PROCEEDINGS

of

TURF CONFERENCE

1966

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PROCEEDINGS OF THE

1966

MIDWEST REGIONAL TURF CONFERENCE

The 38 talks included in these Proceedings are condensations of talks by speakers before sections and divisions of the 1966 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 1962, 1963, 1964 and 1965 Proceedings are available at price below.

A copy of these Proceedings were mailed to:

1. The 635 attending the 1966 Midwest Turf Conference.
2. One person of each member organization within the Midwest Regional Turf Foundation not represented at the Conference.
3. List of those in educational activities.

Additional copies are available at $ 1.00 each from:

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Check below for special articles suggested for first reference as based on your major interest.

For Lawns - first see articles starting on pages

4, 9, 13, 20, 24, 26, 40, 53, 62, 69, 89

For Sod Production - first see pages

4, 21, 24, 25, 26, 27, 40, 43, 53, 54, 62, 72, 74, 82

For Golf Courses - all including pages

4, 9, 13, 16, 34, 42, 62, 84, 86.

TABLE OF CONTENTS

		Page
President's Report	Morgan Boggs	3
Executive Secretary's Report	W. H. Daniel	3
Does Your Turf Use Everything You Feed It?	Roy L. Goss	4
Turfgrass Research in the Pacific Northwest	Roy L. Goss	9
British & American Turfgrass Disease Problems	Noel Jackson	13
Recognition & Control of Turfgrass Diseases	Noel Jackson	16
Key to Common Turf Diseases - Field - Mycelium		18
Key to Common Turf Fungi - Microscopic - Spores		19
Turfgrass Diseases - Suggested Controls		20
Anatomy of Turf Plants	M. H. Ferguson	21
Bluegrasses - Aggressives & Petites	Terrance Riordan	24
Research in Spraying Chemicals	Hayden Watkins	25
Evapotranspiration - Turf & Weather	M. H. Ferguson	26
Pipe for Irrigation Systems	Edward Stoltz, Jr.	27
The Proper Approach to Buying an Irrigation System	Bob Rupar	30
Using Automatic Irrigation Systems on Need	Donald Wright	32
Air-Conditioned Fairways	Richard B. Craig	33
Manicuring Fairway Turf - 3rd Report	N. W. Kramer	34
Preparing for a National Tournament	Ernie Schneider	36
Turf Fertilizers - From Plant to Plant	Hartl W. Lucks	40
A Novel Estate Golf Course	Raymond Freeborg	42
Planning the New St. Louis Stadium Turf	Raymond Freeborg	43
Building New Golf Courses	Pete Dye	49
Notes on the Biology & Control of Sod Webworm	Donald L. Schuder	53
Large Area Soil Sterilization	Dale Habenicht	54
Sod Grower Associations - A Review	R. M. Warren	56
Replacing Weeds With Turf - 2nd Report	D. A. Clemans	59
A Lawn Program That Works	L. M. Bowers	60
What is Grass Chemically	C. Y. Ward	62
Maintenance By Contract	Robert Duke	67
Maintenance By Contract	John Duling	68
Growing Turf On Sand	O. C. Redenbacher	69
Fast Seeding and Mulching	R. H. Stamm	72
Implications on Roadside Beautification	Vincent Koers	74
Problems of People - World Food and Fertilizer Outlook	Werner L. Nelson	76
Soil Warming and Turf Use - Third Report	W. H. Daniel J. R. Barrett, Jr.	79
Sod Production in the South	C. Y. Ward	82
Watering Systems - So What?	James L. Holmes	84
Design & Economy Comparisons of Turf Systems	R. R. Abernethy	86
Crabgrass and Goosegrass Prevention - 1966	W. H. Daniel	89

PRESIDENT'S REPORT

Morgan Boggs, Bunton Seed Company
Louisville, Kentucky

Over the past century we have cut our work weeks, taken more holidays and vacations and increased our per capita output of goods and services by over 600%. Not too many years ago the average man worked too much and leisure was the privilege of the rich. Now, free time is widely dispersed among all classes of people, turning the traditional "leisure class" topsy-turvy, with the executives and professionals benefiting least and working men most.

Americans as a group will take some 100 million weeks of vacation during 1966. More holidays, longer vacations and a shrinking work-week, together have brought the average worker an additional 155 hours of annual time off since World War II. Many forces have played a role in these great gains in leisure time, including new state and federal laws, and our remarkable productivity - the ability of new machines, modern technology and a better educated work force to turn out more and more good in less and less time.

An ever-growing population, which has more leisure time assures more usage of turfgrass areas. Although there has been remarkable progress, concentrated effort for appropriations to provide technical research must be expanded and intensified to stay abreast of the need. Today, thanks to earlier effort, both public and private, turfgrass research and management are assuming the stature, the prestige and slowly gaining the financial support that has long evaded them.

"TURFGRASS IS A $4 BILLION DOLLAR INDUSTRY" was the headline of October issue of Turf-Grass Times. The home owner with annual expenditures of over $3 billion, Highways with $471 million, cemeteries with $363 million, golf courses with $237 million, and on down the line of turfgrass users for a whopping total of over $4 billion. Gentlemen, this is big business, and it challenges all of us to plan and work together to meet the demands for more and better turf areas for the "thundering herds" of the future.

In closing, I want to express my sincere appreciation for the honor and privilege to have served as President of the M.R.T.F. for the past year. Also, to thank Dr. Bill Daniel, his staff and students, the Board of Directors and all of you for your continued participation in the M.R.T.F., for your work and support continues to be the "life blood" of this successful organization.

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EXECUTIVE SECRETARY'S REPORT

Twenty years of successful M.R.T.F. Still going strong! Still a research oriented University sponsored group! Still a focus point for idea exchange!

It continues to be a pleasure to work with turf in the Midwest. Our finances have held steady - our needs gradually increase - but increased grant research funds have kept the program strong. I would thank those who are members, 351 in 1965, and ask more of you to join with them in continued support.

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DOES YOUR TURF USE EVERYTHING YOU FEED IT?

Roy L. Goss, Dept. of Agronomy
Western Washington Research Center
Puyallup, Washington

It has been only a few years ago when we, as turfgrass manager, had a very small selection of commercial fertilizers available for our fertilization needs. Ask any older turfgrass manager what his fertility program was 30 years ago, and you will be appalled when you compare it to our souped-up program of today. In my own area am surprised to learn that back in "those good ole days" that they had relatively few problems with grass production, both from the quality standpoint and, also, from disease and other pest problems. Unless the memories of some of these fellows have grown dim and their observations are still correct, then the obvious answer to the question of how did they do it without our modern programs has to be answered something like this:

1. The soils were relatively new and probably had less deficiencies.

2. Our turfed areas had less pressure from traffic and use.

3. We did not manage them as intensively then as we do today.

4. Perhaps we settled for less all the way around back then.

5. Have we then depleted some of the reserves we had at that time and are now operating on sub-marginal fertility levels?

These questions are some that we had in mind at the time we established our research program at the Washington State Experiment Station, Puyallup, Washington. We hoped that we would be able to answer questions about how much fertilizer should we apply, in what form should we apply it, what ratio of plant nutrient should we be recommending. We also hoped to provide information to our Soil Testing Laboratory that would help interpret soil test results. The fertilizer studies that I am reporting have been in progress for over six years. Both lawn and putting green turf have been under investigation, and I would like to share some of the results of this research with you at this time.

Experimental Procedure

In 1959 we planted Colonial bent on a Puyallup fine sandy loam soil. The area that was to be used for putting green studies was fumigated with methyl bromide, but the lawn investigation areas were not fumigated. In addition to Colonial bent, the lawn area had as its other mixture Rainier red fescue. Experimental results reported in this paper were obtained from the putting green turf area, but we have every reason to believe that the lawn area would respond in a similar manner. In fact, this is being investigated at the present time.

The putting green area has been subjected to 18 different fertilizer treatments and one check plot. (Table I). Nitrogen has been applied at 3 levels, phosphorus at 2, and potassium at 3. Urea (46% N), treble superphosphate (45% P_2O_5), and muriate of potash (60% K_2O) were used for sources. The plots were fertilized every 2 weeks throughout the growing season, and all materials, with the exception of superphosphate, were applied in a water dilution through a small plot boom and sprayer.

All clippings have been removed from these plots from the beginning. Before any treatment was made every plot was tested for pH, organic matter, phosphorus, potassium and calcium. They have been tested periodically.

Table I. Initial and Soil Nutrient Levels after 6 years. Goss, Wash. Exp. Sta.

Treatment/1,000 sq. ft. per season				Initial (1959)			Present (1965)		
	N lbs.	P lbs.	K lbs.	P	K	Ca	P	K	Ca
1.	20	0	0	15	500	2650	12	215	1930
2.	20	4	0	16	491	2600	24+	145	1790
3.	20	4	4	15	481	2500	24+	200	1790
4.	20	4	8	15	488	2375	24+	350	1790
5.	Check			15	481	2430	14	255	2210
6.	20	0	4	16	500	2200	10	280	800
7.	20	0	8	14	498	2400	9	435	1265
8.	12	0	0	14	500	2450	13	200	2070
9.	12	0	4	15	482	2300	13	270	2070
10.	12	0	8	16	400	2410	12	475	1930
11.	12	4	0	16	500	2385	24+	170	2210
12.	12	4	4	17	500	2350	24	250	2210
13.	12	4	8	17	500	2280	24	385	2210
14.	6	0	0	17	500	2180	16	195	1930
15.	6	0	4	18	500	2195	16	330	1930
16.	6	0	8	18	500	2120	17	500	1790
17.	6	4	0	19	500	2130	24+	190	2070
18.	6	4	4	18	500	2180	24+	380	2070
19.	6	4	8	18	500	2100	24+	440	1930

What Has Happened to Phosphorus?

It is obvious from the table above that phosphorus soil levels have decreased during the last 5 years where no phosphorus has been applied. Wherever phosphorus was used it accumulated as shown by increased levels. Where none was used after six years the availability was over 80% of original.

What Has Happened to Potassium?

This is probably the place where the greatest change has occurred. Table I shows that potassium levels have decreased in every case, regardless of the amount applied. The heaviest potassium treated plots received 8 pounds per 1,000 square feet per season and had 87% as much available as original level. Adding 4 pounds annually let the supply drop to less than 60%, and not adding any allowed the supply to drop to less than 40% of original.

Calcium?

Soil calcium levels have consistently lowered during the 5-year period; however, none are critical with the possible exception of treatments No. 6 and 7. It is interesting to note here that these are the only two plots not responding to 20 pounds per 1,000 square feet nitrogen treatment. All other plots, regardless of pH, are responding to N applications.

The Effects of Fertility on pH

In 1959 the average soil pH level was 5.7. Within the plot area the variation was no more than 0.1 pH reading. By the end of 1963, however, the pH values were being segreated out on the basis of the intensity of nitrogen application.

Table II. Nitrogen applied and pH Changes.

Nitrogen applied/annual lbs.	pH (average)
20	4.0
12	5.0
6	5.3
initial	5.7

Since the calcium levels initially ranged from 2100 to 2600 pounds per acre and in 1963 ranged from 1790 to 2210, we cannot infer that there is a calcium deficiency. For our purposes we still class this as high available calcium in turfgrass areas. It was interesting to note, however, that treatment 870-0-145 and 870-0-290 (lbs./acre/5 years) showed calcium levels of 800 and 1265 pounds per acre, respectively. These two plots, likewise, had low phosphorus levels. It is evident then from this pH data that when we apply high amounts of nitrogen, particularly from certain sources, we can expect a rapid decrease in soil pH values.

How Do We Interpret These Data?

About the only conclusions that can be drawn from the above data are that large amounts of plant nutrients have been applied but are not now available in the soil. Such variables as how much leached, became fixed in the soil, was removed in the plant tissue, or was mineralized from the soil are not considered. If we knew how much the plants removed this would control one important variable. Therefore, studies were set up to investigate plant removal.

Tissue Studies

Since the analyses of plant parts for N, P, and K can become expensive, only 6 treatments out of 19 were selected for tissue studies. These were: 20-4-8-, 12-4-8, 12-4-4, 12-0-8, 12-0-4-, 12-0-0. Experience has shown that 12 pounds of N is more practical for putting turf; hence, the reason for more of the 12 pound N treatments.

Clipping samples were collected from these plots approximately once each week, dried and weighed as a measure of yield. Over a period of 29 weeks during the year the turf was cut about 85 times, and 14 representative clippings were selected for tissue analysis (Table III).

Table III. Dry Matter Yield and Nutrient Recovery as Estimated by Tissue Analyses, Goss, 1965

Treatment 1,000 sq.ft. lbs.	Treatment acre $N - P_2O_5 - K_2O$ lbs.	Mean Dry Matter Yield per acre* lbs.	Nutrient Recovery acre* N lbs.	P lbs.	K lbs.
20 - 4 - 8	870 - 174 - 348	5,472	279	19	158
12 - 4- 8	522 - 174 - 348	6,288	299	22	172
12 - 4 - 4	522 - 174 - 174	5,406.	273	18	144
12 - 0 - 8	522 - 0 - 348	4,608	233	15	130
12 - 0 - 4	522 - 0 174	4,746	243	15	124
12 - 0 - 0	522 - 0 - 0	5,675	278	17	138

* Figures extrapolated from 14 weeks dry matter and nitrogen yields to 85 weeks.

It may be surprising to some to note that the 12-4-8 treatment resulted in a significantly higher yield of dry matter, N, P, and K, than the 20-4-8 plots. There may be two significant explanations:

1. The grass cannot assimilate this much nitrogen, allowing it to be leached away

2. A combination of nitrogen and potassium at these levels definitely caused turf injury, especially during the hotter months of July and August.

It is felt by the writer that tissue analyses are the best measure of nutrient status, with the exception of tissue and lysimeter studies. Of course, we cannot ignore the standard chemical soil test as an excellent tool, also, since this gives us a measure of what is available in the soil.

Clippings from the best treatment 12-4-8 contained only 32% of N, 30% of P, and 60% of K applied. This leaves 68% of N, 70% of P and 40% of K of the total applied either left in the soil, tied up (fixed), or leached - at least not in the clippings. It is reasonable to expect that a large amount leached away with excessive rainfall and irrigation water.

What About Nutrient Ratios?

For sometime we have indicated that plants remove nutrients in about a 3-1-2 ratio of N, P, and K. If we consider that the 12-4-8 treatment above is the best one, then we find that potassium averaged about 60% of nitrogen in the tissue. Furthermore, soil test results indicate that a 3-1-2 ratio is maintaining adequately high soil levels of K_2O.

These data also indicate that 4 pounds of P_2O_5 is ample for excellent quality turfgrass. Also, it is found that over 8 times as much potassium is removed from the soil in the 12-4-8 treatment as phosphorus. Therefore, when we put one part of phosphorus in a 3-1-2 ratio fertilizer, we are being extremely generous.

Some Considerations of Seasonal Removal

It was interesting to note that in the early part of the year and again in the late part that tissue nitrogen levels were the highest. During the peak of the growing season, however, nitrogen levels were considerably lower. This sounds reasonable since little growth occurs early and late, and the plants are making maximum growth in approximately May and June. The total amount of nitrogen removed, however, still occurred in May and June, and this indicates that nitrogen removal is strictly a function of yield.

The seasonal tissue analyses, however, revealed one important factor when we consider potassium. Tissue potassium level was found to be low in the early and late part of the season,but rose to its highest level during the period of maximum yield, which was in May and June. It is a well-known fact that turfgrasses will utilize potasium to the point of luxury consumption, if it is available. This probably then accounts for these extremely high levels in the amount removed in the tissue. What would happen then if insufficient potassium was available to the plants during this period of maximum growth? Our data have consistently shown that the plots receiving the highest levels of potassium are rated highest in quality during this period of time. It is my feeling, also, that plots receiving little or no potassium during this maximum growth period may be deficient, and we may be sacrificing turf quality at the period of time that we need it most. Our observations have also pointed out that heavy applications of potassium during the hotter months of July and August have caused excessive turf injury in some cases due to fertilizer burn. It has been our experience, therefore, to make our larger potassium applications in spring and fall, then just lighter rates during hot weather, then reduce them drastically to maintain availability.

Summary

1. Avoid excessive applications of nitrogen. Twelve pounds per 1,000 square feet per season appears to be ample.

2. Maintain a 3-1-2 ratio of N, P, and K.

3. Try to get most of your potassium on the turf during the cool months.

4. Periodically use chemical soil tests to help determine the available supply.

5. Heavy N applications tend to lower the pH; therefore, watch this as well as your calcium levels.

6. Fertility programs alone will not control turfgrass diseases. Be sure to follow good fungicidal programs.

(Editor's note: In the Midwest it appears ratios of 6-1-4 should maintain ample phosphorus under turf).

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TURFGRASS RESEARCH IN THE PACIFIC NORTHWEST

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Climatic and Geographic Variations

The Pacific Northwest has two distinct and dissimilar climatic areas. The interior, or area east of the Cascade Mountains, has a climate more continental in nature and has rainfall varying from near zero to 22 inches per year. The winters can be as cold as -30°F., and the summers as high at 110°F. Snow cover is usually moderate, but can be heavy. Bluegrasses are the dominant turf in this area. Grass seed is widely produced in this area.

The area west of the Cascade Mountains from Vancouver, British Columbia, south to Eugene, Oregon, are more densely populated and have the most highly managed turfgrass areas. Here the winters are very mild due to the influence of the Japanese Current and the Pacific Ocean, and are extremely wet. Rainfall is quite variable and ranges from 13 inches (in a few isolated rain shadows) to over 160 inches near the ocean. The average metropolitan areas average close to 45 inches per year and most of this falls from October through April, just when we don't need it. The summers are excellent for outdoor recreation due to little rain between July 1 and September 15, and temperatures rarely exceed 85°F. with low relative humidity. This is bentgrass/fescue/<u>Poa annua</u> country and some grass growth occurs all winter. This climatic and geographic description may help to explain some of the problems we encounter in our research programs.

Summary of Pacific Northwest Research

Some research (fairy ring investigations) was commenced as early as 1948, but the bulk of our program was initiated after 1955. Most of the research in western Washington was directed toward diseases until 1958, when our main agronomic turfgrass research areas were developed. At the present time, our combined agronomic and pathologic (cooperative) area is in excess of 3 acres of plots. The area is about evenly divided between lawn type and putting green turf.

The chief pathologic investigations, both at the Experiment Station at Puyallup and on outlying areas, have been concerned with fungicidal controls of our most important turf pathogens. The agronomic program has been chiefly concerned with fertility studies, especially the proper rates and nutrient ratios. Soil and weed studies have been conducted at the Experiment Station and outlying areas for the past eight years. The following research summaries represent part of our research program and may be of value to your area:

Disease Research

This program has been under the direction of Charles Gould and in cooperation with Roy L. Goss and H. M. Austenson, Agronomists, and V. L. Miller, Chemist.

<u>Fusarium Patch</u> (<u>Fusarium nivale</u>) - Experiments were conducted in the field from 1956 until the present time in search of fungicides that give the best control

of Fusarium patch disease (pink snowmold) caused by the fungus Fusarium nivale. Many experiments and hundreds of materials have been tested at various rates and timing in order to come up with the best program for control. Only three materials, phenyl mercury acetate (PMA), Calo-clor, and Cadmium compounds were found to be highly effective against this disease. During the seasons of most disease (predominantly fall), recommendations are to spray every 10 days to 2 weeks at 3/4 liquid ounce of PMA, 2 ounces of Calo-clor, or 1 ounce of Caddy in 10 gallons of water per 1,000 square feet. In off seasons, sprays are recommended once per month as preventative. Alternating schedules of PMA and Caddy, or Calo-clor have given best results up to present.

Red thread (Corticium fuciforme). This diease is quite prevalent in the Northwest and can seriously reduce turf quality when heavily infected. It produces a scorched appearance and an abundance of small, red threads (stromatia) which gives an off-color. Late summer and fall have been the periods of greatest infection. Fungicidal research has shown that a good Fusarium control program will also control Red Thread. Under lawn turf conditions, it has been found that two or three Cadmium applications will stop the disease. Sometimes Red Thread occurs in the same infected area as Fusarium, making control a little more difficult.

Ophiobolus Patch (Ophiobolus graminis). This diease was identified and described at our Station in 1960. It occurred in our research plots and attempts to control it with the usual fungicides were not successful. Completely dead areas of a few inches to several feet in diameter occurred. Since we have had considerable experience working with it now, we realize that it has been with us for sometime in various parts of our state, but has been casually diagnosed as fairy ring, Fusarium patch, snowmold, or just plain burning injury.

The roots and crowns of bent and Poa annua are killed by the fungus and the centers of the spots fill in with weeds and eventually Poa annua. Again, Kentucky bluegrass seems to be resistant. There is usually a zone of activity of one to 3 inches at the perimeter of the spot of a coppery color. Tests with fungicides have proven unsuccessful so far, even with soil injections. Irrigation tests during the summer of 1964 indicated that excessive watering greatly increased the infection, as well as turf puffing and scalping. Fertility effects play an important role and are reported in the following discussion.

Snowmold (Typhula itoana). Snowmold occurs only in areas east of the Cascade Mountains. It is especially devastating on bentgrass/Poa annua turf when lax fungicidal programs are followed. Management programs that discourage Kentucky bluegrass and encourage bent and Poa annua, such as over-watering and excessively close mowing, result in heavy losses to this disease. Essentially, a good program of applying mercury fungicides, either organic or inorganic forms at the proper timing, has proven very effective in disease control. As little as 2 or 3 treatments have given good control, provided the last one was applied as close to snow cover as possible.

Agronomic Research

The Effect of Fertilizers on Fusarium Patch Disease. Results of studies conducted over several years indicate that if phosphorus and potassium are not limiting factors in plant growth, then nitrogen source and level play an important role in Fusarium patch development. After minimum levels have been exceeded, the higher the rate of N, the more severe the infection. This is probably more closely related to softer tissues, allowing easier infection and, also, it is possible that higher N levels may induce certain chemical changes in plant cells which permits greater infection. Only minor correlations were observed between phosphorus and potassium and Fusarium development.

The source of N plays an important role in Fusarium patch development. Our studies show that high rates of N from urea cause much more disease than from other sources, including most organics. Here again, the exact cause has not been determined, but more work is being planned.

Sulfur had a decided suppressing effect on this disease in preliminary tests in 1964. We observed a 300% reduction in the number of disease spots from the application of 1-1/2 pounds of wettable sulfur per 1,000 square feet and, also, a decided greening of turf, especially in the highest N plots.

The Effect of Fertility on Red Thread Disease. In brief summary, nitrogen rates of 4 pounds per 1,000 square feet or more for lawns and 8 pounds per 1,000 square feet or more for putting greens overcome the effects of this disease during the growing season. The principle involved here is simply one of making the grass blades grow faster than infection occurs and removal of infected parts. Nitrogen, however, does not solve the problem in the fall, when growth rate of the grass slows; hence, the need for fungicidal controls. All fine-leaved fescues seem to be more severely attacked than other grasses; however, some infection has been observed on nearly all grass species in western Washington, even orchardgrass (Dactylis glomerata) in pastures. At this time no other fertility elements appear to be as closely associated as nitrogen.

The Effect of Fertility on Ophiobolus Patch Disease. This disease infects young turf much the same as Fusarium nivale, that is, the higher the N level, the greater the infection, but as the turf becomes older N seems to help overcome infection. This effect was especially observed on our area after fumigation with methyl bromide.

In 1961 phosphorus applications had no effect on this diease. This is probably due to the fact that soil levels were high, but by 1964 phosphorus appeared to be the controlling factor. Thos plots receiving 4 pounds of P_2O_5 (1.76 lbs. P) averaged only 15% as much disease as those receiving no P. Photographic records show that the disease is sharply confined to plots receiving no P. The interesting problem here is that soil test values indicate P to be adequate for good turf growth.

