natural drainage. On turf in the deep south, the entire area can be attacked at the same time. A green can be one solid mass of "cotton" and the turf (usually rye) is killed in a matter of hours. One of the worst factors of Pythium is that the entire plant - roots - stems - leaves - nodes - is usually completely killed. This is one good reason why Pythium is so devestating.

Control

A combination of environmental conditions is usually present before Pythium becomes excessively damaging. If just one of these combination of factors can be eliminated, Pythium attacks will be much less severe. Of course, we can do little about the temperature and humidity. However, we may control water somewhat. If greens are built so that excess water is carried away, we can have more control. We can, also, control water by making sure greens are not watered in excess during periods of high heat and hmidity. Trim low growing brush around greens and encourage air circulation as much as possible; keep mat and thatch to an absolute minimum; loosen soil if compacted and thus favor evaporation. Actually, control of Pythium (or any disease) through manipulation of environment adds up to all around proper maintenance practices.

Pythium is extremely difficult to control with chemicals. Often there is free or excess water to dilute and remove the chemical and the usual occurrence of rain at the time Pythium is active. In this particular area, copper sulfate at 1 to 2 oz. per 1,000 sq.ft. seems to give as good a control as anything thus far used. I suggest that you try copper sulfate on a test basis to determine if it will work for you. However, be sure to check the pH to determine if it is above 6.0. If it is not it could be dangerous to apply copper sulfate as copper toxicity is known to be a problem on acid soils. Hydrated lime often seems to reduce damage by Pythium. It seems to make little difference whether the lime is sprayed-on or powdered-on. During hot weather I would be reluctant to apply more than 2 lbs. of hydrated lime per 1,000 sq.ft.

Many has reported that Kromad, Acti-dione and Auragreen have controlled this disease. I would certainly suggest that you try one or all of these if Pythium is a problem.

From his work at Tifton, Dr. Wells has observed that Captan, Phygon XL, Acti-dione (and various Omadine salts which are not commercially available) are quite effective against Pythium. It appears that a mixture of Captan andActi-dione complement each other, or are synergistic. When used together they are more effective than either used alone. Dr. Wells suggests that you try the following when Pythium is active:

1. Put a small amount of water (20-30 gals.) in the spray tank and add Captan (50% active) so there is enough chemical present to apply 4 oz. to every 1,000 sq.ft. to be treated.

2. Keep mixer running and add another 10 - 30 gals. of water.

3. Add Acti-dione - ferrated or Acti-tabs - so that 0.6 of a gram will be applied to every 1,000 sq.ft. to be treated.

4. Fill spray tank to desired amount.

5. Figure water and material so that 5 to 10 gals. of water, which carries the desired amount of chemical, are applied to each 1,000 sq. ft. of turf to be treated.

6. Dr. Wells reports that Dichlone 50% active (2, 3 - Dichloro - 1, 4 - Naphthoquinone; Phygon XL at 4 to 6 oz. per 1,000 sq.ft. is quite effective against Pythium. However, this material is somewhat toxic to bentgrass and should be used with caution. Control of Pythium is increased when Dichlone is mixed with Captan. On bentgrass, it you wish to try this mixture of chemicals, I suggest you apply them to a test area and observe results.

If you try all these various prescriptions and nothing works, perhaps the next step is to hurry off to church.

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CONTROLLING SMALL ANIMAL DAMAGE

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Damage to lawn areas by small animals can take several forms. Most serious are mounds of dirt brought up from below that smother the grass and interfere with mowing operations. These are generally caused by two species of animals: (1) moles - cone shaped mounds with or without connecting ridges of earth, (2) pocket gophers - generally larger, fan shaped mounds without visibly connected runways. Neither type has external openings. While moles are common throughout most of this area, pocket gophers are found only in several northwestern counties in Indiana, Central Illinois, and westward.

Another type of damage is the burrow openings of ground squirrels, Norway rats, mice and crayfish. The burrow openings of ground squirrels and rats are about 2½ to 3 inches in diameter. Those made by rats are usually marked by a pile of loose dirt in front of the hole, which is not true in the case of the striped ground squirrels. Some species of ground squirrels do leave mounds. Smaller holes under two inches in diameter are made by mice or crayfish. Mouse holes go into the ground at an angle, while crayfish burrows go straight down. There may or may not be a mud chimney, but in most cases water can be detected in the bottom of the crayfish burrow.