Potassium exhibited a suppressing effect on the amount of disease in 1961 and 1964 regardless of P levels. It was less than the effect of phosphorus, but it did have practical significance.

Post-emergence Herbicide Research. As we all recall, it has not been many years ago when the control of mouse-ear chickweed, pearlwort, Japanese clover, crabgrass, etc., just to mention a few weeds, was very difficult. Today, these present practically no problem to acknowledgeable turf managers. We can attribute this to the chemical industry for developing good herbicides since World War II and to our research programs for determining their effectiveness and safety.

Turf weed research at Washington State University, as at many other locations, has been concerned with those which are more difficult to control and can be summed up as follows:

Mouse-ear chickweed (Cerastium vulgatum) - Dicamba, MCPP, Silvex
English lawn daisy (Bellis perennis) - Silvex, Dicamba
Japanese clover (Trifolium dubium) - Silvex, Dicamba, MCPP
Pearlwort (Sagina procumbens) - Silvex, Dicamba
Crabgrass (D.sanguinalis & ischaemum) - Dacthal, Betasan, Azak
Poa annua (seedlings) - Dacthal, Betasan

The weeds and controls shown do not represent the total list by any means, but are examples that gave us trouble a few years ago. We still recommend good management practices (fertility, etc.) as being one of the best control measures. Our research today shows that we have far fewer weeds with optimum as compared to low fertility, especially nitrogen. We have also found that 3/4 inch mowing height of bent/fescue turf produces fewer weeds and less thatch than 1-1/2 inches. There are many other points which could be mentioned, but would probably only be repetitious.

Other Research

Other problems on which we have conducted some research over the past few years can be listed as follows:

1. Soil fumigants for pre-plant weed control
   - a. methyl bromide
   - b. calcium cyanamid
   - c. vapam
   - d. mylone
   - e. vorlex

2. Studies regarding mowing heights and nitrogen levels and their effects on shoot and root production.

3. Nematode investigations.

4. Soil mixture studies for golf courses and athletic fields.

5. Mechanical soil compaction studies.

6. Wetting agent (surfactants) studies.

7. Turf renovation studies

8. Light intensity studies.

We feel that we have helped solve some of the immediate problems in turfgrass management in our area, but we also know that we have scarcely scratched the surface and must continue our programs in both the fundamental and applied areas.

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BRITISH AND AMERICAN TURFGRASS DISEASE PROBLEMS

Noel Jackson, Dept. of Plant Pathology
University of Rhode Island, Kingston, R.I.

As an introduction to the subject it is proposed to spend a little time in tracing the development of turf culture in both countries, and also in describing the climatic differences which have an important bearing on turf disease incidence.

With a climate admirably suited to the growth of grasses, it is probable that lawns have been part of the organized scenery in Great Britain for many centuries but intentionally or otherwise, plants other than grass often formed the swards. The all-grass lawn gained in popularity during the 1800's, but the invention of the cylinder mower in the 1830's was the most important single factor in lawn history giving impetus to the lawn vogue by the provision of an efficient and less exacting alternative to mowing with the sickle or scythe. The problem of producing and maintaining a turf surface suitable for a variety of recreational activities was eased,and as the mowing process became mechanized in the early 1900's, then the area devoted to lawns and sports turf increased considerably.

About 52 million people now occupy the 94,000 square miles which comprise the United Kingdom, something like 550 to the square mile. There are around 14,000,00 houses (and an estimated annual need for 200,000 to 300,000 new ones over the next 20 years), the majority with garden lawns. This acreage of turf added to that devoted to sporting facilities, parks, etc., must place ornamental and sports turf as one of the most widely cultivated crops -- and with ever increasing leisure time available, the demand for more and better recreational facilities involving turf continues to grow. No figures are available but the amount now spent each year on turfgrass in Britain must run into millions of pounds per annum.

Though commencing a little later, much the same story probably can be traced for the development of amenity turf in the U.S. However, in a country over 30 times the size of the U. K., and embracing wide climatic variation, it is understandable that the problems of turfgrass management are often vastly different and more complex. The British Isles have a marine climate characterized by moderate temperatures both winter and summer, rainfall light but often, between 20 to 40 inches annually. One would have to move south almost 20° latitude, i.e., south of latitude 35°N, to find winters in America as mild as they are in Southern and Western Britain. The climate of the West American coastline from Vancouver Island, Canada, down to Northern California approximates most closely the English climate. Oregon and parts of Washington, for example, can grow most of the plants grown in Britain, and it is interesting to note that two turf diseases common in Britain are also common to the above mentioned states and nowhere else in the U.S..

The comparative ease with which grass grows in the marine climate of the U. K. is still accepted unconsciously by most residents. This "for granted" attitude may have some bearing on the fact that the first attempts to apply scientific principles to the cultivation of turf began in the U. S. back in the 1890's! However, the first three decades of this century saw increasing interest in the study of turfgrass management in both countries culminating in the development of centers for research and advisory work. While there is still only one independent organization in the U. K. (in fact, the only one in Europe), many research centers now operate in the U. S. serving a fast-growing industry variously estimated as representing a four to nine billion dollar annual investment.

In both countries turfgrass is an important crop. Continuing research leading to the introduction of new management techniques, herbicides, fertilizers, and mechanical equipment, the breeding of new grass varieties and production of quality grass seed, make advances in turf quality possible.

It seems ironical, however, that as the standard of turf improves further problems arise, not the least of which is the problem of turf disease. Intensive management techniques undoubtedly provide turf of increased susceptibility to disease, but it should be remembered that the high quality turf now demanded ensures that any blemishes are more readily noticeable than they would be on a less perfect sward. These diseases are most commonly the result of fungal infection, or incorrect growing conditions (functional or abiotic diseases). Both here and in the U. K., bacteria and viruses are not recognized at the moment as important turfgrass pathogens, though their possible importance should not be overlooked. Similarly, attention is being drawn to the numerous species of nematodes which can parasitize turfgrasses, but the extent and nature of the injury is often difficult to assess. Hence, at the present time, with the possible exception of functional diseases, parasitic fungi must be regarded as the most common cause of serious turf diseases in both countries.

Functional diseases - the overdose of weedkiller or fungicide, fertilizer scorch, incorrect watering, mower scalping, pollution damage, gasoline and urine scorch, deliberate vandalism, etc., are truly international and occur with the same annoying frequency wherever turf is cultivated. The hundred or more species of fungi known to be capable of causing disease do differ somewhat in their world distribution, but a particular disease may be absent from an area (even if the causal fungus is present) due either to lack of suitable environmental conditions, or the lack of a susceptible host. In Britain almost all of the better quality fine turf both for private lawns and sports turf, mown at 1/2 inch or less, is based on mixtures of Browntop bentgrass (Highland Colonial) and chewings fescue (from Oregon or Holland). This mixture, usually 7 parts fescue to 3 parts bentgrass, when established, will withstand mowing down to 3/16 inch. The bentgrass eventually dominates the sward, wears well, and maintains reasonable winter color. Nitrogen fertilization on such turf seldom exceeds 1-1/2 to 2 pounds actual nitrogen per 1,000 square feet per annum.

Creeping bentgrass with its higher nitrogen requirement, abundant thatch production, poor winter color, and vegetative means of propagation has to date not found much favor in the U. K., but the seeded variety Penncross is in trials there. As in this country, annual bluegrass (Poa annua) is a common volunteer species in fine turf, often comprising a considerable proportion of the sward. It contributes in no small way to the susceptibility of these swards to disease, of which the commonest and most damaging in the U. K. is Fusarium patch disease. (This disease is not to be confused with Fusarium blight, a high temperature summer disease of Kentucky bluegrass caused by F. roseum and confined largely to the U. S. Merion bluegrass, in particular, has suffered considerable damage in the Washington, D.C. area in recent years).

Fusarium patch disease is caused by the fungus Fusarium nivale, a fungus that is encountered in the U. S., but most commonly as a low temperature "snowmold." Only in parts of Washington and Oregon, where conditions resemble those in the U. K., does this pathogen cause the typical early spring or early fall patch disease. Conversely, it is seldom that snowfall is sufficiently deep and persistent in Britain for low temperature injury by this fungus. The severe 1962-63 winter proved an exception in this respect, since Fusarium nivale and also another low temperature "snowmold," Typhula incarnata, caused widespread injury. Typhula blight is a common winter disease on the North American continent, but prior to 1962 it had not been reported previously on turf in Britain.

Fine turf in Britain is subject to summer infection by Corticium fuciforme, the cause of Corticium patch disease, commonly termed red thread or pink patch. This disease is widespread in the U. S. and, as in the U. K., is particularly common on turfgrasses in low vigor. Sclerotinia dollarspot, also a summer disease of low vigor turf, is common to both countries, but it is much more extensive in the U. S. and affects a wider range of grass hosts. Whereas most of the turfgrasses in the U.S. may succumb to dollarspot disease, in Britain it is confined almost exclusively to red fescue, in particular creeping red fescue of sea marsh origin. Lawn bowling is a popular recreation in Britain and, since the majority of bowling greens are sodded with sea-marsh turf, Sclerotinia dollarspot most commonly is associated with these turf areas. No explanation is available as to why bentgrasses and bluegrasses remain free of infection in the U. K.; the causal fungus, Sclerotinia homoeocarpa, is the same in both countries, but strain differences exist within the species.

Though Ophiobolus patch disease must have occurred in the U. K. prior to the 1950's, it was not until this time that reliable diagnosis of the disease was established. The disease, a serious disorder of bentgrass turf, previously must have been overlooked or wrongly diagnosed, probably as "brownpatch." Like other high temperature diseases, for example, Pythium grease spot, true brownpatch caused by Rhizoctonia solani, is not a problem in the U. K. because of the moderate summer temperatures. In 1961, Ophiobolus patch disease was recorded for the first time in Northwestern U. S. - presumably the disease had been overlooked or wrongly diagnosed here also!

Most coarse turf in the U. K. for playing fields, second-quality lawns, etc., is composed of a mixture of grasses - perennial ryegrass, bluegrasses, red fescue, crested dogstail, and brown top bent - but predominantly perennial ryegrass. Considerable variation in turf forming ability is demonstrated by the numerous varieties of perennial ryegrass but provided a suitable variety is used, sufficient fertilizer is applied, and the sward not mown too close (1 to 1-1/2"), then this freely available, quick-establishing agricultural species performs quite well. It has the disadvantages of being rather aggressive to companion grasses and being difficult to mow cleanly, but it is relatively cheap and, adequately fertilized, it is not troubled too much by fungal disease. Rust, caused by Puccinia coronata, and leaf blights (Helminthosporium species), may occur on the perennial ryegrass. Other Helminthosporium species may attack the companion grasses, but usually the injury is insufficient to warrant fungicide treatment. Corticium fuciforme will infect all sward components, but though this common disease is unsightly and weakening to the turf, the injury is seldom fatal.

Smooth-stalked meadow-grass (Kentucky bluegrass) does not as yet enjoy the popularity as a turfgrass in the U. K. that it does here; consequently, melting-out disease (Helminthosporium vagans), stripe smut (Ustilago striiformis) and rust (Puccinia graminis), are not a serious problem. However, these fungi are all present in Europe, and as the use of Poa pratensis increases in Britain, so these diseases could become important there.

The ubiquitous "damping-off" organisms - Pythium spp., Fusarium spp., Helminthosporium sp., etc., probably are less damaging to seedling turf in the U. S. than they are in Britain where the generally lower soil temperatures allow for slower establishment. Conversely, the fairy ring organisms (another ubiquitous group of turf fungi) are less frequent (or at least less noticeable) under the cooler, most conditions.

Climatic variation and the reliance on different turfgrass species accounts for much of the difference in the turf disease picture for the two countries. Yet, there does seem to be an underlying difference in approach to turf disease control. This difference relates back to the suggestion earlier that turfgrass is still taken much for granted in the U. K. (the hard sell is yet to come!), but also to the fact that less money is available; hence, emphasis is placed on less expensive cultural control measures. Whereas in Britain turf treatments tend towards the necessary minimum (hence often falling short of the optimum); in the U. S. turf treatments tend towards the maximum (hence often exceeding the optimum). Obviously, this is a broad generalization and a happy medium is attained by many turf managers in both countries, but it may be one reason why turf disease and chemical disease control figure more prominently in the U. S.

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RECOGNITION AND CONTROL OF TURFGRASS DISEASES

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In the present state of knowledge, with the possible exception of abiotic disease, fungi must be regarded as the most common cause of serious turf disease. Though some abiotic (functional) diseases may present a problem in diagnosis; e.g. pollution damage, all too often accident or negligence is the cause and the perpetrator of the injury, is only too well aware (but often not too keen to admit!) as to how the damage occurred. The big problem is how best to remedy the situation before wrath and indignation descends on the miserable offender.

Although a formidable list of fungal species which are capable of causing disease of turfgrasses has been assembled, it is fortunate that not all are of major importance. Many are only weakly parasitic on turfgrasses, causing minor injury. A number are confined to the inflorescence and hence are more the concern of the seed grower than the turf manager. However, there still remains a hard core of fungal turf parasites which are a continual embarrassment to the turf manager and the object of considerable financial outlay each year. In the absence of a fungicide capable of controlling all turf fungus diseases, it is essential that the pathogen involved should be identified accurately so that the most effective remedial measures can be taken. The diagnosis of turf diseases is not always easy even to the plant pathologist, and it is with some trepidation, therefore, that the following aids to disease identification are presented. The aids entitled "Key to Common Turf Diseases" and "Key to Common Turf Fungi" are being published in the "Turf Manager's Pest Handbook" produced by the Mallinckrodt Chemical Works, copies of which will be obtainable gratis upon request to the Company.

It should be pointed out from the start that these keys provide the layman with a rough guide only. They are intended to help the turf manager make a tentative working diagnosis and allow control measures to be attempted quickly. However, confirmatory diagnosis should be sought as soon as possible from the local Agricultural Extension Agent, or from the plant pathologist at your State Agricultural Experiment Station.

Using the Keys

Visual examination. Examine the diseased turf carefully. Note the form of injury, i.e., whether to leaves, stem, roots, or to the whole plants. Note any distinctive features of the disease patches, i.e., shape, coloration, wilting.

In many instances the fungus will not be visible to the naked eye except, perhaps, in the early morning when dew is still present. Then, the fungal threads (hyphae) which make up the mycelium may be discernible. If there is no sign of the suspected fungus, place a sheet of glass or a small, clear plastic food container over the diseased patch and examine for mycelium after 24 hours incubation. Assemble all the information gathered and consult the "Key to Common Turf Diseases."

Microscopic examination. For those blessed with a microscope, an examination of diseased tissue may reveal fruiting bodies and spores of the parasite present. It is highly likely to reveal also fruiting bodies and spores in profusion from fungal species which are not parasitic! The "Key to Common Turf Fungi" is an aid to the identification of some of the more common fungal parasites of turf.

Sampling diseased turf for confirmatory diagnosis. Cut a 4" diameter plug from the margin of an active diseased patch so that both diseased and healthy plants are included in the sample. Wrap the plug tightly in aluminum foil, or polyethylene film, avoiding contamination of the turf surface by soil. Label clearly, pack carefully, and promptly dispatch the sample fo your Extension Agent, or to the plant pathologist at your State Agricultural Experiment Station.

KEY TO COMMON TURF DISEASES -- FIELD, MYCELIUM

N. Jackson, 1966

A. 1 Mycelium observable on diseased turf . . . . See B

2 Mycelium generally not observable . . . . See G

B. 1 Mycelium gray or dark colored . . . . See C

2 Mycelium hyaline, white, pink or red colored . . . . .See D

C. 1 Mycelium dirty white to gray; light brown sclerotia present in plant debris. A low temperature "snowmold". . TYPHULA BLIGHT

2 Mycelium gray to brown; "smoke ring" bordering the patches; black sclerotia often present . . . . RHIZOCTONIA BROWN PATCH

3 Mycelium dark brown to black, in mats on stem bases and roots; patches circular or "doughnut"-shaped with bronze/yellow margin. On bentgrasses . . . . OPHIOBOLUS PATCH

4 Mycelium as in C. 3; injured areas shaped as in C.3, but bleached. On bermudagrass . . . . SPRING DEAD SPOT

D. 1 Mycelium hyaline or white . . . . See E

2 Mycelium pink or red . . . . See F

E. 1 Mycelium fine and cobweb-like, injured turf spots bleached; leaf lesions with dark marginal bands . . . . SCLEROTINIA DOLLARSPOT

2 Mycelium white and cottony; dark "greasy" bordered patches, collapsed plants form matted crusts . . . . PYTHIUM BLIGHT

F. 1 Mycelium white to faintly pink; pale rose to pink spore masses on dead tissues. Occurs during cool moist conditions, and as a low temperature "snowmold" . . . . FUSARIUM PATCH

2 Mycelium pink to red; salmon to red spore masses on dead tissues. Occurs during hot, humid conditions . . .FUSARIUM BLIGHT

3 Mycelium in pale pink to pink gelatinous strands; forms red "threads" (stromata) when dry. . . . . . . CORTICIUM PINK PATCH

G. 1 Fruiting bodies observable on spotted or blighted leaves . . . . . See H

2 No fruiting bodies observable on spotted or blighted leaves . . . . See J

H.1 Spots vague or variable in shape, fruiting bodies in straw-colored or bleached leaf lesions . . . . LEAF SPOT (Stemphylium, Alternaria, Ascochyta, Septoria, Phyllostica)

2 Pustules observable on leaves . . . . See I

I. 1 Scab-like sporulating pustules with black spines evident on leaf lesions . . . . ANTHRACNOSE

2 Erumpent orange-brown pustules on yellowed leaves . . . . RUST

3 Salmon pink to orange spore aggregates on leaf blades; affected patches of turf on coppery-orange color . . . . . . COPPER SPOT

J. 1 Irregular yellow-green to brown patches in thinned turf . . . . MELTING or FADING OUT

2 Prominent "eyespot" lesions on leaves of St. Augustine . . . . GREY LEAF SPOT

End.

KEY TO COMMON TURF FUNGI-- MICROSCOPIC -- SPORES

N. Jackson, 1966

A.1 Spores present . . . . See B
2 Spores absent or rare . . . . See N

B. 1 Spores formed in definite fruiting bodies . . . . See C
2 Spores formed on hyphae . . . . See H

C. 1 Fruiting bodies spherical or ellipsoidal, dark colored . . . . . See D
2 Fruiting bodies not spherical or ellipsoidal
light colored or red . . . . See G

D. 1 Spores colorless, without crosswalls . . . PHYLLOSTICTA (Leaf Spot)
2 Spores colorless, with crosswalls . . . . See E

E. 1 Spores oval, one crosswall. . . . . ASCOCHYTA (Leaf Spot)
2 Spores threadlike, multiseptate . . . . See F

F. 1 Spores threadlike, multiseptate, in pycnidia . SEPTORIA (Leaf Spot)
2 Spores threadlike, multiseptate, in perithecia . .OPHIOBOLUS (Patch)

G. 1 Fruiting body a flat mass of spore-producing hyphae, black
bristles present, banana-shaped spores. COLLETOTRICHUM (Anthracnose)
2 Fruiting body an erumpent pustule containing
numerous roughly-rounded urediospores . . . . . . PUCCINIA (Rust)

H. 1 Spores colorless . . . . See I
2 Spores colored . . . . See J

I. 1 Spores borne on short hyphae; elongate to threadlike spores
in slimy matrix, salmon-pink in mass. . GLOEOCERCOSPORA (Copper Spot)
2 Spores on loose cushions of hyphae in bright-colored
masses. Banana-shaped spores with crosswalls. . FUSARIUM (Patch & Blight)

J. 1 Spores with crosswalls in more than one plane . . . . See K
2 Spores with crosswalls in one plane . . . . See L

K. 1 Spores not in chains . . . . STEMPHYLIUM (Leaf Spot)
Spores in chains . . . . ALTERNARIA (Leaf Spot)

L. 1 Spores more or less cylindrical HELMINTHOSPORIUM (Melting out)
and smooth . . . .
2. Spores not cylindrical . . . . See M

M. 1 Spores curved or bent with one of the central
cells distinctly larger than other cells . . CURVULARIA (Fading Out)
2 Spores with two crosswalls, apical cell
coneshaped . . . . PIRICULARIA (Gray Leaf Spot)

N. 1 Mycelium colorless, no crosswalls except
for fruiting bodies . . . . PYTHIUM (Grease Spot)
2 Mycelium containing crosswalls . . . . See O

O. 1 Hyphae dirty white to gray, light brown sclerotia. .TYPHULA (Blight)
2 Hyphae branching at right angles, light - dark brown
in color; may form sclerotia . . . . RHIZOCTONIA (Brown Patch)
3 Hyphae not branching at right angles . . . . See P

P. 1 White, delicate cobwebby mycelium . . . . SCLEROTINIA (Dollar Spot)
2 Hyphae forming moist pink strands or
dry red threads . . . . CORTICIUM (Pink Patch)

 End.

Turfgrass Diseases	Suggested Controls
Anthracnose Colletotrichum graminicola	Phenyl mercury acetate, Tersan OM, Ultraclor, Kromaclor
Copper Spot Gloeocercospora sorghi	Dyrene, Tersan OM, Kromad, Ultraclor, Kromaclor, Daconil (Where dollar spot is cadmium resistant use Dyrene)
Corticium Pink Patch Corticium fuciforme	
Fusarium Blight Fusarium roseum	Tersan OM, Caloclor (Scorch risk at high temperatures)
Fusarium Patch Fusarium nivale	Phenyl mercury acetate, Mercurous/mercuric chloride mixtures, e.g., Caloclor, Tersan OM
Grey Leaf Spot Piricularia grisea	Thiram, Daconil
Leaf Spot (as listed)	Dyrene, Ortho Lawn & Turf, Ultraclor, Kromaclor, Zineb, Maneb, Tersan OM, Phenyl mercury acetate, e.g., Phenmad.
Melting or Fading-out Helminthosporium spp.	Dyrene, Tersan OM, Kromad, Daconil, Zineb, or Maneb
Curvularia sp.	Phenyl mercury acetate (may scorch on Merion)
Ophiobolus Patch Ophiobolus graminis var. avenae	Phenyl mercury acetate Mercurous/mercuric chloride mixtures
Pythium Blight Pythium spp.	Dexon
Rhizoctonia Brown Patch Rhizoctonia solani	Tersan OM, Difolitan, Ultraclor, Kromaclor
Rust Puccinia graminis	Actidione-Thiram, Zineb, Maneb, Dyrene
Sclerotinia Dollar Spot Sclerotinia homoeocarpa	Increased N fertilizer. Cadmium-containing fungicides, e.g., Cadminate, Ortho Lawn & Turf
Spring Dead Spot (?)	Nabam
Typhula Blight Typhula incarnate	Cadmium fungicides Mercurous/mercuric chloride mixtures Tersan OM, PCNB (Quintozene)

Other chemicals and formulations may be available.
These are suggestions for general information.

ANATOMY OF TURF PLANTS

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Grasses are among the most widely distributed of the economic plants. Some species of grass are found on almost every part of the earth. Some grow under very cold conditions; some under very hot conditions; some grow where it is very wet; and some where it is very dry. The types of grass that are adapted to the conditions they encounter will survive, while those that are poorly adapted will die.

How does a Plant Adapt to Its Environment?

Some changes can be made by a plant in any one generation to aid in the matter of adjustment to environment. For example, roots will become shortened in a water-logged soil. Leaves will curl or fold on the grass plant 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 generations by the process of natural selection. This concept of natural selection is sometimes spoken of as the "survival of the fittest." We may understand this process a little better by considering the example of bentgrass. When bentgrass is grown in the Pacific Northwest, it grows in an area which is admirably suited to the needs of bent. Therefore, this species has no difficulty in surviving and even the weak types may thrive. However, when we move bentgrass to the Desert Southwest, it finds itself rather poorly adapted to its environment and only those plants which are equipped with mechanisms which allow them to cope with drouth and the other unusual environmental conditions may survive. The adaptive mechanisms which permit one type to live in an area where another cannot grow may be of various natures. These are primarily biochemical and biophysical factors and there are also certain structural characteristics that are involved in a plant's ability to thrive under a given set of conditions.

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 must undergo dormancy 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. This is true in the case of deciduous trees and shrubs. This ability to shed leaves is not found so much among the grasses, but we find such species as buffalograss in which the leaves dry up during seasons of 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. There are other grasses like bluegrass which are not equipped with this mechanism of dormancy which would permit escape from drouth. Bluegrass, therefore, would die under comparable conditions.

We may also consider the difference in perennials and annuals as this characteristic of longevity relates to adaptation. 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 habit of some plants enables them to reproduce themselves year after year by seeds, even where there are some seasons extremely unfavorable to their growth.

Seed moficiation is a very important factor in the plant's adaptive ability. Some plants produce seeds which may lay dormant for a certain period before they will germinate. Other plants produce seeds with hard seed coats so that the seeds will not germinate all at once. Such mechanisms which prevent the seed from all germinating at one time serve to insure the plant against complete destruction by any one period of unfavorable weather during the time the plants are in the seedling stage.

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. The plant is able to protect 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.

Physical Modifications

It has been mentioned that some of the structural characteristics of grass plants are important in the plant's relation to its environment. One of the highly variable physical characteristics is that of root length. It is known that bermudagrass roots will enter a good soil to a depth of six feet or more; whereas, such grasses as red fescue and bluegrass in similar soil will produce roots to a depth of only about three and one-half 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.

Another example which may be visualized is the contrast between goosegrass, which is an annual grass, and Poa annua, which is also an annual grass. Goosegrass produces a prolific root system which is almost impossible to pull up when the grass is firmly established; whereas, Poa annua may be very easily pulled out of the soil. Such characteristics are extremely important in the ability of plants to compete and to maintain themselves under various conditions.

There are many modifications of grass stems which affect the plant's ability to grow in a given environment. In speaking of stems we think not only of the upright stem, but also of the stolons and rhizomes, which are modified stems. 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. The fescues and bluegrass are characterized primarily by stems which grow upright though they do have short rhizomes which permit some degree of spreading.

Bermudagrass stems are mostly prostrate or underground. This characteristic permits bermudagrass to be mowed very 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. Relatively little additional information has been published since that time. Lewton-Brain attempted to devise a taxonomic key based on leaf anatomy. He failed in this attempt because temporary modifications caused by environment were greater than differences between species.

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 size and shape. The arrangement of these cells is important. Most grasses have a rather heavily cutinized lower leaf surface. This layer of cutin affects moisture loss in the leaf and it varies greatly in its thickness. One type of cell which is found in the epidermis is large and thin-walled. These are characterized as motor cells. These usually occur in rows and they lose water rapidly under conditions of moisture stress. When 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 amount of pubescence, or hairiness, or leaves affects the rate of water loss, and the number and arrangement of stomata is also important in this respect.

There is also variation in the structural elements for support of the weight of grass leaves. These leaf components consist of fibers and thick-walled cells which make up the conducting tissue. Another type of cell which is sometimes important as a structural element is the thin-walled parenchyma cells. These cells when filled with water are turgid and hold the leaf upright. When the plant is under a 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 is sometimes damaged severely when subjected to traffic during such periods of stress.

There are many other ways wherein the plant may relate to its environment through structural, chemical and physical modifications. The ones mentioned in this discussion are merely examples of the great variation that exists in plants.

Plant Structure Affects Management Needs

The examples of structural differences which have been discussed indicate that even grass plants vary greatly in their ability to fit into a given environment. These examples will serve also to demonstrate the fact that a type of management must be provided which will take into account the tolerances of the particular grass being grown. Some grasses must be watered often because their structural makeup does not allow them to resist drouth. Some grasses may not withstand close mowing because their food storage organs are removed by such treatment.

Most of the accepted management techniques employed in growing turf have come about as a result of trial and error through the years. However, when one looks closely at the individual plant and considers the effect of any particular treatment, he should find good fundamental reasons for following wise practices. Equally important, we should be able to predict the effects of management treatments by understanding the requirements and tolerances imposed on individual plants by their structural attributes.

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BLUEGRASSES - AGGRESSIVES AND PETITES

Terrance Riordan, Graduate Student in Turf
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This present study has its basis in observations of numerous phenotypic variants made here at Purdue prior to 1965. Many of the present better selections are descendants of large clones of bluegrass from the fairways of the Chicago Golf Club.

There is need for new and improved turfgrass types, which are adapted to the wide range of possible uses. Plants which have wide leaves, deep roots, drouth tolerance, and vigorous growth are suited for roadsides and airplane landing strips; while bluegrasses that have narrow leaves, low growth, and dense tillers are more desirable for golf tees, home lawns and cemetery areas.

In 1964 statistical estimates were made on various outstanding bluegrasses. The results suggested that selection would lead to large amounts of improvement among the various genotypes.

1965 program

1. 3600 individuals were tested.
2. 164 varieties were used.
3. Spread,
4. Height,
5. Rust infection, and color were measure twice.

The 1966 program will be to

1. Re-measure spread and height.
2. Measure seedhead height and quantity.
3. Measure leaf width.
4. Plant 3000 new individuals - fewer varieties from seed of 1964 planting.
5. Test these plants.
6. Use computer to analyze data -
   a. Find best individual for different turf types.
   b. Make basis for increase
7. Make large plot observations.
8. Make seed production observations
9. Get release approval after wide testing.
10. Cooperate in seed production work.

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RESEARCH IN SPRAYING CHEMICALS

Hayden Watkins, Graduate Assistant in Research
Purdue University

Within the field of Turf Management many are particularly interested in herbicides. Some of the work we are doing here at Purdue with herbicides, durin the past year, has been with wetting agents, eradication of established turf and Poa annua control.

Wetting Agents

We have used nine (9) experimental materials in testing their effectiveness as additives when added to herbicidal sprays. Our results indicate that they may, under certain conditions, increase herbicidal activity. However, none have shown any definite superiority to the commercial wetting agent used as a standard. We plan to continue this study with additional materials.

Turf Eradication

Potassium and sodium azide have shown some promise as a plant eradicator and soil sterilant when applied to established turf. One hundred pounds per acre of either material failed to give complete plant kill. It appears that 200 pounds or more per acre is required for assurance of complete turf kill. These materials disappear quickly from the soil and reseeding could be done in about one week. Apparently the killing action is by contact with very little translocation in the plant. Some residual nitrogen could be expected from higher rates of this material. Since both materials are experimental, their cost is unknown.

Poa annua Control

During the past summer and fall we have tested seven (7) chemicals that showed some promise as selective post-emergence annual bluegrass control in Kentucky bluegrass turf. The results were encouraging. From the seven (7) materials tested in the field, two (2) showed enough promise to warrant further test. These two materials have been tested during the winter in the greenhouse. Our results show that these materials will kill Poa annua when applied post-emergence. None of these materials have been tried pre-emergence. Slight injury to Kentucky bluegrass occurred at some of the higher rates. Additional work is planned to determine rates under different conditions.

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EVAPOTRANSPIRATION - TURF AND WEATHER

Marvin H. Ferguson, Mid-Continent Director, and
National Research Coordinator USGA Green Section
College Station, Texas

Evapotranspiration is a term used to describe the water loss resulting from the combined effects of evaporation from the soil surface and transpiration from plant surfaces. This water loss is a substantial factor and it is the concern of several separate but related disciplines.

The water economists and the hydrologists are interested in the amount of rainfall which is dissipated back into the atmosphere by these forces. From their standpoint, this is water which is lost, is unusable, and which represents a debit entry in the account of available water.

The meteorologist is concerned with the effects of evaporation and transpiration on weather and the reciprocal effects of humidity, wind movements, and temperature upon evapotranspiration.

The plant morphologist studies plant structures in relation to moisture loss. He is also interested in the effects of moisture and atmospheric conditions upon plant modifications.

The plant physiologist is concerned with evapotranspiration as a plant growth process. Is it a necessary evil? Does it perform any necessary function in the plant?

The turf manager is concerned with all these things, though he is unlikely to study them in such intimate detail. Being a practical man, he is interested in the effects of evaporation and transpiration upon his turf, upon his watering program and indirectly upon his labor requirements. It is a complex and complicated subject.

Evaporation occurs when the molecules in a liquid mass of water attain sufficient velocity to entirely overcome the attractive forces holding them in the liquid. Transpiration is a modified form of evaporation inasmuch as evaporation occurs in intercellular spaces and moisture vapor, then diffuses outward through the stomata. This type of transpiration (stomatal) accounts for most of the water loss from growing plants. Some direct loss from leaf surfaces (cuticular transpiration) occurs and in woody plants there is often a loss of moisture from stems through the lenticels of bark tissue (lenticular transpiration).

The magnitude of transpiration is highly variable. The variation occurs at different times of day, at different seasons and it is highly dependent upon soil and atmospheric conditions.

Ecological factors involved in evapotranspiration are humidity, atmospheric pressure, soil temperature, soil water, soil aeration, air temperatures, and wind movement.

Morphological factors which influence transpiration are hairs on plant surfaces, the number, arrangement,and location of stomates, leaf folding and rolling mechanisms, the cuticular covering of the leaf and the depth and degree of proliferation of the root system.

The effect of transpiration on plants is a matter of many facets. It is a process which is regarded by some observers as a necessary evil. Transpiration results in loss of water and in cases of very rapid transpiration accompanied by slow uptake, wilting may occur. A great deal of controversy exists with respect to the role of transpiration in the processes of water absorption, salt uptake, the movement of water and the dissipation of solar energy. There seems to be reasonably good evidence that transpiration plays no really important part in any of these processes, though it may contribute in some degree to all of them.

The practical aspects of evapotranspiration, as they relate to Turf Management, revolve about the wilting of turfgrasses. This can occur when water loss is high and water intake is low. A restricted root system, a dry soil, a waterlogged soil, or a poorly aerated soil can contribute to a limitation of water uptake. When the soil is too wet, the damage is called "wet wilt." The other conditions contribute to the more easily recognizable form of wilt.

The remedy for any of these aliments is to slow down water loss. This may be done by showering or syringing turf to cool it and to raise humidity in the immediate vicinity of the plant. Materials which will cause stomates to close may also reduce water loss.

Thus, the manager may approach the problem from two directions. He can strive to create conditions conducive to ready uptake, such as deep rooting,good aeration, and good moisture conditions in the soil. He can also compensate to some degree for deficiencies in these matters by raising the humidity, or by imposing barries to the loss of water from leaves.

A thorough understanding of the principles of evapotranspiration will enable the turf manager to know the "why" of soil-plant-water relations. His intelligence and common sense will tell him the "how" of coping with his problems.

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PIPE FOR IRRIGATION SYSTEMS

Edward Stoltz, Jr., Johns-Manville Sales Corp.,
Waukegan, Illinois

The turf market today is expanding at a terrific rate and one of the reasons is because of economical irrigation systems. Hand-watering of large turf areas is rapidly becoming obsolete because piping systems provide a superior watering pattern at lower cost. On turf systems today we find various mechanical systems, among which are portable piping, self-propelled sprinklers connected by hose, and permanent underground piping systems.

Since the underground piping system represents a sizeable sum of money - sometimes as high as $ 100,000 for an 18-hole golf course - it is well to have an understanding of the pipe which comprises as much as half of the cost of many systems. The major types of underground pipe in use today are:

Asbestos-Cement   Cast Iron   Galvinized   Plastic

Occasional systems have used steel and aluminum under certain circumstances, but their effect on the current market is insignificant.

No. 1 - Asbestos-Cement

This pipe as manufactured by Johns-Manville is called TRANSITE and is a mixture of asbestos, cement and silica which produces a pipe of highly uniform quality. TRANSITE pipe will not tuberculate or rust; it is highly resistant to corrosion both inside and outside; it is lightweight and can be handled manually in the sizes used for turf; it possesses adequate strength; it is easy to handle and install; it has tight flexible rubber joints, and last but not least, has a high flow capacity which is maintained throughout the life of the pipe. Over 60 years of world wide experience has resulted in a piping material well suited for irrigation. It is available in sizes 3 inches and above.

No. 2 - Cast Iron pipe as we know it today is generally centrifugally cast from various compositions of iron to produce a product of uniform quality. It is available with a tar-coated, unlined interior, or with a thin cement lining covered with a sealer to resist corrosion. It is fairly heavy, requiring mechanical equipment, but is easily joined. Today's cast iron almost always has flexible rubber joints which are tight. The lead joint days are gone for good, we hope. It posses high strength and an initial high flow capacity, which may or may not be maintained, depending on many factors. A history of long life is another good feature of cast iron pipe. It is available in sizes 2" and above.

No. 3 - Galvanized Pipe is essentially steel pipe with a zinc coating inside and outside to retard corrosion. Assembly is generally made by threaded connection which provides a degree of flexibility. This product is lighter than cast iron, although considerably heavier than plastic or asbestos-cement. The larger sizes (3", 4", 6", etc.) usually require mechanical handling, while the smaller sizes can be manually handled.

No. 4 - Plastic Pipe as used in turf are thermoplastic types, including polyethylene, PVC, ABS, etc. Polyethylene is coiled and comes in small sizes 1 - 2 and is still widely used on home lawn systems. ABS, because of its high impact strength, was used for a couple of years. As the price of PVC resins were reduced and their strengths increased, it dominates the small diameter pipe market. This pipe has, until recently, only been available with solvent weld joints, but within the last two years rubber-jointed pipes have appear on the market. The rubber-jointed pipe has the big advantage of exceptional flexibility, no cemented joint problems due to poor cementing techniques, and automatic expansion and contraction. All PVC pipe, regardless of joint type, is lightweight, flexible, simple to handle and strong. Quality ranges from good to exceptionally good, depending upon the supplier. However, the trend is rapidly approaching excellent quality and uniformity of product as well-financed major companies enter the field. NSF approved plastic pipe will not contaminate the water and is often used to serve drinking fountains around a golf course. There are now plastic pipes on the market without the NSF seal, which have been designed specifically for irrigation purposes.

Well, enough of the background information on types of pipe. Now, let's ask ourselves, "What do I want in a pipe." Strength? - Yes. Handleability? - Yes. Long life? - Certainly! But, what I really want is a pipe that will carry as much water many years from now as it does when it is new. This is what a pipe is supposed to do - CARRY WATER. All types of pipe do this but with perhaps surprisingly different end results as we shall see.

The American Cast Iron Pipe Company's manual says - "The carrying capacity of a given pipe line is limited only by its internal resistance to the flow of water." Engineers express this by using a value "C" which is a factor of flow coefficient. The higher the "C" value, the smoother is the inside of the pipe, and consequently the lower is the internal resistance to flow. To give you an idea of what this difference in smoothness means, let us look at the pressure drop in 1000' of 2" pipe and a 4" pipe for different "C" values at an approximate velocity of 5' per second. Incidentally, the most economical velocities for turf are between 3' and 6' per second at pressures up to around 125 psi so this is why we recommend 5' per second.

1. For the same velocity a 4" pipe delivers 4 times the amount of water as does a 2" pipe. Putting it another way, discarges are proportional to the squares of the diameter.

2. The 4" pipe has less than 1/2 the pressure drop of the four 2" pipe.

3. Notice how the pressure drop increases as the "C" (smoothness) value is reduced.

4. With increases in velocity, the proportional pressure drop would increase. With decreases in the velocity, the pressure drop would be less.

For the same head of pressure, the velocity will be less in the smaller pipe, and thus the discharge will vary as the 2.63 power of the diameters, i.e., the square root of the fifth power. For instance, if the pressure is the same in both pipes, you will need almost 6 pieces of 2" pipe to equal a 4" pipe, almost three pieces of 4" pipe to equal a 6" pipe, 2 pieces of 6" pipe to equal an 8" pipe.

The amount of water that a pipe can carry is also determined by its inside diameter. It is obvious that sometimes you do not get what you think you are getting.

Now, what does this all mean to your irrigation pipe sytem?

1. When you select pipe consider the demands of the system. How much pressure do I need? How much water do I need? How fast will the system run?

2. The same size pipe in various types of material does not deliver the same amount of water under the same conditions. ("C" value and inside diameter varies).

3. To plan for possible future changes, pipe of one material of a larger size may be required than pipe of another material. Thus, the system may cost more money. (In today's money market, $ 1.00 borrowed means $ 2.00 just twelve years from now since 6% money doubles itself in 12 years).

4. It is imperative that pressure reaching sprinkler heads be fairly uniform. If your pressures decrease as the "C" value deteriorates, you will notice a narrowing of fairways. A fairway sprinkler that initially was throwing water 180 feet may have its throw reduced to 170 feet or less if the pressure drops 10 psi.

5. Even though "C" values may drop off with time, more or less uniform pressures can be maintained by increasing pumping pressures. Obviously this uses more electricity and increases cost of operation.

The purpose of this paper has not been to downgrade or praise any piping material, but to remind you of facts available to anyone who is willing to make comparisons.

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THE PROPER APPROACH TO BUYING AN IRRIGATION SYSTEM

Bob Rupar, Irrigation Engineer, Rainy Sprinkler Sales
Peoria, Illinois

Turf production is now a multi-billion dollar industry in the United Sates, in which the irrigation system is a widely accepted and essential production tool. Efforts at controlling the cost of installing or using this production tool, as in any industry, can be easily appreciated and deserves further attention.

Substantial capital expenditures, both initially and annually, are required for turf irrigation systems. Manually operated systems require lower initial investments, but much higher operative expenses than automated systems. Since the cost of labor and water consume approximately 80% of maintenance expenditures with manual systems, efforts to reduce these costs through automation are well-founded. According to the Economic Research Associates, a firm in the field of land use economics, the additional cost of the automatic system over the manual system on the west coast is paid for in 1.4 years; thus representing an investment return of 70 to 75%. Here in the midwest the payout is usually considered to be 5 to 7 years, which is still a good investment return.

Not only the cost of labor, but it's the lack of availability and reliability make this comparison more interesting. However, who can place exact dollar values on such things as water control, flexibility, and uniformity of application? These are obvious merits adding to the utility and results from an automated irrigation system.

The desire to control costs has led to many serious errors in judgment and misuse of equipment, unfortunately at the expense and reputation of earlier automatic systems. Automatic irrigation is sophisticated and complex, and requires the best possible coordination of those who specialize in engineering, design and installation. Cost shortcuts may be simple, but can lead to very expensive headaches. If you are considering an irrigation system for a large turf area, it may pay you real dividends to know what channels to work through and the pitfalls of taking the wrong approach.

The easiest and most common mistake for a club to make is to let their intentions to purchase an irrigation system be known, request two or more equipment distributors or manufacturers to design a system using their equipment, and then have several contractors bid on the various plans. Let us assume that everyone involved is reputable and sincere. What a ridiculous situation we have created - IF the only consideration in final selection is price - not the individual merits of design or equipment.

Irrigation system design requires the talents of professional people who are experiencedin sprinkler selection and performance, pipe sizing and routing; also, pump, valve and controller selection.

The highly competitive market and the desire to avoid equipment misuse has forced equipment manufacturers to offer design services at nominal charges. Keep in mind, however, that equipment manufacturers are not in business to offer competitive design services.

So, rather than request designs from several manufacturers, a more logical approach is to survey the equipment market thoroughly until you have developed confidence in one line of equipment, request a design from that manufacturer (or distributor), then obtain competitive installation bids.

This procedure, though much better than the first approach, still leaves many burdens upon the turf manager, which he may or may not be able to handle. Due to their complexities, these burdens, which entail such things as specifications and contract writing, contract negotiations, and jobsite inspection should be handled professionally to expedite the project. In fact, when planning irrigation systems on larger turf areas, it may be well to consider an independent consultant.

The design consultant, the installation contractor, local equipment distributors, and the turf manager form a team of experts through which a first class, dependable irrigation system can be obtained. Each team member performs a vital function and the success of the project will depend upon their close cooperation.

The consultant engineer or architect performs several vital functions:

1. Makes the preliminary survey and determination of system needs.
2. Prepares the design, showing system layout and installation details.
3. Prepares project specifications and contracts.
4. Assists in negotiation of contracts.
5. Repeatedly inspects the job during installation.
6. Prepares a final "as built" drawing for files.

It may be well to point out at this point that like a good design, the specifications and contract are of vital significance to the success of the project. The registered professional engineer or architect is formally trained and experienced in all phases of such project functions. His opinions are unbiased, and he is obligated to specify the equipment which he feels will perform best for you. The consultant's fee, usually 4% to 8% of the project cost, is very nominal in consideration of the vital function which he performs.

The function of the installation contractor is quite obvious and self explanatory. The contractor who specializes in work of this nature is very essential, not only because of his experience and ability, but also because he is more competitive than the general contractor. The local distributor, who has helped develop your interest in a modern system, will furnish the equipment to the installation contractor during the project. After project completion you will rely upon him for service, parts and assistance, so he is an essential member of the team.

Conclusion

Many of the objections to earlier automated irrigation systems have stemmed from efforts to cut cost in the wrong areas. One of the most serious error has been in the approach taken in purchasing the system. Use every resource available. Avoiding the pitfalls of misjudgment and excessive cost cutting in the initial phases of a project can mean dollars saved in the long run.

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USING AUTOMATIC IRRIGATION SYSTEMS ON NEED

Donald Wright, Supt., Camargo Club
Cincinnati, Ohio

Carefully programmed automatic irrigation is very important for the modern superintendent, who is thinking in terms of better and better turf. This is especially true as the numbers of players seem ever increasing. Before programming each superintendent will need answers to the following questions:

What kind or kinds of soil are found on the course?
What is the nature of the surface and sub-surface drainage?
What kind of grass is he trying to produce for the player? Since some superintendents have more than one kind of grass to water, this may take more than one kind of water application. Water needs for each situation need to be thought out and wisely programmed.

Programming irrigation boils down to how to use whatever hours are available to water. Most superintendents will have ten hours available for watering. Some may need more and some less, but for an example let's program a ten-hour day. We can split the system up into three categories: tees, greens, fairways. Now, in ten hours, all or part of these three areas must be watered. Since most superintendents consider greens most important, let's program them first.

If you have been using thirty minutes of water a night on each green and you can water six greens at one time, this gives a total of one and one-half hours running time for the greens. If the tees require the same, three of the ten hours watering time have been used. The fairways can be programmed to use all or any part of the seven hours remaining. If the average number of fairway heads on the course is 280, in seven hours time all of these heads can water for 30 minutes at a time. This type of automatic irrigation system would require 1000 g/p/m and a good source of water.

The amounts of water just indicated can be programmed on the clocks in very different ways. Programs I and II following are two examples. They are very different, but arrive at the same amount of time and water.

Program I. Irrigation of greens starts at 8:00 o'clock and turn off at 9:30. The tees turn on at 9:30 and turn off at 11:00 o'clock. The fairways come on at 11:00 and turn off at 6:00 A.M. The total running time is ten hours, and all is well, or is it? In watering with automation this way, unless your soil is 100 percent sand, you are doing more harm than good, both soil-wise and plant-wise. If there was run-off and saturation neither one does any good for the grass that you are trying to grow. Always remember that automatic irrigation puts out the maximum effort. The least amount of water that you can use at any given time, the better off you are.