Mole Control

The most effective bait for moles is earthworms dipped in poison baits. As these must be treated with deadly toxicants, which are not generally available, they should only be prepared by pest control operators. Large worms with several anterior segments removed to prevent burrowing, should be moistened and dusted with strychnine sulfate, or soaked in a solution of Compound 1080 (sodium monofluoroacetate) for about an hour. Place two treated worms in an active mole runway by means of probe holes, making about four placements per runway system. Plug hdes so no light enters. Another good bait used in same manner and available commercially, is thallium sulfate-treated peanuts.

Trapping is effective when traps are properly set. Moles make many "feeding runs" in their search for food. The moles regularly use main runways in moving from nests to the general feeding areas. To locate these runs, roll or stamp down with the foot the earth ridges at various spots, particularly near stone fences, stumps, trees or rough ground. Those sections that are raised up should be flagged for trapping. The best technique is to dig out a small section so the trap can then be located in center of the runway and there will be no obstruction to interfere with its action. The hole is filled up again and tamped lightly so that it is in contact with the trigger.

An indirect method of control is obtained with soil insecticides that kill earthworms and grubs that form the chief food supply of moles. Chlordane at the rate of 4 oz. actual toxicant per 1,000 sq.ft. (10 lbs./A) and Dieldrin at the rate of 2 oz. toxicant per 1,000 sq.ft. (5 lbs./A), or arsenicals may be mixed with sand or fertilizer and spread with a fertilizer distributor. If possible apply the material before a rainstorm, or soak it in with a hose. Earthworms and grubs can be reduced for several years with one application.

Pocket Gopher Control

The most practical method of controlling this rodent is by the use of poison bait. Cut sweet potatoes, or carrots into sticks about one-half inch in diameter and two-three inches long. Two quarts of these baits are dusted with 1/8 ounce of strychnine alkaloid and shaken in a bucket until the material is evenly distributed over the surface of the bait. The runway is located by probing into the ground with a pipe or broomstick handle at a point twelve to eighteen inches directly in back of the plug formed in the center of the horseshoe-like fan. When the probe enters the runway system, the lack of resistance will be felt.The probe should be removed, two or three pieces of root baits inserted and the hole plugged. Treat all fresh mounds in the area.

While it is possible to trap gophers with regular steel traps, it is best to use a type especially made for this purpose, such as the Macabee gopher trap. Dig out the mound in the same place you would insert a probe until the runway is found. As the mound is at the terminal of a lateral runway, uncover the system until the main runway is found, which is perpendicular to the lateral. Use two traps, one on each side of the lateral with the jaws facing down the tunnel and the trigger out. These should be securely staked down. Leave the hole open as the gopher, in his haste to block the opening, will push dirt into the trigger and be caught as he passes between the sharp prongs of the trap.

Ground Squirrel Control

The most effective control measure for ground squirrels is the use of calcium cyanide (Cyanogas "A" dust). This is applied by means of a foot pump duster specifically designed for use with this material. After about an ounce of gas has been blown into the system, plug the opening. Treat all burrow openings at the same time. An alternate method is the use of wettable powder, dieldrin, which is also dusted into the runway. However, the burrow system is not closed in this case. The recommended bait is strychnine-treated, crushed oats which can be obtained from the Rodent Control Fund at Purdue University. Tablespoonful quantities should be placed near the burrow entrances.

Norway Rats

Control of this pest is accomplished by gassing with calcium cyanide, or dusting with dieldrin as described in the case of ground squirrels. As this rodent is usually found near human habitation, it is also advisable to expose poison baits in places frequented by these animals. At present the most effective bait is the use of one of the anti-coagulant poison materials, such as Warfarin, Pival, Fumarin, Diphacin, or PMP. These are generally used in a grain-based bait, such as non-degerminated yellow corn meal and oats. Sugar should be added to make an effective attractant.

Fieldmouse Control

While mice are not a particularly bad problem on mowed lawns, their presence indicates a serious hazard to nearby shrubs and trees. Control is by use of strychnine grain,as outlined above, is placed in tablespoonful quantities under vegetative cover along the trails.