Program II. short irrigations, repeated with soak-in time between. This allows total absorption and greatly reduces run-off, plus has other side benefits.

Program the fairways first at night and water them until 3:00 A.M. for a total of six times at five minutes each. Do the tees next until 4:30, six times at five minutes each. Water the greens last to get the morning dew off the plant as well as to water it properly. Rest fifteen minutes inbetween each five-minute cycle.

Another advantage of the five minute cycle is the ability to cool your grass during the day. In 15 minutes you can cool all tees; all greens in fifteen minutes and all fairways in one hour and ten minutes. With five cycles you can put on any amount of water (up to thirty minutes in 10 hours). By using the skip-a-day part of your clock you can say "yes" or "no" to any part of the program.

Remember, program automatic irrigation to apply water as the soil and the plants can take it, not how much you can apply at any given time.

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AIR-CONDITIONED FAIRWAYS

Richard B. Craig, Supt., Losantiville C. Club
Cincinnati, Ohio

Automatic irrigation used daily to air-condition fairway turf? This talk, I must admit, is based on only one year's personal experience, and the use of light, daily watering of grass is far from a standard accepted practice. But, because we had much Poa annua in the fairways when the water system was installed, the development of an irrigation program that would keep Poa annua turf alive through Cincinnati summers could not begin to be anything normal. The technique of using light applications of water has been used with success in garden crops, such as tomatoes and strawberries, and by Don Likes at Hyde Park Golf and Country Club in keeping Poa annua. The principle of keeping the soil surface moist does agree with the very nature of Poa, a plant with a shallow root system preferring a damp, cool climate.

The real key, I think, for keeping Poa annua and the programming of your automatic water system is to have, every morning in the hot weather, sufficient water in the Poa annua rootzone to carry the plant through the hot afternoon. The soil water content of this surface soil was thought to be near 100% of the field capacity daily. This abundant water in the soil surface was necessary to supply needed moisture for plant root uptake all that afternoon, and it also was necessary to cool the plant. The real significance of this water is its cooling by the lowering of plant and soil temperatures as the water changes from a liquid to a vapor in evaporting from their surfaces. This evaporting water lowers the grass plant temperature and the soil temperature, which in turn increases the relative humidity in the plant's micro-climate, and ultimately reduces the water loss from the plant through transpiration, leaving more water in the plant for growth and development processes; thus, a healthy turgid plant.

To accomplish having the soil surface near field capacity every morning requires almost nightly application of water through the summer months. The amount of water applied always fluctuates, but an average rate was approximately 1/10th of an inch of water per night. This was never applied all at once. We usually water fairways in 3 cycles with the first two cycles occurring as early in the night as possible to allow maximum time for soil absorption, and the third cycle starting after dawn to knock the dew down.

By no means does this automatic system replace or reduce the work load of the superintendent. He has to know each day what the water status is in every foot of his 40 acres of fairways, and must decide for each 200 plus sprinklers how much water will be required that night to bring the soil back up to desired water content. He must review the next day's weather forecast and out-guess it, and modify the clocks if needed. One thing I did learn was that you can never anticipate rain. If it's not actually raining use your water system because if you don't have sufficient water the next morning to hold your fairways through the next day, you don't have time to water then. I am seriously considering changing my title from Greens Superintendent to Fairway Superintendent. I am now spending more than half my time each day riding over the fairways, checking and then rechecking.

Many people have hinted that electronic moisture sensors would help, but I believe they would be of little overall help unless there were nearly as many sensors as sprinklers because we know that 40 acres is not going to dry out uniformly. I feel there just isn't an economical replacement for a good pair of eyes and a willingness to go out and look.

I do want to mention that I did not use the above procedure on my putting greens. These were irrigated as they needed water. The significant thing about the greens was that for the first time in my life I was able to keep my bent roots down. I ended up the summer with roots 4 inches in depth or more. I think this was due to the use of the automatic water system which let me add limited water to the greens when they needed it, and in the amount needed; thus, keeping a uniform moisture in the soil profile. In the past, night watering was done only once or twice a week and was accomplished by men from the day crew coming back after supper and working 3 to 4 hours more. With this type of situation you watered when the men could work. With this program I can set and observe the watering program as part of supervision activities.

In summary I believe that <u>Poa annua</u> survived because there was an abundance of soil moisture for plant root absorption and for water evaporation which cooled the plant and soil surface to a tolerable level. Daily watering can be done with no more supervision than other schedules. The turf responded well. During 1966 daily air-conditioning will be our target again.

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MANICURING FAIRWAY TURF - 3rd REPORT

N. W. Kramer, Supt., Point O'Woods Country Club
Benton Harbor, Michigan

I have spent many hours trying to find a real answer to good fairway turf. Let's go back to the basic problem at Point O'Woods Country Club. First, it was a large forest and estate before a course was established in 1959, and second, it was heavy clay soil. Third, there was little air, light and water drainage. Where to start?

I started with air drainage and a complete pruning program on the trees. This also meant, of course, all underbrush. Next, hundreds of feet of soil drainage in which we used perforated fiber pipe covered to the surface with pea gravel. We are now using pea gravel in slit trenches without tile and it is doing an excellent job.

The next problem we faced was the Highland bentgrass. It not only would not adapt itself to soil conditions, but as soon as we started mowing it short it began to thin out. At this point we decided to buy equipment that would enable us to plant a new strain of bent into the fairways. We chose a slicing type of machine along with a sweeper for picking up the grass clippings. We also overseeded 30 pounds Seaside bentgrass per acre, using a Brillion seeder - with excellent results. By 1963 another problem - how were we going to control the Poa annua, which was making inroads fast?

After careful study I presented a program to the Board of Directors which required a special allocation of money to be used for the purchase of calcium arsenate 85% powder for use on the fairways. They accepted the program and we started in the fall of 1963. We applied the powder with a sprayer at the rate of 10 pounds per 1,000 square feet on a limited acreage. It looked quite encouraging, so in the fall of 1964 we decided to broadcast the powder at the rate of 5 pounds per 1,000 square feet. It went on with little trouble and everything looked good until the spring of 1965. What a shock! Wherever there was overlap, the Poa annua had completely disappeared over the winter.

I want to remind you at this point that the overseeding program that I had started in 1962 was still in full operation, but some Seaside had passed out also. A quick check pointed out two things: a broadcast spreader was not the answer (if using powder). However, the one thing not thought out beforehand was the soil moisture level. Here we have found that if soil moisture is near or at field capacity the calcium arsenate will and has done a fine job in controlling crabgrass, Poa annua and earthworms.

In 1965 our fairway program was as follows:

April 21	-	we mowed the fairways for the first time
May 21	-	fertilized with ammonia sulphate - 200 lbs./acre
June 14	-	fertilized with 45% urea - 100 lbs./acre
June 28	-	fertilized with 45% urea - 70 lbs./acre. We also started applying 2 gallons on one acre plots on #18 fairway using liquid fertilizer - Plot #1: 20-20-12. Plot #2: 10-20-10. Plot #3: 20-10-20.
June 30	-	phosphoric acid was sprayed on #5, #6, #7, #8 and #15 at the rate of 1 pint per 150 gals. of water sprayed on 4 fairways. This was to reduce arsenic toxicity until seedlings started.
July 12	-	sprayed with 20-10-20 at the rate of 2 gals./acre
July 23	-	sprayed for disease control
July 26	-	W.G.A. amateur started.
August 5	-	sprayed 20-10-20 at 2 gals./acre
August 21	-	sprayed fairways with 20-10-20 at 2 gals./acre

September was very wet

September 14 - sliced fairways & overseeded with 20 lbs. Seaside/acre

September 27 - fertilized with 45% urea 100 lbs./acre

November 1 - trenched 1750 feet of fairway low spots and filled slit trench with pea gravel. (Editor's note: Suggest overflow fill of trench with sand above pea gravel).

Our general practice is to mow the fairways with a mower set at 11/16th of an inch 3 times a week and 4 times a week when the grass is growing rapidly. When starting the season I had planned to get 8 pounds of nitrogen, 4 pounds of phosphate and 8 pounds of potash per 1,000 square feet on the fairways. As it turned out we only got on 7 - 3 - 7 pounds due to the heavy rains.

In summarizing, I would like to say that there is much room for improvement. Last fall we had the finest grass growing season I have ever had the pleasure of going through. The wet and cool season brought on even more Poa annua. We have had an open winter for our part of the country, having only a total of 63" of snow. Looking at the fairways on Friday we have a mild case of snowmold on the fairways.

I give the chemical industry a challenge. Give the Superintendents a chemical that controls Poa annua and at the same time will still enable us to continue our seeding and fertilizing programs. The turf industry would be very grateful, and I am looking forward to the time when it may become a reality.

(Editor's note: Prior reports are in 1964 and 1965 Turf Conference Proceedings). If Poa annua control with arsenics is wanted, then only the least practical phosphorus should be used.

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PREPARING FOR A NATIONAL TOURNAMENT

Ernie Schneider, Supt., BEllerive Country Club,
St. Louis, Missouri

In September 1963 I was invited to come over to Bellerive Country Club near St. Louis, to look at their golf course. I took a quick tour, had lunch with the Greens Committee and some of the Board members, and they made me a proposition. The terms they offered were O.K., but I wanted to think it over for a few days. I accepted the position the third of October, and was to report for work February 1.

As I made out my work program, I knew that the first thing that had to be done was to renovate the traps. These traps were put in without any drains; they were scooped out in a fashion that after every rain the sand would wash out. Some were even located so that the drainage off of the greens washed through the traps. This was remedied by use of swails to carry the water away from the trap. All the traps had to be dug out by hand. All the traps that were on a slope were dug out next to the green one to two feet, creating a sort of shelf. In draining the traps I picked out the low end of the trap, dug a hole three feet deep and three feet across; then dug a drainage ditch from this hole. This hole was filled with large gravel within four inches of the top; then a plastic drainage tile was placed in this ditch. I put two inches of pea gravel over the large gravel and also over the plastic pipe; then two inches of coarse sand. The ditch was then filled with dirt and sodded. We used brown sand in the bottom and topped them off with white sand. This white sand was put on at least four inches deep all over. All traps were renovated before June, 1964.

My biggest disappointment were the greens. For a new golf course they were poorly constructed, just a gravel bed under them for drainage and no tile; the mixture was about 40% sand, but very poorly mixed. To my surprise the greens had thatch on them better than an inch and a half thick. Some of the greens had as many as three hundred circles, which were identified as "fairy ring." Every green had them - some worse than others. A soil check showed the pH was very low - from 5.4 to 6.1. The first thing I did was to remove some of the thatch by different methods, use of delmonte rakes, aero-blade, brushing and combing. Also, applied 30 pounds per 1,000 square feet of Dolmetic limestone and two pounds of sulpho-mag. In the mid-summer 10 more pounds of lime and again in the fall 20 pounds, and again last spring 20 pounds. Greens were topdressed spring and fall. I used a regular fertilizer program, using various types of fertilizers. Greens were treated with a wetting agent twice in the spring at the rate of 8 ounces per M, and in the fall 8 ounces. The fairy ring disappeard on all the greens except two; one had 3 rings and the other 4.

Marv Ferguson made one of his annual visits, and as we were touring the golf course I told him that I had done everything to the greens which I knew, and they had not responded as I wished them to. So, he took a look and discovered the worst infestation of frit flies that he had ever seen. It took three sprayings, four days apart to rid these pests. I sprayed Malathion at 2 ounces per M. They reappeared in '65; I used DDT at the recommended rate, and couldn't get rid of them, so had to go back to Malathion.

The greens average 10,500 square feet. It takes six men three hours to cut the greens. On No. 18 green we removed the sod, cut a hump down 3 feet for better spectator view; then dug out 8 inches of soil, replaced this soil with a regular greens mix, and replaced the sod. I had to remove the sod off the corners of two other greens because these areas were so rough.

The fairways required a lot of work. A crew of six men spent the entire summer sodding and stolonizing areas. Drainage is very poor on the fairways, and it was impossible to eliminate all the low places in such a short time; so, we concentrated on the worst ones, especially in the landing areas. All these areas had to be filled and sodded because there was no grass. Lack of moisture made this a very rough job, since it was very dry and windy. I used two men constantly to follow up watering all these areas because the fairway sprinklers would miss some and were not in the proper positions for others; hence, we had hose strung all over the place.

The areas that were stolonized were done very fast with the method I used. First, we eliminated the crabgrass, then scattered the stolons, which we secured from thinning out a tee or other area. I used a unit consisting of a Rogers Aero-blade with one-fourth inch tines, followed by a coulter, behind which was a roller. The Aero-blade made the seedbed, the coulter pushed the stolons in the ground, and the roller smoothed it out. These areas were watered immediately.

All fairways were fertilized at 1#N/1,000 at least four times and some six times. By fall we had decent coverage; I even irrigated the fairways after they were dormant because of lack of moisture. Crabgrass was kept out by use of DSMA. In August the fairways were laid out to ninety feet by Mr. Dey and Trent Jones.

This gave us a lot of bermuda rough. Extra work was made for us by the fact that this water system was put in before the fairways were graded, so many of the snap-on heads were above the ground, or some were too low. The only time we could work on this was when the water was shut off, a couple of months during the winter. This water system did not have any drainage valves and it used to take them two days to pump it out. I have put some drain valves in, but still pump out some of the main lines which are seven feet underground.

Tees had good grass on them, but they were exceptionally thatchy. We removed the thatch; we rebuilt and lengthened one tee, and built two new tees. No. 10 was shortened by 100 yards for spectator purposes; No. 5 was lengthened 50 yards; No. 3 made larger; No. 6 was lengthened 18 yards; No. 14 lengthened 20 yards; No. 18 lengthened 15 yards. I installed 34 slabs of concrete, each 4 feet by 10 feet, at tees - both women's and men's, large enough to hold a bench and marker sign.

Due to the dry fall and spring the roughs did not respond like they should. All the roughs were aerified, fertilized with 400 lbs. 16-8-8 to the acre, seed was planted with a regular grass drill. Only wherever we watered did we have good germination of seed. The roughs were fertilized three times with 16-8-8, 400 pounds to the acre spring, fall and spring.

Being a new golf course they had hundreds of young trees on the place. They had a dry fall in 1963, had dug wells around the trees to water them,and filled the wells with a mulch that had considerable rubbish in it, such as rocks, glass, bones, etc. This material had to be removed and the wells backfilled. There were so many dead trees it took a man a days and a half just to mark the dead trees. Where there were culverts under the fairways to drain the adjoining property, they would start at one edge of the fairway and be terminated at the other edge of the fairway. The ends of the culverts were so eroded it was impossible to maintain, except with a cycle. Extensions were put on with fill and grading to give a neat appearance. All the erosion areas on the golf course were filled, walls were put in where necessary to hold the dirt. I hired a hi-lift for two weeks to help straighten out along No. 2 and No. 17 fairways where the contractor had left piles of rubbish, stumps, etc. Stumps were piled and burned up; all the area was graded and seeded where possible, and sodded where needed. One of these areas was an old creek bed. Some of the cart paths were started before I came here, so we added more, extended some and built some new ones. Most of this work was performed with club labor, only the black top was let out on bid.

We have four ponds on the golf course, all required some work. One would not hold water, so we bulldozed the old dam down, scooped out the pond and built a new dam. Now this pond holds water very well. I hired a drag line; he promised to come but did not get there until November; when his equipment wasn't broken down, his help was taking off to go hunting, so by this time the bad weather had set in, and we dug out the rest of this pond by hand 6 to 18 inches deep. We deepened the other pond and graded all the banks, so now we can mow right up to the water's edge.

In the fall of '64 they graded all the eighty acres that adjoins the golf course for a subdivision. This mud washed down on the golf course in several places. We had to use a bladeon the fairways to scrape it up in piles and haul it off. One half acre of No. 4 fairway was real bad and we ended up removing it and sodding the area. All the sod we had was used, but the Westwood Country Club generously supplied me with enough sod for this area; also for in front of #14 green. Mr. Frank Hannigan of the U.S.G.A. went over the golf course with me and we picked out places where we thought the temporary bridges should be erected. We installed five temporary bridges from 20 to 80 feet long and 10 feet to 14 feet wide. We had to install two more even after the qualifying started to handle the traffic.

Also, in this last week the insurance company came out and told me I had to remove some dead wood out of over 25 large trees. It happened that one of the men on the Greens Committee knew a tree trimmer he could get on such short notice. We had to clean up all this brush and haul it away.

Early spring of '65 I received a letter from Joe Dey of the U.S.G.A. regarding the heights of cut throughout the golf course. I passed this information on to my Greens Chairman, but some of the members had other ideas on the height of the grass, particularly in the rough areas. I gave in and left the grass grow. In the meantime we erected five miles of snow fence completely around the golf course. It took three men three weeks. This fence and stakes we got from the state - it was not in the best of shape, but did serve the purpose.

On Saturday before the tournament Mr. Dey came. He asked me if I received his letter regarding the heights of the cuts. I told him "yes." He wanted to know why his instructions had not been followed. I turned around to look at the men responsible for the tall grass and no one said a word. Then he informed me that this work had to be done and now. It was done on Saturday and Sunday. All this grass had to be raked up and hauled off.

Next thing Mr. Dey found wrong was the width of the fairways. We had to widen four fairways. Cutting back 2 inch bermuda to 3/8 inch was quite a job. I had to have the operator run over it, then we swept it and ran over it again. This took several passes before we finally got it down. This just left brown stubble. Two of these fairways were going to be on TV. My Greens Chairman, Marvin Ferguson and I talked it over and decided to color these two fairways, No. 17 and No. 18. Dr. Ferguson helped me obtain the dye; had it air-expressed in from Texas. Thursday evening at dusk we sprayed these two fairways and they turned out beautiful.

The different heights of cuts on the golf course were as follows: greens 3/16 inch, around the collars 1/2 inch; twelve feet beyond collars 4-1/2 inches; beyond that 5 inches; tees and fairways 3/8 inch; bermuda roughs 1-1/2 inches; roughs cut at 5 inches; around ponds and traps 2 inches. The golf course for the Open played at 7190 yards. There were 74 traps, three of which were added for the tournament; two were enlarged.

This story would not be complete without mentioning my good friend, a member of our club, Art Feuerbacher, who spent countless hours of his own time working on the golf course, spraying weeds and poison ivy in the hard-to-get areas. He also supervised the erecting of the storm fence. During the tournament he did errand running and carried ice water in portable coolers to the tees for the players. He reported every morning at 5:00 and did not leave until 8:00 P.M. Thanks to Dr. Marvin Ferguson who came several days ahead and offered much help. Also, thanks to the local superintendents, dealers and salesmen, who helped out in different ways, such as manning the greens and traps during play.

If we were ever get another big tournament I would follow the man's instructions to the T, regardless of what the members desired. Many of my headaches could have been avoided and personal feelings spared if we would have followed Mr. Dey's instructions. We had perfectly beautiful weather all through the National Open, temperatures from mid 80's to 90, but the next day after the play-off we got a 2 inch rain which flooded the whole golf course. We lost all our temporary bridges but one; the flood left mud up to 4 inches thick in some places. This was on Tuesday, got another 2 inches on Wednesday and the course was closed to play until the following Sunday. If this would have happened during the tournament we would have been out of business.

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TURF FERTILIZERS - FROM PLANT TO PLANT

Hartl W. Lucks, Manager, Turf and Garden Products
Smith-Douglas Co., Columbus, Ohio

Probably no single industry has followed more closely the growth of America with its frustrations as well as its days of property as has the fertilizer industry. From the placing of a fish (natural organics) in the hill of corn, to the application of nitrogen derived from air, has been a phenomenon both of man's ingenuity to produce as well as his ability to use the fruits of his imagination.

From plant to plant - from production to usage is ordinarily not too difficult, for generally only sales of the product is involved. When the automotive manufacturers were able to build better cars, they did not have to wait for super highways. Improvements in the airplane did not wait for the modern airport. Not so with the fertilizer industry. Here the manufacturing of higher nutrient content fertilizers depended first on the availability of basic raw materials; secondly, on proper equipment to apply it; and last,but not least, on varieties of plants and farming techniques to use it efficiently.

During the growth period in the fertilizer industry, the main emphasis was on production of fertilizers suitable for use on food crops. Some work was being done by a few manufacturers, university, and the United States Department of Agriculture on the fertilization of turf. The first specific fertilizer offered to the public in this section of the country for use on lawn was in 1924. This was a 4-12-4 grade. It was one of the highest analysis at the time. Contrast that with the 25 - and yes, even the 30 unit nitrogen available to the turf specialists today.

As the increase in analysis was taking place, there were several other things happening. First, we were using higher concentrated materials from which secondary and trace elements had been removed in the purification process. As an example, the 4-12-4 mentioned previously contained approximately 22 units of secondary and trace elements; whereas, the 20-10-5, to which no secondary or trace elements have been added, would likely run somewhere less than 2 units of secondary and trace elements.

The second most important thing that was happening was, that contrary to our experience with field crops, as the nutrient content increased in turf foods, the pounds used over a given area decreased. As an example, when 10-6-4 came into use, we recommended 50 pounds for 5,000 square feet. When the 20-10-5 came into use, we dropped down to 22 pounds for 5,000 square feet. Here, once again, we find that the road "from plant to plant" has obstacles. This decrease in weight upon increase of nutrient content was brought about primarily because of our inability to use the higher analysis without damaging our turf.

In speaking of usage, on many occasions - yesterday as well as today - we find the use of plant food misunderstood. Here is a brief news note taken from a very early edition of the American Fertilizer Review. "The view by Mr. Wilson, the Honorable Secretary of Agriculture, that fertilizers are a stimulant, is an ill-chosen word. The effect of fertilizer is a matter commonly called growth. There is nothing akin to the stimulant of either the pipe or the glass-bottle variety. Ultra-dry districts may be inclined to look unfavorably upon fertilizers if Mr. Wilson persists in calling them stimulants."

The fertilizer manufacturer was also confronted with the problem of making the 22 pounds of a density so that it could physically be applied to 5,000 square feet. Thus, the use of light-weight carriers, such as vermiculite and corncobs, came into being.

The granulation or pelletizing of a turf product is not too different from the basic methods of pelletizing farm grades of fertilizer. Various materials are used with a sufficient amount of liquid to produce a semi-liquid state. If a carrier such as vermiculite or corncobs is used, it should be an integral part of this whole mix. If it is not, but is added at a later time, we are likely to have separation in the bag as well as in the spreading equipment.

At about the same time interest was developing in light -weight, the product Urea Formaldehyde became available in sufficient quantities for widespread usage. This brought about a new concept of chemically fixing nitrogen so that it could be held in the soil for longer feeding periods. This product combines the two basic chemicals, urea and formaldehyde, as is in the plastic that is used to make telephones; however, the molecular structure differs.

Urea formaldehyde is available as a 38 percent solid. Its use in complete turf foods is by far the simplest. Usually, however, a slurry is not made and this results in a blended product in which you can see the urea formaldehyde, and again separation can result. Use of the liquid urea formaldehyde is much more complicated. Correct mole ratio between the added urea and the formaldehyde must be added, proper temperatures and reaction, as well as pH, must be delicately controlled. If they are not the reaction may produce plastics much like the telephone case and be unsuitable for plant usage.

In order to establish some sort of a comparison, by law we must show the water insoluble nitrogen, or the W.I.N. on the bag if we are going to take credit for the ureaform. This, however, is not the total answer. We must also know the availability of the water insoluble nitrogen to plant. Usually it is suggested that the availability index be between 35 and 50 percent.

What can we look for in the future? Probably not too much in the way of increase in analysis, but certainly different physical forms to make application easier and safer. And probably too, newer compounds to increase the safety factor. Certainly better utilization of our knowledge of the atom and radioactive isotopes to increase our understanding of the interrelation of plant nutrients. Possibly fertilizers will have increased use as the carriers for vitamins, hormones, and systemic pesticides and fungicides. As we continue to rob our soils of important micro=nutrients, these elements will undoubtedly come into the picture.

And now in closing, since all of us are extremely interested in growing things, I would like to leave you with a little riddle. Who am I? I cannot walk. I cannot talk. If I could walk I would seek food and water. If I could talk I would ask man to place these at my disposal. I am very unselfish - I ask of these things not for myself alone, for I place myself at the disposal of both man and animal. I am health and continued life. I am also agonizing death. I am food, clothing and shelter. Without me armies will fail and civilization will perish. Who am I? I am the Kingdom of Plant Life.

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A NOVEL ESTATE GOLF COURSE

Raymond Freeborg, Agronomist-Consultant
Link's Nursery, St. Louis, Missouri

Our objective was to design a small estate golf course with a limited number of holes that would offer continued interest to golfers with fair ability - something better than the light chip shots usually found on a small layout of an acre.

The Sycamore National Golf Club course consists of 4 greens, each with approximately 700 square feet of putting surface. There are 5 tees, each consisting of approximately 40 square feet of teeing area. Each green and tee has a coded color combination. Thus, we could play from red tee to red green, black tee to black green, yellow tee to yellow green, and white tee to white green.

The owner of Sycamore National Golf Club, a southern gentleman, decided on a theme of some of the more noteworthy battles of the Civil War. Holes were identified as Fort Sumter, Shiloh, Chickamauga, and Bull Run. The nineteenth hole, every course must have one, is appropriately identified as Appomatox.

As you play the course you must play across Cemetery Ridge, around Jocky Hill, and over Hells Bunker, and as we approach the finishing hole you must pass between Jocky Hill and Cannon Hill over a devestating sandtrap called the Robert E. Lee to get onto a very sharply sloping green. After this hole Appomatox is needed to repair the shattered nerves of the weary golfer.

SYCAMORE NATIONAL GOLF CLUB

	Hole	Tee color to green color	Yards	Par
Fort Sumter	1	Black to Red (Cemetery Ridge)	85	4
Shiloh	2	Red to Yellow	90	4
Chickamauga	3	Yellow to Black	87	4
Fort Sumter	4	Black to Red (Dogleg)	170	5
Bull Run	5	White to White	62	3
Shiloh	6	Red to Black (Cemetery Ridge)	85	4
Fort Sumter	7	Black to White	62	3
Fort Sumter	8	Black to Yellow	87	4
Chickamauga	9	Yellow to Red	89	4
TOTAL OUT			817	35

The course is surrounded by out of bounds markers which are used to control direction of play, as well as to confine the golfer to the Sycamore National Golf Course property. All rules and regulations are based on U.S.Golf Association rules and are followed as much as possible during the two day tournament held each year in September. A maximum of three foursomes can be using the course at one time.

The area had previously been graded and planted with a mixture of ryegrass, bluegrass and tall fescue. Trees were of fairly good size and placed so they would fit into a playing pattern that would meet the requirements.

The grass selected for green and tees had to be relatively maintenance free and capable of withstanding abuse in all months. We discarded bentgrass mainly because of the extreme amount of maintenance required in the summer. Of course, there were other limiting reasons such as soil structure, drainage, etc. Bermudagrass was discarded because of possible damage from play in late fall, winter and early spring. Also, because of its susceptibility to spring dead spot, which has been a problem in St. Louis. Meyer zoysia grass was selected. Admittedly this does not provide the smoothest putting surface, but with thinning in the spring and fairly frequent cutting during the summer, about five times every two weeks, it has given an acceptable putting surface.

By using the Meyer zoysia we were able to lay sod on the existing soil without any modifications. The areas selected for the greens and tees had to have at least 50% of the available sunlight. This, of course, influenced how holes would be laid out. All work was completed by May 1, 1964. Topdressing and additional fertilizer was applied again in mid-May.

The design of the course has proved satisfactory. The lowest score for eighteen holes is 65. This was turned in by one of Missouri's leading amateur golfers.

For two years Meyer zoysia has held up well and given acceptable putting and teeing surfaces with a minimum of care. Fairways are predominantly bluegrass. Yearly labor and expense on the course is minimum (as part of the 2-acre back lawn), enjoyment by the owners - maximum.

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PLANNING THE NEW ST. LOUIS STADIUM TURF

Raymond Freeborg, Agronomist, Link's Nursery
St. Louis, Missouri

The Busch Memorial Stadium, a development of the Civic Center Development Corporation of St. Louis, is designed to seat 50,000 spectators for baseball. Lower stands near the dugouts for baseball are movable on tracks so they may be centered along the football field. Also, about 5,000 temporary seats can be added if needed. The total area in the stadium field is approximately 130,000 square feet with about 119,000 in turf and 11,000 in base path, pitcher's mound, and coaches box. The engineer-architect firm, Sverdrup and Parcel retained, through Link's Nursery, Dr. W. H. Daniel and me to supply consultant services for the turf area. Our objective was to incorporate all of the best proven principles known for the establishment of superior turf, and maintaining the best playing conditions.

The initial stadium specifications called for a duplication of the complex tile drainage system found in the old stadium with pea gravel just above the tile and 6 inches of topsoil placed over all; then common bluegrass sod to be laid. Less than $ 80,000 was allowed for the work.

Internal Drainage

The design for hand-dug tile of the old stadium had five radial lines from center and then tiles in junctioning pattern every 20 feet. This gave 130 junctions of tiles; required 138 elevations to be set. It required 8 setups of a trencher to lay one tile with junctions everywhere - - so modernize - for machinery use!

The redesigned tile system was based on long parallel runs on 20-foot centers, draining in two directions from the center of the turf area into the drainage system that surrounds the playing field. Four inch perforated, asbestos-cement tile was trenched from 12 - 24 inches into subsoil and backfilled with pea gravel to overflow of subgrade level. (Then the water system was installed). The subsoil was graded between lines; then a washed sand layer was placed over pea gravel and subsoil. A minimum of 3 inches was specified as was a uniform grade to contour. This gave quick, uniform drainage under the rootzone.

Rootzone

The rootzone analysis was based on a permeability rate of 5 inches of water per hour, or greater, after compaction. As long as the rootzone would hold enough moisture and plant nutrients to support good plant growth, fast penetration was acceptable. The final rootzone mixture selected consisted of the following:

Material	Mesh	Analysis %	Dry volume %
Washed sand	on 8	0	40
Mississippi	16	27	
River source	32	28	
	60	33	
	150	11	
	through 270	less than 1	
Calcined clay	on 4	0	30
(Terra-Green)	10	8	
	30	91	
	40	96	
	60	98	
Breakdown passing 80 mesh sieve		2.75	
Absorption - Ml. of water absorbed per gram sample - 0.86 ml.			
Density - 35 lbs. per cu. ft.			
Peat (air dried, cultivated black-brown)	Organic content 90% plus; Moisture holding capacity - 40% plus; Weight per cu.ft. not to exceed 30 lbs.; Moisture content at delivery not to exceed 66%		20
Soil (silt loam selected)	Clay - 6%; Silt - 78%; Sand - 16%		10
			100

The laboratory analysis of mixture showed:

Bulk density when compacted - air dry	1.22
Bulk density when compacted - saturated	1.66
Percentage of large pores	22%
Percentage of small pores	21%
Permeability when compacted	19.8 inches per hour

This material was pre-mixed off-site out in St. Louis County. Briefly, mixing included alternate piling of all materials in proper ratios; then turning once with an endloader; then passing this proportioned mix through a large soil blender to get an acceptable uniform mixture. The rootzone will be placed to a final depth of 8 inches (+ 1 inch) over the coarse sand layer.

Total volume of the mixed rootzone included the following:
(as determined by weight slips, etc.)

Vol. of Materials	cu. yds.	lbs.	Proposed by vol. %	Realized by vol. %
Sand	1250	3,750,000	40	37
Calcined clay	1000	945,000	30	29
Peat	770	625,000	20	22
Soil	400	1,200,000	10	12
	3420	6,520,000		

A separate mixture for the base paths, pitcher's mound, and coaches' box was also developed. It was important that this mix be related in particle size, and permeability as closely as possible to the base rootzone mix to give acceptable performance. It was also necessary to design the base path mixture to be firm enough to give solid footing for the base runners. It was also desirable to have the color of the base paths as dark as possible so that they would show up well in contrast to the turf areas. The base path mixture was made up of the following -

Materials	% by volume
Iron Mountain trap rock sand (95% passing a 10 mesh screen)	40%
Calcined clay (24-48 mesh)	20%
Peat	20%
Soil	20%

This base path mix was also blended at the same site as the rootzone. It will be placed as the top 2 inches over the rootzone. It may be necessary to add additional binding to this base path mix to meet the stability running requirements. This can be done by adding even 5% clay as a binder as needed. However, an analysis of this mixture was made along with analyses of mixtures from Cleveland base path areas taken in 1964, and samples from paths taken in St. Louis at the old Busch Stadium in 1965. The new mixture proved similar to the Cleveland material. It was less sticky than the St. Louis mix, and differed primarily in the amount of clay, which made the old base path mix tighter.

Mechanical renovation equipment will be used as needed. Also, additional peat, calcined clay or rootzone blend can be added as needed and incorporated by aerifying. These can encourage additional drainage, or increase water and nutrient retention.

Turf

Turf for the playing field had to be developed to include grasses that would meet both summer heat conditions (± 95° F), and winter cold (± 0° F), a range in excess of 120°F. We set out to develop a turf that would come very close to meeting all weather conditions with combined Zoysia and improved selections of bluegrass. The turf had to be the best available under all weather conditions since the field is to be used for both baseball and football. The Midwest and Meyer zoysia grasses are to serve as the major foundation for summer turf; then the bluegrasses serve during the winter and early spring. Additional growth of bluegrass during fall, late winter and early spring will be supported by soil heating accomplished with electric heating cables buried under the turf.

Maintenance schedules must be designed to support both Zoysia and bluegrass. Responses of either grass will be encouraged or discouraged as necessary, to maintain a uniformity of both types. This may be done as needed by selective fertilizing, mechanical thinning, use of soil heat, mowing height, etc.

Turf for the stadium was planted on a five acre off-site at Link's Turf Farm one year prior to the date it is to be moved into the stadium as sod. Specifications for grass to be in the final turf include the following:

1. Midwest zoysia - Zoysia japonica Steud., vigorous, medium density, released by Purdue University in 1963. To be planted vegetatively at 450 sq.ft. of nursery sod per acre of sod planted.
2. Meyer zoysia - Zoysia japonica Steud., dense selection, released in 1950. Planted vegetatively at 800 sq. ft. of nursery sod for each acre to be planted.
3. Bluegrass - Poa pratensis, which was interplanted with the Zoysias. Nursery bluegrass sod consisting of experimentally tested strains with superior vigor as 16F, 16B, and K-5(47) plus Newport, Merion, Delta, Park, Windsor, Arboretum, and Common Kentucky Bluegrass was shredded and planted vegetatively as clones at 1,350 sq.ft. minimum per acre to be planted.
4. In association with the vegetative planting (from 2600 sq.ft. of sod) seed of a blend of bluegrasses selected for their performance was also used.
   a. Seed mix composed of 20% each of Newport, Merion, Delta, Windsor, and Common Kentucky bluegrasses.
   b. Seed was planted at 25 lbs./acre.

Soil was prepared for planting by plowing, disking and harrowing. Agricultural limestone, fine grade, was applied at 3-1/2 tons per acre, and 16-8-8 fertilizer applied at 800 lbs. per acre. These were disked in after plowing. This work was completed by May 1, 1965.

Planting procedures started May 1, 1965. A modified Bray planter was used to plant vegetative grasses so species of grasses average one foot apart. Seed was applied same day with a cyclone seeder. After seeding all areas were mulched lightly with straw, and watered frequently.

All plantings were completed by June 1, 1965. Within two weeks after planting all areas were sprayed with Tupersan at 6 pounds active per acre. This procedure was repeated again within two weeks at the same 6 pound active rate.

Fertilizer was applied throughout the summer. Total applied per acre by October 4 amounted to 413 pounds of nitrogen, 168 pounds of P_2O_5, and 150 pounds K_2O. The sod is to be placed in the stadium in mid-April 1966.

Irrigation

Irrigation will combine automatic pop-up sprinklers and soil sensors. The 7 manual outlets for hose available along the outer wall of the stadium were the original system planned. These were augmented by a snap-on valve located behind second base, in a sod cup, to permit easy access to the center field part of the base path for hand-watering as needed.

The automatic system, with permanent sprinklers, is designed to cover the major part of the field uniformly. The base path areas have lighter coverage, receiving about 60% of the water that covers the turfed area of the field. Thus, the base path can be dried out by raking, etc., or wet manually as players and playing conditions require.

The irrigation system is set up with 11 subzones, each subzone controlled by a 2 inch electric valve supplying 3 - 4 pop-up sprinklers. In sequence time cams deliver water to one of the 4 zones for 15 minutes of each hour (divided over the area with 3, 3, 3, and 2 electric valves) to distribute pressure. Sprinklers will supply from 7 to 16 gallons per minute. Sprinklers were selected for performance and for the small surface size of the head. The smaller head would present less surface area to interfere with play.

An important control of watering is realized by the use of soil moisture sensors (Automist system). Each of the 11 electric valves will have a soil sensor to control the valve and a reserve. These are buried at a 2-inch and a 3-inch depth in each watering area to measure available moisture. The control panel is designed with 11 individual controls in percentage increments which can be set to desired percentage - 50, 80, 95%, etc. These individual controls permit watering when the rootzone moisture falls below a pre-determined percentage. Thus, when sensor signals dial need, when time-block permits use, when cams open valves, each zone will receive water in sequence until sensor is wetted, which cuts off water immediately for that subzone.

The permanent rotary pop-up sprinklers, 44 total, have a special cover to protect the player from injury. The cover is one-half inch thick, resilient synthetic material, Tartan brand Surfacing. This material retains its properties when subjected to extended periods of outdoor weathering. It is resistant to bacteria, mildew and other forms of biological attack. The surface is indented to present a nonslip surface, both wet and dry. It has an indentation hardness of 45 measured on a Share A-2 Durometer-ASTM-D-1706-61. This irrigation system will supply adequate water and the sensitive control of water application, which is so important to the more permeable rootzone.

Soil Warming

Soil heating is a tool in maintaining the two grasses which differ in their cool or warm temperature response. This will be the first large scale electric soil heating installation in the United States. Installation should be completed in 1966. Soil warming in actual use areas has been very successful in Britain and Sweden. Research in the United States has been conducted at various locations to support work completed in Canada, Britain and Sweden.

Some of the major reasons for introducing soil heating in St. Louis include the ability through heat to maintain thawed soil, keep soil drier, aid in snow melting, increase grass growth, aid in seed germination, allow early renovation of turf before baseball season starts, improve player safety, improve precision of the game, supplement covers, reduce damage to cover and need to use covers, and support early sod establishment in initial construction stage.

The heating cable to be used in St. Louis is polyvinyl-chloride insulated nylon-jacketed cables. There will be a total of 49 cables used, measuring in length from 1796 feet to 2741 feet. Total footage of cable is approximately 110,000 feet. The soil heating cables will be placed 7 inches below the surface of the soil, and spaced 1 foot apart. The heat output is to be 5 watts per linear foot while operating at 277/480 AC. The system may operate on off-peak periods to heat soil when air temperature falls below 40°F., and soil temperature at 2 inches falls below 50°F.

Cable is to be sliced into the sod using a modified subsoiling tool preceded by a rolling coulter. With rolling and watering the turf can be made smooth enough for use immediately after installation of the cable.

One soil temperature sensor, and one reserve, are located to control each of 4 zones. These soil sensors, which measure reserve supply of heat, are set to permit soil heating when temperature 2 inches below the surface is below 50°F. An air temperature thermostat, set about 5 feet above ground in the shade, is set to permit heating when the air temperatures reach 40°F. (which indicates cooling of area). W. L. Waltke and B. A. Merritt of Union Electric Company summarized the periods of possible use based on previous St. Louis temperatures as follows:

Total Hours of Below 40°F. Average Weather (in St. Louis)

November	287
December	511
January	600 (Est. by Editor)
February	421
March	347
April	46

Off-peak operation (9 hours nightly) of the heating cable is planned for economy. Also, a manual switch must permit either scoreboard or soil heating use from same transformers. Assuming 100% use of the soil heating during the off-peak hours of each month that has in the past had air temperatures below 40°F., the maximum cost estimated would be approximately $ 4,000.00. With a minimum bill service required, there may be no additional cost for use of the power necessary to heat the soil.

With adequate subsurface drainage, porous rootzone, improved turf conditions through better, more stable grasses, automatic irrigation, and soil warming to offset undesirable weather conditions, the Busch Memorial Stadium must offer some of the best playing conditions ever realized. The entire stadium complex and overall playing field design with its improvement is proof of the care and foresight of the engineers-architects, Sverdrup and Parcel, and the owners, Civic Center Development Corporation. The baseball and football Cardinals should find their new playing conditions among the best in their experience.

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BUILDING NEW GOLF COURSES

Pete Dye, Golf Course Construction Company
Indianapolis, Indiana

That golf is a humbling game is a saying of the famous Scottish professional, James Braid. The design, construction and maintenance of golf courses teaches many lessons of modesty. My Dad designed and constructed the Urbana Country Club in the late twenties. One of my first lessons in modesty came at the age of sixteen when, due to the manpower shortage, I was put in charge of this course the summer of 1941. Nobody knew as much about maintenance as I thought I did. The sixth and seventh greens were slightly off-color. An application of sulphate was in order. We had an old fifty gallon wooden drum. My younger brother with a paddle was the man-made oscillator. I applied the much needed nourishment with a five gallon flower can, swinging this implement to and fro carefully to give the surface an even application. We watered in this treatment with extra care. Old six and seven immediately began to regain color - green, dark green, blue, black, straw.

First, in order for a new golf course, is site selection. The best land to purchase will be the first thing to engage the attention of a club. The importance of obtaining the right soil and sufficient acreage can hardly be overstressed. Many clubs, selecting their sites in haste, have never been able to correct their initial error. They have had to live with mediocre golf or spend vast sums to increase their acreage, or to modify the soil. In a few cases they have had to flee from the unconquerable problems, to buy a better site, and start all over again. One hears some tragic stories of what it has cost certain clubs to add a few acres to their original holdings in order to lengthen or to rearrange their courses. A wise club will, therefore, buy at the start a larger acreage than seems at the moment necessary for its requirements. If wisely chosen the surplus land will one day yield a handsome profit. Of no less importance is the obtaining of the right soil. Well-drained, slightly rolling country with a sandy or a deep rich loam is ideal.

Of most importance is the finding of land with desirable contours. Do not go into hilly country if that can be avoided. Nearly all courses built in hills are expensive to construct and tiresome to play. Avoid, also, country that is broken into many ravines. Such hazards are often quite picturesque, but they are rarely desirable, and for the uncertain player they are fearful to look upon. Climbing in and out of canyons to retrieve balls is most exasperating, and the play is so delayed.

For the same reasons too many streams and ponds are objectionable. In saying this I do not forget the many beautiful holes which are played over water, but one or two such holes in eighteen will be quite enough.

Relatively flat land is rarely thought to be desirable for golf, and it is likely to be chosen only as a last resource. If this land is easily drainable and there is sufficient borrow area, I am quite sure this is a mistaken point of view. Not only some of the most popular, but some of the very interesting courses have been made on flat land. The greens can be placed anywhere, the layout in general should be without flaw. The length of the holes will not be governed by certain topographic situations, but will be decided by ideal considerations. With heavy equipment one can shape the surface at will and create the desired effect which can rarely be found provided by nature in the ideal location.

Many sites have been purchased without knowledge of the availability of adequate water. One only has to read the editorials of the daily newspaper to be conscious of water supply. Geographic location, types of grass, soil condition and fairway irrigation all have to be considered in obtaining the amount of water needed. Wells and reservoir, versus cost of possible city water, is a complete subject of its own.

The typical committee site is hilly, deep ravines and completely wooded, and no water availability. Wooded area is very costly to clear and to put the land in good condition. When a wooded site is selected, the clearing of this area for golf holes many time depletes so much of the woods that the original intended effect is totally destroyed.

The precise acreage which is desirable depends upon the nature of the land. It would be safe to say that 200 acres would be luxurious, 150 acres adequate, 125 acres limited, 100 acres distinctly meager, and anything less would be desperate.

Laying Out the Course

The site for the club house will be the first problem. In recent years more and more space has come to be required in the areas immediately around the club house. Once the location has been established, the architect will consider the following points in making his routing:

1. He will take the desired length and plan that each nine should start and finish at the club house.

2. There should be little walking between the green and tees,and there should be enough elasticity to allow tees to be lengthened in the future if necessary.

3. The two nines should balance each other in yardage, interest and quality, but the last nine may be the severest test of golf.

4. Holes of the same character should not follow each other. The type of trapping, contour of greens, shape of tees and the greens, and variety of planting should all vary to give particular distinction to each hole.

5. Most important is that the hole presents some problem to the player. The slant of the green, the undulations here and there, the positions of the bunkers, the openings for certain shots - these are the methods an architect uses to present the problems. To make holes thrilling to play - to force the player to play certain shots, is also the job of the architect.

6. If the proper site has been selected it should not be necessary to have holes playing toward the setting sun. Should a hole play westward it should come early in the nine - not in the last four holes.

7. The four Par 3's should be distinctively different. They should run in different directions - one Par 3 playing 140 yards; one 155 yards; one 170 yards,

and the last 190 yards.

The Par 4 holes should vary in length - angle and direction. Of the Par 4's four should be long, strong holes; three medium length, and three short - all intermingled throughout the eighteen.

The Par 5 hole is the hardest to design. The architect has to go all out to make these challenging holes. Sheer length does not make a good Par 5.

Placement of Hazards

Without well-molded greens of true surface, golf would lose most of its charm, and without well-placed hazards, golf would fail to arouse and to satisfy man's sporting instincts. Hazards - how well chosen the name! They are risks, and penalties must come with those who take risks and fail. Hazards make golf dramatic, and the thrills that come to one who ventures wisely and succeeds are truly great. Without hazards golf would be a dull sport with life and soul gone out of it. No longer would it attract the adventurous, but would be left to those who favor some insipid form of walking.

The positioning of green and fairway traps should create a challenge to the plus golfer. Traps on both side of the green many times make the shot easier for the low handicap player and harder for the high. By proper placing of the trap and eliminating the opposite, the hole can become a real challenge. The shape and the way this green is contoured will be all important in creating this effect.

Green traps should not necessarily run parallel to the green, but at a ninety degree angle. This will catch the poorer shot and the player who completely misses the green and bunker will be left with a difficult pitch. Deep bunkers should be used to protect the short Par 3's and Par 4's. The shallow bunker should be used to offset the stronger hole.

Bunkers should be constructed:

1. where surface water will not drain into them
2. contoured so the ball will roll away from the lip
3. banks of the bunker should be contoured so that power equipment can cut to the edge of the sand
4. where they come into full view from the shot area.

All mounds should be constructed with a large base so not to appear high. The tops should be pointed and their shapes be as irregular as possible. Fairway bunkers should be wide and shallow to allow a good shot to reach the green. There should be easy access to and exit from all bunkers.

Contouring of the Greens

There is nothing quite so vital in golf course construction as the proper placing and contouring of the greens.