Crayfish Control

For small infestations it is practical to fumigate individual burrows by use of chemicals, such as chloride of lime, coal tar creosote, turpentine-soap powder, sodium hydroxide, or carbon bisulfide. To be effective, these materials must reach the water in which the crayfish live. The most favorable time is usually in September when all adults are in their burrows. For more extensive areas, where treatment of individual burrows is not practical, a poison bait can be used. This consists of 50% wettable DDT powder applied to ground corn cobs, or dried silage and broadcast over the area.

Skunk Control

Preventing skunk damage to lawns is best achieved by removing grubs the skunk is seeking in the turf with th use of soil insecticides. (See Mole Control).

For more information write to the U.S. Fish and Wildlife Service, Agricultural Experiment Station, Purdue University, Lafayette, Indiana.

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SOILS

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(See Howard article, page 4 also)

Soils upon which turf is to be established deserve considerable attention whenever rebuilding or remodeling is contemplated. Putting green soils are so often the source of turf trouble that the USGA Green Section began about 10 years ago to sponsor research dealing with the physical relationship of soils. This work has been done at Beltsville, at Oklahoma State University, at UCLA, and more recently at Texas A & M College.

There are four primary functions of a soil. It provides support, nutrients, water and air (oxygen). In addition to these primary functions, the soil used in a putting green must fulfill other peculiar requirements.

1. It must resist compaction under traffic and during all kinds of weather conditions.
2. It must hold a properly played golf shot, yet be firm enough to resist the pitting caused by golf balls played with a high trajectory.
3. The soil must provide the primary requirements to a plant handicapped by the attrition of traffic and constant close mowing.

Soil is not an inert material, but is rather a complex chemical, physical and biological system with numerous interactions. Few examples will serve to demonstrate this.

1. Oxygen and carbon dioxide in the soil affects the plant's ability to take up water and nutrients and to use them in its growth.
2. Air affects the depth and distribution of roots and in turn influences support as well as nutrient "foraging" ability.
3. Water and air in the soil vary in inverse proportion.

The discussion of air and water content of a soil leads to a consideration of pore space characteristics. We have evidence that a well-tilled loam soil is composed of about 50% solids and about 50% pore space. The pore space in turn is divided about equally between capillary pore space (which may be thought of as the space which holds water) and non-capillary pore space (which may be considered air space in a well drained soil).

A putting green cannot be tilled and the preponderance of relatively small particles, which, when wet are crushed and pressed together by foot traffic, causes the air spaces to be reduced. The use of a higher percentage of sand will tend to increase the large pores, but reduce the total pore space. Thus, it appears that 38% is the maximum total pore space obtainable in a good putting green soil. This appears adequate, however, if the amounts of large and small pore spaces are about equal.

The considerations of pore space are important as they affect drainage and aeration of a soil. Both are affected by underlying strata. A clay layer near the surface may impede the movement of water, create a false water table and cause roots to be shallow. On the other hand, a layer of gravel below topsoil may reduce capillary pull of water from soil and thus reduce "drouthiness" in a sandy soil.

Appropriate laboratory measurements include:

1. Mechanical analysis
2. Pore space amount and distribution of sizes
3. Permeability (measured as inches per hour with a .25 inch hydraulic head)
4. Moisture retention

The use of these measurements upon compacted trial mixtures of soils, together with careful interpretation, will permit the making of a putting green soil that will maintain its suitability over along period of time.

The procedures which have been outlined in Leon Howard's talk, page 4, may increase the costs of putting green construction, but it is believed that subsequent maintenance ease will more than offset this initial cost.

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STRUCTURAL CHARACTERISTICS OF THE GRASS PLANT AS RELATED TO ADAPTATION

Marvin H. Ferguson

Many of the accepted management techniques employed in growing turf have come about as a result of trial and error. However, when one looks closely at the individual plant and considers the effect of any particular treatment, he finds fundamental reasons for following dorrect practices. It is equally important that we be able to predict the effects of management treatments by understanding the requirements and tolerances of individual plants imposed by their structural attributes.

How Does a Plant Adapt to Its Environment?