1. The size of a green will be governed by the surrounding contours, the severity of hazards around it and the length of the shot played to the green. A short Par 3 or 4 surrounded by water or deep traps, or located on a high plateau could require a larger green than a long Par 4 located in an open area guarded by shallow bunkers.

2. The green of a hole requiring a pitch shot should be more severely contoured as compared to a green requiring a long shot. This green should have gentle undulation running towards the line of flight.

3. Contour all greens to surface drain three or four ways. Little as possible surface water should drain into the traffic pattern.

4. Greens should be all shapes and sizes, contoured from front to back, right to left - left to right. Tilt some of them almost not at all, and in some cases tilt one downward from front to back.

5. All slopes around the green should be a minimum of twelve to one, or 8% - fifteen to 1, or as gentle as 5% is excellent.

6. The most satisfactory of all greens are often those which follow the natural lay of the ground and require little or no contouring.

7. Many times it is better to excavate in front of the green, leaving the putting surface the natural lay of the ground. This hollow in front of the green will make the green appear elevated and allow the golfer to have full view of the green and the hazards adjacent to it.

Tees

The size and placement of the tees are vital problems.

1. Make tees whenever possible indistinguishable.
2. Tees should change the angle and length of a hole.
3. They should be placed at an angle to avoid the full load of the traffic.
4. The slope should be a maximum of 5%.

The material of this speech was compiled and quoted from the following five books:

Advance Golf by James Braid - published in 1901. Mr. Braid designed Glen Eagles.
The Links by Robert Hunter - published in 1926.
Golf Course Design, Construction and Upkeep by Martin Sutton, H. S. Colt and C. H. Allison, published in 1933. Pine Valley, Detroit Golf, Sunningdale are some of their work.
Golf Architecture in America by George C. Thomas, Jr., published in 1927. Los Angeles Country Club and many California courses have been built by Mr. Thomas.
Golf Architecture by Dr. MacKenzie, published in 1920. Cypress Point, Pebble Beach, Master - University of Michigan are some of Dr. MacKenzie's creations.

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NOTES ON THE BIOLOGY AND CONTROL OF SOD WEBWORMS

Donald L. Schuder, Dept. of Entomology
Purdue University

Sod webworms have caused considerable damage to turf for the past three years. The most abundant species in Indiana is the larger sod webworm, Crambus trisectus Walker; while in Kentucky and Illinois, the common species is the bluegrass webworm, C. teterrellus (Zincker). The other species taken in Indiana are the lucerne moth, Nomophila noctuella; the bluegrass webworm, C. teterrellus (Zincker); C. albocla-vellus Clem.; vagabond webworm, C. vulgivagellus Clem.; and Thaumatopsis pexellus Zell. These insects have been of periodic importance in Indiana since 1915.

Adults of the larger sod webworm are present from late May until the occurrence of the first killing frost. Swarms of the moths fly in zig-zag fashion, across lawns whenever they are disturbed. The larger sod webworm normally has two generations per year; but under favorable conditions, such as a warm, open fall, there is a third generation.

Crambid moths deposit their eggs randomly in the grass. The eggs are small, .5 x .4 mm in size and prominently ridged. They resemble miniature nail kegs. A technique is available for recovering eggs from sod, thus predicting the severity of future infestations. Eggs are the overwintering stage.

Sod webworm larvae live in silken tubes at the base of the grass plant. The larvae and their webs occur at the soil line, or, if thatch is present, at the top level of the thatch. There is evidence that heavy accumulations of thatch favor heavy populations of sod webworms, a good argument for using grass-catchers.

Sod webworm larvae have voracious appetites and can brown and denude quite large areas of turf. Superficially sod webworm damage can resemble drouth, disease, dog or weed killer damage. Close examination of sod webworm damaged areas will reveal unevenly cropped grass with billets of chewed foliage surrounding the larval hiding place. The presence of large numbers of birds picking at the lawn is also a good diagnostic symptom. Sod webworm larvae are slender, cream colored with black spots on their backs. Pupation occurs in the silken tube.

Food plants of the webworms include: bluegrass, crabgrass, various crop grasses, such as corn, wheat, oats and timothy; and it can subsist on clover. Large numbers of these snout moths can be found congregating around porch, driveway and patio lights during the evening hours.

Blacklight traps have been used for the study of the seasonal abundance of the sod webworms for the past two years. Trap records indicate that 68 percent of the webworm population is the larger sod webworm. Approximately 70 percent of the sod webworm moths captured were females. Dissection of preserved females revealed that each female sod webworm still carried an average of 217 eggs. This fact suggested that omni-directional blacklight traps, which catch gravid moths, might prevent sod webworm damage to lawns. Sampling of lawns in the late summer of 1965 confirmed this hypothesis, for very few larvae or pupae were obtained 75 feet from the traps.

A Taylor air trap was used in the late summer of 1965, during the peak emergence of the larger sod webworm. This trap collects hourly samples of all insects which fly over the trap. Correlating the sod webworm samples with time and various type of weather information furnished some interesting information.

C. trisectus adults fly during the night, not just at twilight as mentioned in the literature. Ninety-eight percent of the moths fly between temperatures of 52° and 80°F., and 96 percent of the moths fly when wind speed is less than 15 m.p.h.

Control

Chlordane, the turf panacea, has not been effective against the sod webworm the past four years. The following materials have been effective:

Insecticide	Actual toxicant per 1000 sq.ft. ounces
Diazinon (Spectracide)	2
Baytex (Entex, 29493)	2
Dylox	2
Dieldrin	2
Baygon	2
Dursban	1
Ethion	1

Various experiments for control of the sod webworm indicate that granular formulations of insecticides are more effective than sprays, and that the best time to apply the materials is during the period mid-May to mid-June to kill the first batch of larvae.

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LARGE AREA SOIL STERILIZATION

Dale Habenicht, H&E Sod Nursery
Tinley Park, Illinois

For the past six years we have experimented with soil sterilization or fumigation for the complete prevention of Poa annua in our bentgrass nursery. Through research we sought new techniques to improve methods of application, as well as ways and means to cut costs. In our opinion, we believe we have a practical application for large areas.

In selecting a soil fumigant we must know how it works and what it controls. A soil fumigant can kill weeds and viable weed seeds in the soil, such as Poa annua, quackgrass, crabgrass, orchardgrass, sedge, broadleaf, etc. This is the primary use on turf areas. Fumigants may also control nematodes, soil insects, such as white grubs, sod webworms and wireworms. Even soil fungi, root rot, damping off and wilt may be inhibited.

I am familiar with three soil fumigants. We have used Vorlex and Vapam on large areas, and Dowfume MC-2 on a small plot. Vorlex can be injected into soils having a temperature between 30 - 90°F. The Vorlex was applied straight at the rate of 30 - 40 gallons per acre and tarped immediately after application.

Vapam can be injected into soils having a temperature of 50 - 90°F. This product was diluted with equal parts of water and applied 75 - 100 gallons of actual Vapam per acre.

Dowfume MC-2 is not very adaptable on large areas. It must be injected at 1 pound per 100 square feet underneath a sealed tarp which is supported by cans, stakes or the like to aid in even gas distribution.

When preparing the soil prior to fumigation, it is important to break up the clods and loosen soil thoroughly by cultivation and roto-tilling. Deep tillage is recommended. For one week prior to fumigation the soil must be kept moist to a depth of six inches.

For Vorlex injection we use a John Blue Fumigator with chisel-type applicators spaced 6 - 8 inches apart, and set 4 - 6 inches deep. To prevent evaporation of the fumigant it is recommended that the ground be immediately floated or rolled in order to close up the slices made by the chisels.

I believe tarping the soil after application is almost a necessity for good weed control. We use 2 mil clear Polyethelene on 12 foot rolls without any folds. Each strip is cut off at the end of the field. At present we are using a tarp-laying machine mounted on a three-point hitch. This machine puts the tarp down faster than can be done by hand and with much less labor. Wind is a very small problem.

The fumigator is 6 foot wide. On the second pass it drags a chain to denote where the next pass will start (11-1/2' over). The tarp is immediately laid after the second pass. The field, therefore, is sterilized in 12 foot alternating strips. The tarp is left in place for 3 to 4 days, after which it is picked up and destroyed. We found it does not pay to reuse them. The intermediate strips are now ready for the same fumigating procedure.

The soil should be surface cultivated for at least three weeks before planting.

Cost breakdown in 1965 on per acre basis:

Vorlex	35 gal.	$ 212.25
2 mil Polyethelene ($2.75/1,000 sq.ft.)		120.00
Equipment & labor		60.00
Removal of Polyethelene		10.00
Total cost		$ 405.25

The above costs were our costs for materials and labor and could vary in other situations. We figured overall expenditure of 8-1/2¢ per square yard for sterilizing sod areas. On stolon beds it figures approximately 14¢ per bushel. These costs could be used to determine if soil sterilization is practical on your turf areas.

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SOD GROWER ASSOCIATIONS
A REVIEW AND DEVELOPMENT

R. M. Warren, Sales Mgr., Warren's Turf Nursery
Palos Park, Illinois

In numbers there is strength. It makes no difference what the organization - be it the Army, business, politics or a trade association. A group of individuals or firms carry more weight and can accomplish more than an individual person or firm.

For example, starting in 1952 Warren's Turf Nursery began to try to convince the Highway Department of the State of Illinois that their sod specifications were outdated. We spent several years making calls on various individuals and got nowhere. Later on, after a Sod Association was formed, the bureaucrats changed their minds and listened to the Association. Briefly these are the facts.

Illinois had a specification calling for 2-1/2 to 3 inches of soil to be adhering to all sod planted on highways. A survey of all states revealed that the current Illinois specifications were the most unreasonable. For instance, Wisconsin called for 3/4 inches of soil; Indiana 1 to 1-1/2 inches.

Actually it appeared no one was furnishing sod for Illinois highways 2-1/2 to 3 inches thick. However, whenever an operator of a turf nursery tried to supply sod at a reasonable thickness his sod was usually rejected. We made numerous calls to the landscape engineer at Springfield and his assistants scattered over the state. Only two fellows, out of 10 or 12, concurred with our claim, but they told us we were fighting a losing battle. The landscape engineer actually tried to discourage us by flatly stating that sodding contractors had all the sod they needed, and that the idea of nursery grown sod was ridiculous. One person implied that thin-cut sod, delivered where specifications called for 3 inches of soil, was a juicy source of graft. (For a bribe they would approve thin-cut sod). He would not name names, or be specific.

To make a long story short, Warren's Turf Nursery hired a lobbyist. He spent the better part of a year and finally came up with the finding that the only way we would accomplish anything was to form a growers' association. He said the politicians and bureaucrats will listen to a group - but not to an individual firm. So, we contacted Carl Habenicht of H&E Sod Nursery, Roy Mueller of Mueller Sod Farm, Al Schaper of the Sod Nursery, Gerald Dearie of Dearie and Strud, and several smaller growers. At a luncheon we decided to explore the possibility of an Association. After two or three more meetings a set of by-laws were formulated, officers elected and the Sod Growers Association of Illinois was born in 1958.

Our first major effort was to prove to the State of Illinois that their highway sodding specifications were incorrect. This was done by a demonstration planting on the Eisenhower Expressway in Chicago. As a result the state has changed its specifications and millions upon millions of square yards of nursery grown sod have been planted on highways. IF THE ASSOCIATION NEVER ACCOMPLISHES ANY MORE IT WILL HAVE BEEN WORTHWHILE. Every sod grower in Wisconsin, Indiana, and as far away as New York and Denver have been helped. As a result of Illinois' findings some other states have made specification changes. Also, every yard of sod used on the highways took a yard off the home lawn market, thus helping to keep prices firm.

About two years ago it was noticed that growers from Wisconsin, Indiana and Michigan were joining the Illinois Association, so the word Illinois was deleted and Mid-America inserted. My personal opinion is that the name should again be changed to the SOD ASSOCIATION OF AMERICA because today we have members from New York to California. For your own self-preservation, for the good of the profession that feeds you,you should be a member and give willingly of your time to help make the Association a vital, strong organization. Nothing is gained without effort.

The sod industry is still in its infancy. It is just now beginning to get out of rompers and into knee-pants. In the next ten years it will grow to undreamed of proportions,and those of you who are a part of the industry should help yourselves by helping your Association into a strong organization that will carry weight with the federal, state and local governments, and with builders, architects, contractors and other organizations.

For a moment let's take a look at the potential of the sod market. By the year 2000, just 34 years from now, there will be a population in the United States of at least 400 million if the population explosion continues. Are you aware that the population of the United States has almost doubled since Herbert Hoover ran against Al Smith in 1928? To men of my generation that is but yesterday. In 30 years you younger fellows will still be only about my age -- and I am certain I've got several good years ahead of me yet. This expected population increase will mean at least 50 million new homes, with an average lawn area 1,000 square yards, for a total of 50 billion square yards. Now, when we sell the public hard enough on sod, the annual national requirement will run over 1.5 billion yards. This does not include sod needed for public buildings, highways, schools, golf courses, cemeteries, factories, etc.

This is big business. It will be highly competitive and will no doubt incur governmental control. There never has been a business that developed a sizeable dollar volume that did not attract government bureaucrats to it. These government inspectors may never have been called upon to meet a payroll, or sell a bill of goods. We will need a strong association of turf growers to protect ourselves.

Here are just a few things that the Association can do to benefit the industry as a whole and that needs doing now:

1. Correct specifications - aid in proper content.
2. Warn the landscapers against questionable lawn products.
3. Discourage articles of misinformation, such as a magazine article that claimed sod growers net $1500.00 per acre. Such articles should be challenged and the Association should do the challenging.
4. Put pressure on chemical firms for realistic prices. For example, in 1965 a garden center can buy one company's chemical for less than a grower pays.
5. Put pressure on Congress to increase tariffs on sod imported from Canada at ruinous prices.
6. Put pressure on the Federal and State Department of Agriculture on unreasonable plant quarantine laws.
7. Promote the use of sod on highways rather than the planting of excess nursery stock, which eventually makes a jungle and calls for more expensive maintenance.
8. Make contributions and grants to various universities for grass research work.
9. Explore the advantages of sod certification similar to seed certification. I am not sure we need certification, but we should explore its advantages and disadvantages.
10. Educate the public on the use of sod as opposed to seed.
11. Report to growers the merits of various equipment, such as sod roller, conveyors, palletizing, etc.

12. Advise and assist growers in marketing programs, costs, mark-ups, pricing policies, accounting, sales and advertising practices. And above all, in Dealer-Distributor-Grower relationships.
13. Arrange for and carry out a national convention or field day to be primarily supported by vendors to the sod industry through the purchase of exhibition space.
14. Warn and advise farmers against cow pasture sodders who are often under-financed.

There is always, of course, the tendency to "let George do it." There are just not enough hours for 3 or 4 men to do the entire job and still manage their own businesses. A good example is the compiling and editing of the Newsletter. It usually takes a day or so to get it together. This time has got to come from somewhere. In my case it has been evenings and Sundays - incidentally I am the author, so I deserve any "beefs" coming about Newsletter articles. The main purpose is to stimulate interest. We've stepped on some toes and may do so again.

We have created interest in the Association and in so doing brought new members into the organization. One thing the Association needs badly is a full-time executive secretary. His efforts will help cement and firm up a stronger organization and in the long run develop the Association into one of the more aggressive trade associations.

Look about you at other professions and business operations. See how they have benefited themselves. The AAN, American Association of Nurserymen, and their affiliated state organizations have sold the federal government lock, stock and barrel on their "plant America" sales pitch. Even got Lady Bird using your money to plant out signs and automobile grave yards. I understand she's a good saleslady - we ought to get her selling sod.

And, examine the trade unions. You are at their mercy because they stick together. They are organized. You are not. The Sod Growers of America have a lot stronger selling pitch in the way of practical maintenance cost than have nurserymen. It appears that some of the new expressways are being planted so heavily to nursery stock that within ten years all the grassed areas will have to be hand-mowed. Right there is one fight the sod growers can tie into, and in so doing add profits to your individual operations. But, it takes an association to do it.

Sooner or later the seed boys are going to find ways to produce lawns faster with seed, and when that day comes they could jerk the rug right out from under us. In such areas as Detroit, Milwaukee and Chicago it is unusual to see a lawn being seeded. Naturally this cuts into grass seed sales. Some smart "cooky" in the seed business is going to start snipping at us and if we are not prepared it will be our fault. A strong Association can help sell the public more strongly on sod.

We, in the profession of growing and marketing sod, can use the advice of the renowned architect, Daniel Burnham, - "Make no little plans; they have no magic to stir men's blood - Make big plans; aim high - remembering that a noble - - diagram once recorded will never die."

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REPLACING WEEDS WITH TURF -- 2nd REPORT

Donald A. Clemans, Supt., Norwood Hills C. Club
Normandy, Missouri

Last year the first report started as I arrived at Norwood during the winter of 1963 - 1964. By spring it was evident that the weed population was the majority of the fairway cover. My first move was to obtain a 30' spray boom since they had none at that time. I wanted to cover a lot of ground in the minimum of time. Norwood is a 36-hole course, and there were well over 250 acres of fairway and rough to spray.

East Course

I sprayed for the first time in late April of 1964. The spray solution was 1/2 pound of Banvel-D and 1/2 pound 2,4-D with wetting agent in 25 gallons of water per acre. The results were astounding for after the weeds died some fairways were near 50% barren. But, by eliminating weed competition, the bluegrass rhizomes kept growing into the barren spots all during the summer of 1964.

On April 15, 1964, the East 18 course had tri-calcium arsenate applied at the rate of 10 pounds/1,000 square feet applied to all fairways. Phosphorus was eliminated from the 1964 fertilizer program on this course, since adequate levels were available according to soil tests. Control was 100% effective on crabgrass and goosegrass during all of 1964.

In 1965, due to the installation of our irrigation system, arsenic was not applied. We simply did not find time and needed to disturb the trench lines all summer. But, still in 1965 the East Course had 90 - 100% control from the residual effect of tri-calcium arsenate. Some areas subject to hillside washing and drainage showed some incidence of re-infestation. Again in spring of 1965 the weed killer spray was applied to all fairways.

West Course

During 1964 and early 1965 the West Course had not had any pre-emergence crabgrass control applied, but weed control was practiced both years. In August of 1965 the Ladies PGA Tour came to Norwood Hills. Some of the fairways exceeded 50% goosegrass as a playing turf. On August 15, 1965 I sprayed all the fairways on the West Course with 2 gallons of 16% AMA, 1/2 pound Banvel-D, 1/2 pound 2-4,D, a small amount of spreader sticker and wetting agent in 25 gallons of water per acre. The second treatment 5 days later was of the same solution, with the exception that I left out the Banvel-D. This killed all the goosegrass, knotweed,and all the undesirable plants prior to the seeding operation the first week in September.

My seeding process is this: I use a vertical cutting machine to loosen the soil, going into the ground as far as possible - because seed on top of the ground is wasted seed. Next, I spread the seed. In 1965 I used a mixture of Common, Newport, and Delta bluegrass. I then apply the fertilizer and drag the area with a chain-link fence mat. I seed after the vertical cutting operation so I can see the tractor tracks and get complete coverage with the seed. Then in 1965, since my Club provided me with a complete automatic irrigation system costing $ 250,000.00, I applied water for ten minutes at a time at two hour intervals until 1/2 inch of water was applied. In about 10 days seedlings began to appear.

Putting Greens

Goosegrass on the putting greens at Norwood was a serious problem. In 1964 I used chlordane granules for a pre-emergence control with 70% control. In 1965 I used Pre-San. On the East Course the treatment was applied in mid-April after aerifying. We had 100% control of goosegrass. The West Course was then aerified and Pre-San applied the first week in May. I obtained only 85-90% control on the West Course. This proved to me that timing of application is of the utmost importance.

In August, prior to the LPGA tournament, the lake in front of #2 green West was 99% covered with duckweed. After conferring with Dr. Daniel, I purchased some Diquat (Ortho brand). This material was applied with a knapsack sprayer and distributed on the surface of the lake from the bank.. I used 1 quart of Diquat on approximately 1/4 acre of surface. The next morning the duckweed was yellow and I could tell where I had applied a little to the grass banks here and there unknowingly. By the third day the duckweed had settled to the bottom and I had an open water lake.

Lime was applied to all of the putting greens last fall. I started the project with the (approx. 2 gal.) cyclone type spreader pushed by a man across the green. I saw that snow would fall before we finished the job. So, I got a dual wheeled tractor and put on our fan-type p.t.o. tractor spreader. We shoveled on the lime and on a Monday with no members present we drove the tractor across the greens. The greens were firm and the tractor tires merely laid the grass down with a tread design. We watered that night and mowed the greens the next morning. No one knew we had a tractor running across the putting greens. We were able to lime 37 putting greens in 5 hours - quite a labor and time savings.

Through the use of all these techniques and a generous amount of assistance from Nature, I have transformed areas that were 75% turf in 1963 to 100% turf in 1965. The areas that were 80% turf in 1963 are now 95% turf. The greatest problem is to keep a membership of 900 convinced that with my help Nature will grow the kind of turf that they desire if only given a chance and a little time.

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A LAWN PROGRAM THAT WORKS

L. M. Bowers, Duncan Electric Company
Lafayette, Indiana

In 1949 we started building a new factory on 36 acres of land just north of Lafayette. By July of 1950 the sidewalks and parking lots were finished and most of the trash from construction had been hauled away. The parking lot and buildings take up about six acres of land, and this left approximately thirty acres of land for lawn and recreation area. There is approximately ten acres of land between the front of our plant and U. S. Highway 52, which our Company wanted to make into a first-class lawn.

I was put in charge of the grounds, not because I knew anything about lawn maintenance, but because I was the only fellow in our department who had been raised on a farm and knew tractors and equipment. I was advised to contact Dr. Daniel here at Purdue and seek his help in preparing the ground and seeding it to grass. Bill was very cooperative and, with his help and advice, we achieved more than a nice lawn - we got a beautiful lawn.

My first concern was to get equipment to do the planting, then be used later to maintain the lawn. At this time we were only concerned with the ten acres in front of the factory. The land to the rear of the factory was not clearly visible from the main highway and it could be dealt with at a later time, even over a period of years if necessary. We purchased a small farm tractor equipped with a five foot sickle bar, a spring-tooth harrow, a spike-tooth harrow, a fertilizer spreader, a set of large lawn rollers, and a two-wheel trailer. Later in the fall we bought a tractor mounted, three-bladed rotary mower, plus a power hand mower for trimming. With the exception of a few small hand tools and the irrigation system, this is all of the equipment we have today and the only replacements necessary have been the tractor and the mowers.

The construction contractor had done a good job of leveling our front yard, but what a mess it was! Our property is all underlaid with gravel, and when they finished with our front yard, the top dirt was underneath and the gravel was on top. I hired about twenty Purdue students and rented three trucks, and we spent seven days picking up rocks from this front ten acres and hauling the rocks away. Also, we applied a 20-10-10 fertilizer at a rate of 500 pounds per acre and worked this into the soil.

We used two different grass mixtures: a mixture of 6 parts bluegrass to one part redtop was planted in the front of our factory out 100 feet along its entire length. People would see this as they walked from the parking lot to our front factory entrance. The rest of the yard was seeded to a mixture of one part bluegrass to one part alta fescue. We used alta fescue because it would hold its color better in dry weather, and we did not plan to try and sprinkle the entire front area in dry weather. After seeding we went over the yard twice with the spike-tooth harrow and then rolled it once with the heavy rollers.

We completed seeding in mid-August. It rained that night and continued to rain in ideal amounts the rest of that fall. I don't believe there has ever been a better fall to plant grass. The second week in October we were mowing our lawn and we had a wonderful stand of grass. We have not reseeded any of this lawn in fifteen years except where a water main has broken and the yard has been torn up in one spot for a building expansion.