Some changes can be made by a plant, for example,roots will become shortened in a water-logged soil. Leaves will curl or fold and the loss of moisture may be retarded. However, these changes are not heritable; they will not be passed on to the next generation.

More important changes are those which come about over a period of several genedrations by the process of natural selection. This concept of natural selection is sometimes spoken of as the "survival of the fittest." Disease tolerance and variable characteristics of growth often occur by this process.

Mechanisms for Adaptive Ability

Dormancy is one factor - and perhaps the most important factor - in a plant's ability to thrive in its environment. We may contrast bluegrass, bent and fescue to bermudagrass or Zoysia. Bermuda and Zoysia go dormant in order to survive periods of cold weather, whereas bluegrass, bent and other cool season grasses, seem to thrive under conditions of low temperature. Some plants shed leaves in order to protect themselves against severe weather or drouth. In these cases the plant depends upon its reserves of stored food for survival and for the support of new growth when favorable conditions again occur.

Perennials survive because of an ability to store food and to maintain life in protected parts. Annuals do not have this ability, but we sometimes find annuals growing more than one season and thus behaving as perennials when favorable situations exist. Poa annua sometimes lives for several years in cool areas. The annual seeding of some plants enables them to reproduce themselves even where there are extremely unfavorable seasons.

Temporary protective mechanisms may be illustrated by the fact that the leaves of the grass plant will roll or fold during periods when transpiration rates are extremely high. Zoysia protects itself against excessive water loss by the rolling of leaves which closes the stomata, leaving exposed only the heavily cutinized lower surface of the leaf. Bluegrass leaves fold to reduce loss, but bentgrass just wilts.

Physical Modifications

It is known that in a good soil bermudagrass roots will extend more than six feet, whereas such grasses as red fescue and bluegrass will produce roots to about four feet. Bermudagrass roots are coarse and deep, whereas Zoysia roots are finely divided and relatively shallow. However, Zoysia root systems are so extensive that the upper portions of a soil are explored thoroughly for moisture and nutrients.

There are many modifications of grass stems, stolons and rhizomes which affect the plant's ability to grow. Stems serve as storage organs for food material, and in the case of stolons and rhizomes, they are one of the means of enlargement and spread of the plant. The position and form of the stem has a marked influence upon the plant's ability to compete with other plants for ground space. Zoysia and bermudagrass have vigorous rhizomes and stolons which spread through and under other grasses. Bentgrass is not so competitive; it spreads primarily by stolons. Bluegrass has short rhizomes which permit spreading under good management.

Bermudagrass stems are mostly prostrate or underground and can be mowed closely without the removal of a large amount of storage tissue.On the other hand, bluegrass stems are mostly upright; therefore, continual mowing removes much of the storage tissue and the grass tends to die out. Thus, we may see that the physical modification in a grass stem determines to some extent the ability of the grass to thrive under certain types of management.

Perhaps some of the most extensive anatomical modifications among grass plants are those existing in the leaves. Much of the literature on this subject may be traced back to the work of an Englishman named Lewton-Brain. This gentleman published a paper about grass leaves in 1898. There are a great many ways in which leaf anatomy may vary. The epidermis, or skin, of the grass leaf is made up of numerous cells of different arrangement, size and shape. Most grasses have a rather heavily cutinized lower leaf surface. The thicker this layer of cutin, the lower the moisture loss. One type of cell which is found in the epidermis is large and thin-walled. These motor cells usually occur in rows and they lose water rapidly under conditions of moisture stress. As these large cells collapse, the leaf tends to fold or curl, depending upon the number and arrangement of the motor cells. As folding or curling takes place, water loss is retarded. The pubescence, or hairiness of leaves, reduces the rate of water loss, and the number and arrangement of stomata vary between species. Some grasses (bentgrass) must be watered often because their structural makeup does not protect them, nor give drouth resistance.

Another type of cell is the thin-walled parenchyma cells, which, when filled with water, are turgid and hold the leaf upright. Under severe moisture stress, these thin-walled cells may lose much of their moisture and become flaccid. When this occurs, we see wilting and the grass may be severely damaged when subjected to traffic. Plant structure affects management needs and these examples demonstrate that management must consider the tolerances of the particular grass being grown.