The following summer our troubles began. I did not use enough nitrogen on the yard,and due to the fact that our yard was almost solid gravel, it would dry out and the grass would turn to a golden brown in about one week of dry weather. It would then stay that way until we would have a couple of weeks of ample rainfall. Individual sprinklers were not the answer; we needed a <u>lot</u> of water and we needed it <u>often</u>. Our entire factory is air-conditioned and we could use this water after it went through the air-conditioning system. We purchased a surface-type irrigation system that could be easily moved by one person. With this system we can put the equivalent of two inches of rain on our ten-acre lawn in 4 days by running the sprinklers 16 hours a day. This necessitates moving the system twice a day, and it takes one man about thirty minutes to move it.

Our second major problem, mowing, did not come up until the third year after planting. We had a fairly good fertilization program and our grass was growing so fast and heavy that our reel-type mowers were not able to handle it. We were also now wanting to do a better job of mowing on the back twenty acres, and it was too rough for reel-type mowers and the sickle-bar did not do a good enough job. We got a rotary mower that fastened underneath our tractor and this eliminates the problem of wheel marks from the rear wheels. Most of our other problems have been of a minor nature and have not caused us any trouble to speak of.

The maintaining of our grounds now has become a fairly standard operation for us. We contract a man (generally a Purdue student) to do our yard work during the summer. We furnish all of the equipment and material. During the months of June, July and August, when he is not in school, he works from 30 to 45 hours a week. During April, May, September and October he works weekends and evenings, and it takes him about twenty hours a week.

Our lawn program starts the middle of March. At this time we fertilize our front yard only. We cannot use our sprinkler system until May because our air-conditioning system is not yet in operation. After a few years of trying to find the proper fertilizer we have settled on urea every other year at a 350 pounds per acre rate in the spring, and 100 pounds per acre in August or early September. The next year we use a 20-10-10 analysis fertilizer at approximately the same rates and at the same times. I will not say that this would be ideal on any type of soil, but it has given us very good results.

We mow our front lawn twice a week and keep our mower set at 3-1/4" high. I insist on the rotary mower blades being sharpened every time we mow. We mow the back twenty acres once a week and in dry weather sometimes once in two weeks. We do not fertilize or sprinkle any of our back twenty acres, so it does not grow as fast as the grass in our front yard.

It has taken about twelve years before crabgrass came into our front lawn because we mow our grass high and do not have any foot traffic in our front lawn. We started a program for crabgrass last year, using calcium arsenate powder at the rate of 300 pounds per acre. We mixed it with our fertilizer and applied it the middle of March. It appeared last summer that we got about 80% control. This year I am going to use it again at one-half of last year's rate and I hope it will give us good results.

We are not troubled much by weeds in our front yard except for a few dandelions, which we spray for once a year, using 2-4,D as necessary.

This pretty well covers our lawn program. We are fortunate to have Purdue University in our community and the good help and guidance from Dr. Daniel. It makes my job easier. I know our lawn is the envy of a lot of other industrial firms.

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WHAT IS GRASS CHEMICALLY

C. Y. Ward, Dept. of Agronomy, Mississippi State College
State College, Mississippi

A grass plant, like any other living organism, is a great complexity of chemical substances. These substances are housed in specially designed structures which allow the plant to carry out its first and foremost purpose: capturing the energy of sunlight.

As manipulators of turfgrasses, our chief objective should be to present the plant to its environment in such a manner that it can convert this captured energy (process of photosynthesis) into green leaf tissue at an optimum rate. The process of photosynthesis and all the simultaneous reactions, changes and transfer of substances which occur in the cells of the grass plant are called metabolism.

Metabolism is complex. Consider the fact that scientists have labored centuries to uncover but a few of its secrets. Knowing some of these, however, will help you to better manage your turf.

Grass plants are biological factories in which the raw materials are funneled through an "activator" (chlorophyll) and converted into sugars, proteins, structural carbohydrates and "specialty goods." Some of the raw materials are absorbed from the soil by the roots and are often needed in amounts greater than that inherently present, so we add these raw materials as fertilizers.

Chemically all grasses have much in common. Healthy bentgrass (Agrostis palustris) on a golf green in Chicago and Washington, D.C., is almost identical, but small differences, for example, a lack of a trace of iron or other minor element, can alter the metabolism of a grass, slow its growth rate and render it more susceptible to disease.

If you assume from the diagram that fertilizers (both kind and amount) influence plants chemically, you are correct. This being true we can often tell a plant's "ills" by analyzing the tissue and comparing the content of a given nutrient to that which we have previously determined to be the normal concentration necessary for good healthy growth. For example, we know that bentgrass on a putting green should contain approximately 4% nitrogen for good healthy growth; that 6% nitrogen in the leaves indicates overfeeding, and 3% nitrogen indicates underfeeding.

Schematic Diagram of Chemical Breakdown of Clippings from a Putting Green:

Grass Clippings

Water 90% — Dry Matter 10%

Dry Matter 10%: Organic portion — Minerals

Organic portion:

- Fats, Vitamins, Chlorophyll
- Carbohydrates: sugars, starches, cellulose, hemi-cellulose, lignin
- Nitrogeneous: proteins, amino acids, amines

Minerals: Na, K, Ca, Mg, Mn, Cu, B, S, P

The beginning reaction for building of plant tissue is photosynthesis, which consists of a complex sequence of reactions in which three things occur:

1. A CO_2 fixation reaction.
2. An energy and hydrogen adding reaction.
3. A sequence of inter-conversions of sugar-phosphates that regenerate the carbon dioxide acceptor and allows six-carbon sugar to accumulate as the end product.

While we often show the photosynthetic reaction as a simple combination of carbon dioxide and water to form sugar and oxygen, the reaction is considerably more complex. The dozen or so reactions involved require enzymatic proteins which in most instances contain in their chemical structures minute quantities of the mineral elements which we apply as fertilizers. A deficiency in any one of the essential elements will retard photosynthesis and normal plant growth.

Photosynthesis can be thought of as a manufacturing process in which the leaf serves as the factory building; the basic raw products are carbon dioxide and water. The main source of energy for this factory is sunlight. The factory workers here would be analogous to the enzyme systems and the various minute quantities of minerals needed to carry out the manufacturing process. If a worker failed to report for work, for example, adequate iron, the production line (photosynthesis) would be slowed.

Table I shows that the main differences between putting green grasses and other plants are their higher requirements for potash and nitrogen, with nitrogen being the key nutrient. Grasses require larger amounts of nitrogen than any other mineral element. In a later section we will discuss some of the specific functions of nitrogen.

Table I. Average mineral composition in plants vs. grass clippings from a putting green.

Minerals	All Plants *	Putting green clippings
K	1.47	2.5
Na	0.37	0.20
Ca	0.77	0.50
Mg	0.30	0.25
P	0.22	0.30
N	1.52	4.5

*Coop et. al. Soil Sci. Soc. Amer. Proc. 12:359,1947.

Once the energy from photosynthesis is in the form of sugar molecules in the leaf, it can accumulate in amounts greater than that needed for the nutrition of that leaf. This excess is translocated to other parts of the plant. Formation of new leaves has highest priority. A great percentage of it is moved to the lower stem and stolons or rhizomes of the grass plant. These structures serve primarily as storage sites for excess energy. When the sugar molecules reach the rhizomes or stolons they are combined (polymerized) into long chain compounds such as fructosan or starch. The combining of small sugar molecules into large slow moving, lazy carbohydrates reduces the osmotic concentration of the cell sap and prevents damage due to excess pressures.

Actively growing grasses supplied with adequate nutrition always have a reserve supply of carbohydrates stored in the lower anatomy of the plant. These substances serve to supply the turfgrass with energy and building materials during times of stress, such as drouth, disease infestation, periods of excessive defoliation, or when excessive tissue is bruised due to heavy traffic, or other stress conditions. In a manner similar to which the sugar molecules were combined into the long chain starch molecules, they are enzymatically degraded into simple sugar when needed by the grass. This sugar may be utilized as energy in the process of respiration of the individual cells of the plant; it may be combined with nitrogen to form proteins or altered in several ways to form the more rigid cellulose and lignin which serve as structural materials in the cell walls.

One of the main periods when large amounts of reserve energy are needed by grasses is after mowing, or after more severe defoliation, such as vertical mowing. Immediately after such operations the plant leaf tissue is inadequate to produce the necessary energy required for the synthesis of new leaves to restore the green carpet, desirable for putting. Under these conditions, large quantities of sugar in the rhizomes and stolons are utilized for production of new leaves. Therefore, it is best that plants never be completely defoliated, since this removal of the entire photosynthetic factory would force the plant to rely entirely upon its stored energy. At any given time the amount of reserve carbohydrates may be inadequate to produce an entirely new factory of leaves before the supply of energy is completely exhausted, in which case the grass plants would die.

Today we know considerably more about the metabolism which takes place in grass plants than was known prior to the development of radioactive isotopes. Through the use of such radioactive isotopes as $*P^{32}$, $*C^{14}$ and $*N^{15}$, we can trace the path of individual nutrients through the metabolic pathways of the plant and determine functional roles of these nutrients in plant growth. Considerably more is known today about the structure of the plant cells as scientists learn more through the use of electron microscopes and other modern facilities. Through yet undeveloped techniques, the functional role of each mineral nutrient will be elucidated. Such information should enable the plant grower to better understand and meet the nutritional requirements of turfgrasses.

Some Specific Functions of Minerals in Metabolism

Since nitrogen is the fertilizer nutrient used in the largest quantities by grass plants, there should be some explanations for this fact. A look at how nitrogen functions in the plant should give the answer.

1. Nitrogen is an active part of the chlorophyll molecule which triggers the initial photosynthesis.

2. Nitrogen is a basic component of all protein tissue. Proteins are the life-giving substances of all cells. All the enzymes which regulate, govern and assist in the many chemical reactions taking place in the plant are made up of proteins. A great part of the actively growing tissue of grass is primarily protein in nature.

Listed below are some major nitrogenous compounds found in the plants:

Alkaloids	Indole Acetic Acid
Amides	Nucleic Acids
Amino Acids	Phosphatides
Chlorophyll	Proteins
Cytochromes	Purines
Enzymes	Pyrimides
	Vitamins

From this long but incomplete list, we can see why nitrogen is needed in such large quantities, and why grasses lose their sharp green color when nitrogen is deficient.

Phosphorus is another key element in plant metabolism. Through the use of radioactive $*P^{32}$ we have found that phosphorus functions in all energy building and degrading reactions which take place in the plants. Phosphorus is the key ingredient that functions in energy transfer substances within the plant. It is phosphorus which forms the high energy bonds of ATP (Adenosine Triphosphate), which controls the transfer of energy when sugar is degraded to carbon dioxide and water. Phosphorus then serves as a catalyst in the plant. Its concentration in the plant is usually less than .3%. This fact alone would tell us that the same phosphorus molecule is used over, and over, and over again within the plant to aid in carrying out of vital reactions.

Likewise, potash, a nutrient we often supply to turf, functions in the metabolic reactions of the plant. A deficiency of potash will cause:

1. A slow down in photosynthesis.
2. An increase in respiration or loss of energy through the breakdown of sugar.
3. Decreased growth.

Recent work by scientists in North Carolina shows that growth of young active plants may be reduced as much as 70% by a shortage of potash for a period of only seven days. Potash also activates enzyme systems in the release of sugar energy and is believed to function in protein synthesis. Because of its abundance in the plant, it is thought that potash has numerous other functions which are difficult to define because of inability to use a radioactive source of the nutrient. One of the key practical responses we see from supplying plants with adequate potash is the strengthening of plant tissue so that it better resists diseases and winter freeze-up.

<u>In summary</u>, everything the turf manager does alters the metabolism of the plant. You can aid or interfere with metabolism depending on your understanding of how plants grow. For example, during periods of drouth and excessive heat we often syringe golf putting greens and other turf areas. When we do this, we influence at least four things related to metabolism:

1. The water we supply is a functional part of photosynthesis, since the hydrogen from water combines with carbon dioxide to form sugar. Hence, we are supplying the plant with one of its major building blocks.

2. We cool the turf. Temperatures at the surface of the soil are often reduced as much as 40° by syringing or irrigation. This reduces respiration, which is the burning of excessive energy.

3. We prevent lethal enzyme injury. Enzymes are heat labile and are ultra sensitive to damage from heat. This is one reason bentgrasses often die in the summer during extreme periods of heat.

4. Through syringing we keep the plant leaf blades turgid so that they have better exposure to absorb the energy from the sun.

Another practice carried out on golf putting greens and turf areas is aerification. How does this practice relate to the metabolism of the plant? Aerification allows better oxygen and water penetration to the root areas, providing for greater root growth, and in turn increase the absorption of the mineral nutrients needed in photosynthetic reactions. Oxygen is vitally needed for respiration and growth of new roots. Aerification partially satisfies this need.

Plant growth is complex. It is often difficult to understand. But, a dedicated worker, who appreciates technical aspects of plant growth, will find the practical growing of grass to be simpler, if he understands and appreciates the little we do know about plant metabolism.

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MAINTENANCE BY CONTRACT

Robert Duke, Supt., Western Electric Company
Indianapolis, Indiana.

To give some background to the development of our maintenance by contract program, Western Electric of Indianapolis started operations in a new plant in 1951. Most of our grounds maintenance was performed by Company personnel. The exception was a contract covering spraying of trees, shrubs and evergreens. As the years went by, the advisability of doing grounds maintenance with outside help was discussed frequently. Contracting was working well for the Company in many other areas, particularly where specialized skills and equipment were required, or where labor needs were erratic.

There were three prime factors considered. One was cost - could we contract more cheaply than we could do the work ourselves? A second factor was quality - could we continue to maintain the desired appearance level? The third was a personnel problems. Some of our permanent employees had part-time assignments, such as chauffeuring, in addition to their grounds maintenance work and we wanted to retain these men. Temporary help also was hired each spring. Then, being reluctant to lay these men off in the fall, the Company always scratched around trying to find permanent jobs for them at the end of the season. Could we solve the part-time problem and the surplus help problem by going to a contract?

It appeared that if we would continue to do a portion of the maintenance, particularly those items least desirable to contract or items difficult to write into a contract, we would have full-time work available for our regular force, plus eliminating the temporary help problem. With this in mind, our management made the decision to contract for a one-year trial period. Our force would continue with turf fertilization, mowing, renovating, watering, policing grounds, and maintaining recreational facilities, along with other duties falling outside the maintenance category. This left eight items for contractor, which could be performed at specifield intervals and at a standard cost per service. They are as follows:

1. Cultivation of 20 entrance beds scheduled on a weekly basis during the season.
2. General cultivation of all other plant material on a monthly basis.
3. Trimming grass along walks, drives and curbs, usually three times annually.
4. Aerification, also usually three times annually.
5. Fertilizing all shrubs, evergreens and trees once annually.
6. Complete growth control on railroad tracks, storage areas and fence lines once a year.
7. Trimming shrubs, trees and evergreens once annually.
8. Trimming hedges, of which we have both deciduous and evergreen in some quantity, once a year.

The other items covered in the contract were spray applications charged at a per gallon rate, which varied according to the type of spray material. Included were dormant and summer sprays on our ornamentals, broadleaf weed and crabgrass sprays, fungicides, turf insecticides and a separate listing for a clover mite control spray. This little mite has been a real nuisance with us and requires regular attention.

Bid forms were sent out to several dependable firms in the area. The low bidder was the Duling Tree Expert Company of Muncie. This happened to be the same firm with whom the Company had enjoyed a long association, starting with the original shade tree plantings and continuing with a contract since 1951 for spraying our ornamentals. The Duling firm also had furnished additional trees over the years. Due to delay on our part, the first contract did not become effective until well into the 1963 season. It continued for the remainder of the year. In spite of the handicap of the late start on May 1, the results of contracting our maintenance appeared quite satisfactory. In 1964 a new contract was written for a five-year period. As you may have deduced from the program, the successful bidder again was the Duling Company. This, then, is the background on Western's part in maintenance by contract.

Experience has shown that our three primary considerations have been resolved satisfactorily. We believe the savings are worthwhile, our appearance level certainly has not been altered, and we have settled our personnel problem. With the contract, our own men have time to do a considerable amount of what we call construction work. Our place is in an almost constant building program and there is need for transplanting trees and shrubs, grading, sodding and seeding. Much of this work can be done by our personnel. We schedule the contract work by furnishing John Duling and his Company monthly written work authorization listing the type and number of services to be performed during a specific month.

In conclusion, it appears to me that any contract for grounds maintenance must be tailored to fit the needs of the situation - as we did with ours. In spite of diligent effort in preparing a contract, there are always questions to be resolved between owner and contractor. Without the ability to reach a mutually satisfactory agreement, the contract road may become rocky. Both parties certainly have to be sincere in their dealings. In our case, we are happy to say that problems, which have arisen, were settled satisfactorily.

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MAINTENANCE BY CONTRACT

John Duling, Duling Tree Expert Co.
Muncie, Indiana

My remarks are general, yet confirm many of the points that Robert Duke has made. As a contractor of ground maintenance, we find that a greal deal must depend upon the relationship between the contractor and the owner, or the representative of the owner. As various items of the contract may be requested during the season, we find that we need considerable flexibility in performing the services. Sometimes we are faced with weather conditions which prevent the performance of some item; yet,it is important that we make every effort to do so as soon as weather conditions and circumstances permit.

As elaboration on the various items included in the contract, a detailed outline should be completed as a result of the conference between the prospective contractor and the owner. In this conference both parties can arrive at decisions and understandings that are helpful in the future working and specifications of the items. We find that in this conference a relationship of understanding is developed that permits the desired and acceptable results at the time when such services are performed.

As the contractor I feel we must make every effort to produce the services in such a manner that is satisfactory and acceptable to the owner. I think this is just as important as the profits, which may be derived from the contract.

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GROWING TURF ON SAND

O. C. Redenbacher, Pres., Chester Hybrids, Inc.
Valparaiso, Indiana

In looking for a definition for dune sand, I found it under STRUCTURELESS soils as follows: There are two types of structureless soils:

1. Single grain - each particle by itself, as in dune sand
2. Massive - where all particles stick together without any regular structure at all - such as in many clay pans or hard pans."

During 1960 the steel mills started to industrialize the area along Lake Michigan in the vicinity of Burns Ditch, a few miles west of the Indiana Dunes State Park. Most of the dunes in this area had already been removed and used as fill for construction in the nearby areas. The first mill to start was Midwest Steel, a division of National Steel Company. No thought or plans had been given by the engineers in the lay-out of the steel mills for the movement and drifting of the sand, which is peculiar to the dune area around Lake Michigan. This sand is worn by the elements of time, so that there are no sharp corners, and with a slight wind the real fine particles will actually float a few inches above the surface, even within a few hours after a rain.

Construction was started, large areas were leveled for present and future building sites. To add to the problem of tying down the sand was the problem of continued construction even in some of the areas where the blowing sand also needed to be controlled. The blowing sand proved to be a hazard to men, machinery, and the finished product. The assignment was not beautification, but to tie down the sand by any method that was economical and practical.

Many people were consulted; ideas tried included slag from the existing steel mills, soil from adjoining clay areas, oils of various kinds, tars of various kinds, and a long list of grasses, plants, shrubs and trees. Some of the trials included Scotch pines and white pines, three varieties of locust trees, and new hybrid poplars. These were tried both with water and without. Without water they were a complete failure. With water they were a partial success.

Seed and fertilizer were seeded in the sand, and the area was immediately covered with chopped straw, and this was incorporated into the sand so that the pieces of straw would project vertically. This also failed, where no water was applied, but made good growth when water was added. We at Chester Hybrids were convinced that none of these would work successfully, unless ample water was included in with the program. Special machinery was needed. This included flotation tires on tractors, and also flotation tires on any accessory equipment.

In 1963 Bethlehem Steel Company started construction on their new plant, which is the largest construction project in the United States today, and the second largest in the world. They also had problems with the movement of sand. However, much of their area included marsh areas that are covered with water during most of the year, and filled with muck and a poor quality of peatmoss. They shipped colloidal clay from their pits in Pennsylvania, which were applied to test plots with a hydro-seeder. This held the sand together for a relatively short time.

The trial plots were measured and accurate amount of fertilizer, grass seed of different mixtures, including the grasses grown in the arid west, and the coverings of Turf-fiber, Sulphite road-binder, colloidal clay and straw were all noted. All of the plots were divided so that one-half was irrigated and one-half was not. In the late fall of 1963, Turf-fiber was applied at 1,000 pounds and 1,500 pounds through the hydro-seeder with 500 pounds of 16-8-8 fertilizer, and 300 pounds of perennial ryegrass per acre. Due to the lateness of the season they failed to germinate. All of the Turf-fiber was destroyed by the winds during the first part of the winter.

This same treatment of Turf-fiber, along with grass seed and fertilizer, was applied to existing dunes, and these, too, were destroyed by the winds during the first part of the winter. The Turf-fiber held the sand only while it was moist, and when irrigation was applied. It was noted that where the seed and fertilizer were incorporated into the sand, then the Turf-fiber applied on top, germination was much better, and the growth and coverage of grass required much less time than where the seed and fertilizer were mixed with the Turf-fiber and applied on top of the sand.

Another material known as Sulphite-roadbinder, which is unrefined calcium lignosulfonate, was used. This is a by-product of Marathon, a Division of American Company in Wisconsin, and is used as a road-binder to hold the mud and dust problems on unsurfaced roads. This material held the sand in place, and if applied in heavy enough concentrations, one could walk on the sand without any impressions being left. Grass seed and fertilizer were also added to this compound, but they proved unsatisfactory. Applications were made in both the spring and the fall. Road treatments were also made, but the sand drifting in from the surrounding areas destroyed the road treatments within two or three days.

Most of the areas around the mills are divided into two classifications. Those that are to be mowed regularly are called maintained areas, and those that are not to be mowed, but only clipped once or twice a year, are called non-maintained areas. The crop that was found to be most practical and would give the greatest root proliferation in pure sand in these non-maintained areas, was corn, seeded at the rate of 4 bushel per acre.

The growing of any crop on dunes sand with water is very similar to hydroponics; therefore, an analysis of the natural fertility in the sand was necessary. The pH was found to be above 8. Nitrogen was practically nil, the phosphate was medium and potassium was nil as shown by the Purdue tests. Eight hundred pounds per acre of 16-8-8 granular fertilizer were applied when the corn was seeded.

With heavy rain and frequent irrigation the potash was soon lost, and the corn showed potash starvation. This required topdressing with potash and the corn responded very readily.

In order to supply water with the least amount of labor to these large areas, a Valley Irrigation System 1200 feet in length was installed. This covered 102-1/2 acres with each revolution. Fifty-two hours were required for each revolution, and 1-1/2 inches of water were applied over the entire area with each revolution. During the early stages of growth, the irrigation system ran constantly. Fertilizer was also applied through this same system. The corn grew to an average height of four feet. During the latter part of September, rye, at the rate of two bushels per acre, and a seed mixture consisting of 125 pounds of Kentucky 31 fescue, 35 pounds of perennial rye, 25 pounds of Kentucky bluegrass, 15 pounds of Redtop, and 10 pounds of sweet clover were seeded in the corn without chopping or destroying the corn any more than running over it with a grain drill.

The corn provided good protection to the young seedlings from the wind and the sand, and rye is probably one of the easiest crops to grow in the dunes area under the adverse conditions that exist. The following spring this area was fertilized at six week intervals with 10-3-5 liquid fertilizer, with trace elements added.

Water in the maintained areas was applied with underground plastic pipe, and pop-up sprinklers. This covered an area of some sixty acres. These areas were seeded throughout the spring and summer and early fall without the benefit of any type of nurse crop. The grass mixture consisted of Kentucky 31 fescue, creeping red fescue, perennial rye, Redtop, and Merion bluegrass. No emulsion was used, watering was done frequently until a grass cover developed, and this had to support a Ford tractor and mower without making tracks or destroying the turf.

Some of the problems that developed on the maintained lawn pertained to the usage of water. During the dry windy days, large amounts of water had to be used to keep the sand from blowing, and this leached the potash and nitrogen away from the young plants. If the water was used in too small amounts, so that the submoisture and surface moisture did not make contact, the grass would burn during the heat of the day, caused by the reflection of the sun on the sand, creating temperatures beyond what the grass could endure. Frequent waterings were the best way to maintain the grass until it was established, and then daily waterings afterwards.

Topdressing with fertilizer, again liquid 10-3-5 with trace elements, was applied every 30 days during the first year. The second year this application rate was stretched to six weeks, and the third year to eight weeks. The total usage of fertilizer has dropped 60% from the first year mainly because the clippings have all been left on the soil, and a thatch is beginning to accumulate, which holds both the nutrients and the moisture. This method of controlling the sand has enabled the plant to operate with its doors and windows open, free from sand. They have been able to maintain their railroads, switches and general yards without a constant sand removal clean-up crew.

Nipsco, Northern Indiana Public Service Company, also built a large power plant in this same area. They controlled the sand in the areas immediately adjacent to their office, but decided against controlling the sand in the adjoining area. During the winter the sand from the adjoining areas covered the maintained areas to a depth of 3 inches, and this later had to be vacuumed from the grass, and more costs were expended maintaining the small maintained area than it would have cost to have controlled the larger areas in the first place.

The Bethlehem Steel Company also inaugurated an idea of maintenance around the main office, along with a complete landscaped planting, including evergreen wind-breaks with no protection from the adjoining sand areas. During the winter much of the established lawn was covered with sand, many of the evergreen trees were destroyed by the blowing of sand. Now these adjoining areas have been controlled, as was outlined to them originally.

In one of the areas at Midwest Steel the problem consisted of a 90 degree slope, fifty foot in length, covering some 1700 lineal feet around the acid recovery pit. This area was seeded with the same grass mixture as the maintained areas; however, rye was added as a nurse crop. After the grass emerged, five pounds of crown vetch seed was obtained and this was broadcast along the top of the ridge. No effort was made to try to get the seed lodged into the sand underneath the growing grass. The vetch is now making a very luxuriant growth, and seems to be our best method of controlling the slopes of pure sand where water can be supplemented during the dry periods.

In summary, pure sand can be controlled with seed, fertilizer and water. Mulching with top layers of muck, peat, soil, straw or straw asphalt combinations will assist in the growing of grass, but alone will not successfully grow grass. A damp surface is necessary for seed stabilization. Frequent fertilizations are a must during the first and second year. The use of irrigation, particularly a sprinkler type system, adds coolness and enjoyment to the extreme heats encountered both inside and outside of the modern steel plant during the hot summer months. Industry cannot live with the moving,floating sand without creating additional costs and hazards to its finished product. The control of sand with grass adds greatly to the beauty of the area and to the working environment.

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FAST SEEDING AND MULCHING

R. H. Stamm, New Products Mgr., American Excelsior Corp.
Chicago, Illinois

When man trys to improve upon mother nature he frequently errs by not first looking at the way things happen naturally, so let's first take a look at the techniques nature uses to propagate grasses. As seeds ripen they fall indiscrimantely on the ground. Those finding favorable conditions grow quickly; those that fall in a hostile environment either stay dormant until conditions improve, or die.

The most favorable conditions are those where the seed falls into dead grass. There the seed and seedling are protected from the sun, wind and rain, and under these conditions, the seed quickly germinates, and the seedling thrives. Today we take this same seed, bury it in hard ground, hammer it with sprinkler and rain water, bake the seedling in the sun and expose it to the ravages of the wind. It's a miracle that we get turf at all from such treatment.

Can we imitate nature's technique to give the desired turf quickly and economically? Highway builders have a hostile environment in which to establish turf -

subsoil for a seed bed, steep slopes, large drainage areas, and no irrigation. For highway grassing, the use of mulch has been adopted in every state. The most widely accepted mulch is straw, tacked into place with asphalt. Straw blowers, capable of mulching and tacking as much as four acres per hour were developed, and are being used. Other mulches are coming into use because straw is getting in shorter supply each year. Some of these new mulches are excelsior, wood cellulose fiber, fiber glass, cane begasse, cotton seed hulls, jute, sisal and hemp fibers, and even rayon and plastic fibers and nettings.

The next problem that the highway departments faced was how to apply the seed and nutrients at a minimum cost with a minimum amount of labor. In 1938 the Connecticut Highway Department invented the hydro-seeder. With the hydro-seeder and the power mulcher a crew could now seed, fertilize, and mulch as much as 30 acres a day, in practically any type of terrain, directly from the road bed. Since 1938 hydraulic seeders have improved remarkably. The equipment has become one compact unit, mechanical and hydraulic agitation have been added, pumps improved, and the spraying systems developed to a fine art.

In 1958 the International Paper Company invented the wood cellulose fiber mulch that made it theoretically practical to seed, fertilize and mulch 30 acres a day with one machine and a small crew. The bottle neck now turned out to be the hydro-seeder. It was not capable of mixing and pumping the heavy slurries, charging the equipment was slow, and there were frequent stoppages of work due to lines plugging, or other breakdowns. In order to make the technique of hydro-mulching effective, the Hydro-Mulcher was born.

The Hydro-Mulcher has more mechanical agitation, a shredder bar to facilitate the loading of the wood cellulose fiber mulch, a gear pump that will handle twice as heavy a slurry as the centrifical pump, and will also handle vegetative matter, such as stolons, rhizomes and crowns. The technique of hydro-mulching was now a practical matter. Hydro-mulching is suitable for seeding both irrigated and non-irrigated areas. Equipment is available in sizes from 250 gallons, suitable for maintenance at most country clubs, to the 1650 gallon units for contractors and new course builders, or sod growers.

The typical charge in a 1500 gallon Hydro-Mulcher is 1500 gallons of water, 500 to 1000 pounds of wood cellulose fiber, 40 to 80 pounds of seed, and 400 pounds of fertilizer. The equipment can be operated by as few as two men, and depending upon the water supply, as many as five loads an hour can be pumped. Each load will do half an acre. When applied, the seed is trapped in a soft layer of green colored wood cellulose fiber, which, while attractive to the eye, is really used to meter the material by giving the operator something to see. The fiber insulates the seed, keeps it moist, and provides the essential elements for rapid germination and growth. So far we have considered seeding only. The hydro-mulching technique can also be used for vegetative planting, or hydro-sprigging. This process was developed by Dr. Ray Self, Auburn University, and is going to be a real boon to the turf industry.

In hydro-sprigging the stolons, rhizomes and/or crowns are mixed with water and wood cellulose fiber in the Hydro-Mulcher. So far we have not been able to apply the fertilizer with the plant material without some side effects. The material or slurry is then sprayed on the green or seed bed so that the angle of impact is nearly vertical. Reasonably sharp edges can be maintained. The distribution of the stolons is very uniform. The wood cellulose fiber wraps around the stolons, making it necessary to apply only a light topdressing of fiber for final protection. Rolling is not required, except possibly for some of the very springy stolons, such as Zoysia.

At Fort Wayne a three-man local crew, using a 500 gallon Hydro-Mulcher applied 850 bushels of C-15 Toronto stolons to 20 greens in two days on October 1 and 2, 1965. By November 1 the turf was well established, and has done well through the winter. In the South, Tifton 320, under ideal growing conditions, has made playable greens in as little as 28 days after hydro-sprigging. This technique makes it practical and economical to go first class on greens and plant them vegetatively. Labor is reduced as much as 75%, material as much as 40%.

The fast seeding and mulching techniques have definite application in reducing costs, reducing labor, improving quality and establishing the best possible turf in the least possible time.

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IMPLICATIONS CF ROADSIDE BEAUTIFICATION

Vincent Koers, Department of Roadside Improvement
Indiana State Highway Commission

I am here today as a representative of the Indiana State Highway Commission to speak on the implications of roadside beautification, or more specifically the Highway Beautification Act of 1965.

Beauty itself is not something created by the Johnson Administration. Beauty has undoubtedly existed on this Earth since long before mankind was here to appreciate it. As our country progressed, masses of people began to create problems which went largely unrecognized until the early nineteen hundreds.

In the early thirties most highway administrators and engineers were primarily interested in getting the motorist out of the mud. Limited funds precluded appropriation for beautification, or "pansy planting," as it was facetiously called. Some parts of the country were ahead of others in terms of their sophistication of highway design, to the degree to which they had been able to escape from the concept that roads should be built with a minimum of change in the terrain surrounding them, regardless of what this did to the design of the road.

In 1936, a clearing-house for roadside development information was proposed, and in 1943 it became a reality. Through this and similar efforts, new ideas and concepts became more generally accepted on a nationwide basis. But today, in many states beautification, as set out in the Highway Beautification Act of 1965, has yet to be accepted. In some of these areas, Beauty is still a dirty word.

In 1936 members of the Amer. Ass'n. of State Highway Officials published the goals of roadside development, that is, "that they must conserve, enhance, and effectively display the natural beauty of the landscape through which the highway passes, as well as provide safety, utility, economy, and recreation facilities by means of proper location, construction and maintenance of the highways." This goes far beyond simply planting a few trees, or shrubs at specific locations.

At a recent conference, Laurance Rockefeller pointed out that "Americans are becoming increasingly concerned about how we are treating the air, water and land about us. There is a growing conviction in the land that we can restore beauty where it has been ravaged, that we can preserve it where it now exists, and that we can even create it as we rebuild anew." Such a turnabout in public policy has not taken place overnight. It has taken as long as five decades to ferment in the minds of the American people and come to a head.

At a White House Conference, the President said that, "Natural Beauty as you and I conceive it, is the world that we live in. The importance of natural beauty cannot easily be measured. But, it is proven beyond doubt by history of the race and experience of our own lives. Today, natural beauty has new enemies, and we need new weapons to fight these new enemies." In his State of the Union Address, President Johnson further stated that, "We have 265,000 miles of federal interstate, primary and urban highways which handle 46% of all motor vehicle traffic. I want to make sure that the American we see from these major highways will be a beautiful America."

In response to these ideas, the Congress of the United States passed the Highway Beautification Act of 1965, which has three separate sections: control of outdoor advertisement, control of junk yards, and authorizes expenditures for roadside development. The question can rightfully be asked: What is beautification, and, as a practical result of the Act of 1965, what can we expect to see as tangible changes on our highway system?

The State of Indiana, along with Illinois, Massachusetts, California, and a few other states, had engaged in highway beautification prior to the Act of 1965 under the 3% 90-10 program. In Indiana, what this work amounted to was a total of some $ 615,000.00 of Contract Planting in the period from 1961 through 1965, or over a period of five calendar years.

In 1965 we increased our design staff and also began engaging in consulting agreements for design of projects, thereby increasing our ability to plan. We have programmed some $ 2,800,00 of contracts, which should be let for construction in calendar years 1966 and 1967.

What will happen under Section I and Section II of the Act of 1965 is less clear. The Act provides generally for the control of outdoor advertising within 660 feet, and junk yards within 1000 feet of the edge of right-of-way along interstate and federal aid primary highways. But, there are some important exclusions in the Act. The actual effectiveness will be determined by the standards which have yet to be adopted by the Secretary of Commerce. Whatever standards are adopted, they will not become fully effective until 1970.

The actual design of the landscape planting has varied considerably since we first began drawing them in 1961. The original concept of our planting was and still is to create relatively maintenance-free plantings, which will eventually eliminate or drastically cut the amount of maintenance required in the area. This same type of design, with relatively small material and large numbers of shrubs, was continued up to the latter part of 1963, at which time we gradually switched to larger sizes of material and at the same time reduced the number of shrubs considerably.

Late in 1964, approval was given to expand the program to include not only interchanges, but also the right-of-way that lies between them. Guides as to the design criteria were to be two books published by the A.A. of State Highway Officials, the first being "A Policy on Landscape Development for the National System of Interstate and Defense Highways," published in 1961, and the second and more detailed, "Landscape Design Guide," prepared and approved by the operating committee on roadside development in late 1964 and copyrighted in 1965. With this further direction we continued the program essentially as it is today, using predominantly tree material of relatively large sizes over the entire right of way.

The present standard for density of material sets up seven figures expressed in dollars of material per mile, which are as follows: on the Interstate system, Rural is $ 10,000, Urban is $ 15,000, and the inner belt is $ 30,000. On the Primary and Secondary system, Rural is $ 5,000 and Urban is $ 10,000. On interchanges, cloverleafs generally are $ 30,000, and others are $ 20,000. These figures are intended only as rough guides.

Our program in its present phase can relieve the monotony of the highway; it can alleviate specific local problems; it can eliminate annoying and dangerous headlight glare in some locations, and can effectively beautify the roadway. But, we have some built-in inherent flaws which must be dealt with in ways other than planting a tree around it.

Both the previous legislation and the Act of 1965 provide for Safety rest areas and scenic pulloffs. Generally, Safety rest areas will be provided at between 25 or 45 mile intervals along the interstate highway system. Scenic lookouts will be provided wherever feasible, which will be predominantly in the southern part of Indiana. I want to stress one point in particular, and that is that the need for roadside beautification is not a new need. What we need is to begin to recognize the need for roadside development in the same plane as the need for better roadways.

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PROBLEMS OF PEOPLE

WORLD FOOD AND FERTILIZER OUTLOOK

Werner L. Nelson, American Potash Institute
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Before looking at the fertilizer outlook, we must first look at food needs since one of the basic reasons we use fertilizer is to grow more food. The focus now is on the food needs in the developing countries of Asia, Africa, and Latin America.

We are aware that the world population will double in 35 years at the present rate, and most of this increase will come in the developing countries. In these countries the annual population growth rate 1960-1980 is predicted to be 2.5%, while in the developed countries the increase will be about 1.3%. Presently about one-half of the world's population suffers from actual hunger or malnutrition. Malnutrition refers to "hidden hunger" because of lack of proper proteins or other essentials.

Need For Food

The developing countries must double their food output in 15 years in order to even keep pace with their present hunger level. This is an impossible task without help. For example, in Latin America, excluding Cuba, food production in the last five years expanded 6%. However, the population grew more than 11%. Hence, while food production is increasing, it is growing at a slower rate than the population.

Dr. E. L. Butz, in his address before the International Industrial Conference stated - "The world is on a collision course. When the massive forces of an exploding world population meets the much more stable trend line of world food production, something must give. Unless we give increased attention now to the softening of the impending collision, many parts of the world, within a decade, will be skirting a disaster of such proportion as to threaten the peace and stability of the Western World itself. The long-run outlook for international agriculture is essentially one of the race against time and capital in an effort to meet the onslaught of a tremendous upsurge in world population."

Before World War II the developing countries were exporting 11 million tons of grain per year. The flow has reversed and in 1964 they imported 25 million tons of grain.

Yield Per Acre is the Problem

A low yield increase is the basic problem in the developing countries as shown below: (Foreign Agr. Ec. Report No. 25, 1965).

Area	Yield Increase 1934-8 to 1960
	%
North America	109
Latin America	8
Western Europe	37
Eastern Europe & USSR	20
Africa	20
Asia	7
Oceanic	62

Russian yields as percentage of American yields are: corn - 33%; wheat - 36%; rice - 60%; tobacco - 42%, and potatoes - 34%.

How Fertilizer Fits In

Dr. F. W. Parker of AID states that a low level of soil fertility is one of the most important and basic reasons for human hunger. The Food and Agriculture Organization of United Nations, FAO, has made a study of the relationship between $N+P_2O_5+K_2O$ per hectare of arable land by countries and the crop yield value index. The relationship is good: $r^2 = 0.83$. Hence, fertilizer consumption appears to be a good indication of the degree to which a nation uses modern agricultural methods. Soils are generally low in fertility either naturally, or because of long-continued cropping.

FAO is quick to point out that fertilizer is only one part of improved management, but that it is a powerful causitive factor. Hence, if a country wishes to increase its yields, the use of fertilizers must be increased with proper attention to the other factors.

FAO Fertilizer Program

One specific example of an effort to increase crop yields through increased fertilizer use and other improved management practices will be cited. In 1960 members of the world fertilizer industry initiated a fertilizer program under the auspices of the FAO Freedom from Hunger program. About 20% of the $ 300,000 in funds is contributed by U. S. industry.

Number. The main purpose was to carry out simple demonstrations and trials in cooperation with interested developing countries. Some 15 countries are in the program and the number of demonstrations is shown below:

	No. of demonstrations	
	Already in	Planned thru summer 1966
Near East + N. Africa	18,297	28,481
W. Africa	17,595	31,045
N. Latin America	9,125	18,310
	45,017	77,836

Results. Responses have been quite good in general. Of course, a real effort is made to use improved varieties, pest control, water control, etc.

	Avg. yield increase from fertilizer %	Crops to - Fertilizer ratio
Near East + N. Africa	55	2.7
W. Africa	51	3.7
N. Latin America	68	7.3
Avg.	55	3.4

The average return shows the value of yield increase to be $ 3.40 for each $ 1.00 spent for fertilizer. Crop yields can be markedly increased, and such responses would take care of the world food problem, if proper practices would be initiated on large acreages in the hungry countries.

Pilot programs. It is relatively easy to demonstrate responses to fertilizer. The big problem is to get it used because of credit and the marketing problems for fertilizer and the produce. To help overcome this, pilot programs have been initiated in which fertilizer is given to the countries. The countries in turn sell the fertilizer to the farmer either for cash, on credit, or for payment in kind.

Programs have been initiated in Ghana (500 tons), in Nigeria (900 tons), in Turkey (880 tons), with smaller efforts in Kenya, El Salvador, Morocco and Syria. These have been quite successful and give leaders experience in meeting marketing problems.

Government cooperation. This has been excellent. Developing countries are putting in $ 2.00 for every industry dollar, and about 100 workers for every FAO staff member. Too, certain developed countries are channeling some of their aid through the Fertilizer Program. This is a long-term effort, but many people see and are impressed by the demonstrations. Of particular import is the fact that the leaders are being educated. Many more countries would like to get into the program as funds become available.

Factors influencing speed of adoption of fertilizer by developing countries

1. Government stability
2. Availability of transportation and marketing facilities
3. Availability of credit
4. Incentives to buy fertilizer and produce
5. Crop and soil needs
6. Climate
7. Farmer knowledge
8. Technical and fertilizer assistance from developed countries

Other Limiting Crop Production Factors

Poor varieties,pests, and water control limit yield levels. Until these problems are taken care of there will be a low ceiling on yields. The various assistance programs will make substantial advances in getting and applying the technical information to answer many of these questions in the next few years. Of particular importance is the excellent role U. S. universities are playing in improving agriculture in many countries.

Conclusion

The U. S. fertilizer industry will play an important role in the program of Plant Food for Peace. Virtually every major fertilizer company will be affected by the increased demand for food over the world. Careful planning will be essential to keep up with the rapidly changing food and fertilizer needs, and the changing attitudes of many governments with respect to fertilizer distribution and usage.

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SOIL WARMING AND TURF USE - THIRD REPORT

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Soil warming, better defined as turf heating, involves adding heat to the rootzone of turfgrass plants to keep the soil from freezing, keep the turf greener, promote new root growth and blade extension, and help melt snow. This practice,used in Britain and Sweden, now seems adequately tested for acceptance as a part of turf management programs in the United States. The first major electrically heated turfgrass area in this country will be the playing field in the Civic Center Busch Memorial Stadium, St. Louis, Missouri. This installation is to be completed by mid-1966.

The fundamental requirements for installation and management of electric soil warming systems in the North Central States have been determined through cooperative investigations made by the Purdue University Departments of Agronomy and Agricultural Engineering and the Farm Electrification Research Branch, AERD, ARS, USDA.

Soil Warming In The United States

Soil warming research in the United States has been oriented toward improving turf in critical-use areas in addition to assuring frost-free playing conditions. Responses of bermuda grass (New Mexico and Texas A & M), Merion bluegrass (U. of Minn.), St. Augustine grass (Texas A & M), bentgrasses (Toro, Minneapolis), Kentucky bluegrass (Purdue) and Zoysia (Link's Nursery, St. Louis) are being investigated. These are the major turfgrasses used in football fields, baseball parks, and golf greens and fairways.

Progress reports, 1964 and 1965, concerning work at Purdue presented factors investigated to gain information about energy input relations to temperature, performance of cable types, installation procedure, control systems and grass response.

In 1964, Daniel, Barrett and Coombs reported that Kentucky bluegrass sod had increased rootgrowth during the winter, had extended growth period in the fall, had earlier growth in the spring, and, in high-wattage areas, had growth throughout the winter. Plastic coverings reduced electric energy requirements, maintained greater greenness in blades and favored growth. However, extra attention to remove and replace covers to avoid excessively high temperatures and disease buildup was necessary during variable spring weather. In a report at the 1965 Conference, Daniel and Barrett confirmed that soil warming as a turf management tool can improve adverse conditions by thawing soil, melting snow and maintaining a more vigorous turf.

Soil Warming in Canada

Lebeau at Lethbridge, Alberta, Canada, studied the effect of controlled minimum temperatures on grass plots during winter. Results of three years of research showed that raising soil temperatures a few degrees in field plots brought non-hardy turfgrass through the winter in southern Alberta in a lush, vigorous condition. Merion bluegrass, annual bluegrass and creeping bentgrass (Penncross) were lush and green throughout the winter in plots with minimum controlled temperatures of 32°F. and above. Lebeau further commented that raising soil temperatures a few degrees would extend the growing season of many herbaceous perennials and give them a vigorous start in the spring. As a result, longer use of turfgrass areas could be made during the season. He stated that extended use of this method (adding supplementary heat) will depend largely on the future cost of supplying heat energy.

System Design Considerations

The exact design of each installation will depend on the extent of, and use for, each turf area, the climatic location, the availability of power and the grass species used. General guidelines pertaining to heating cable type, installation depth and spacings, control systems and power densities can be found in our other publications. System designs and installations should be in compliance with the National Electric Code.

Program of Operation

Use of the turf area will determine the program of operation. The application of heat should begin as the earth cools if improved conditions are desired for an extended fall season. For this circumstance the system is used to buffer a heat loss. The advantage of early spring application can be best utilized by warming the soil as normal soil temperature buildup begins.

In areas used for both football and baseball, supplementary heat can be used to sustain a frost-free growing turf until the close of the fall season, then turned off, or used in minimum amounts to help the turf repair itself, until air temperatures warm up in the spring. Then the turf can be thawed, or warmed up, and active growth forced as much as 4 - 6 weeks prior to opening of the baseball season.

Management of golf greens would be similar, practice greens can be available for play whenever weather permits outdoor activity. Heating golf greens at low wattage densities may improve winter survival and avoid winterkill.

The biggest single consideration with large heated areas involves economics, both installation and operational costs. Approximately 600 KW power capacity is needed to heat a football field turf area at 10 watts per square foot. This is comparable in size to a field lighting system; in fact, the switch gear for field lighting can be used for warming systems. In smaller areas, with less investment and more return per square foot of heated turf, the relation between costs and return is more favorable.

Installation Procedure

Plastic insulated cables can be installed under existing turf using a modified subsoiling tool preceded by a rolling coulter to slice the sod. A rigid metal tube guides the cable to desired depth. With ample rolling and watering, the turf can be made smooth enough for use immediately after burial. Utmost care must be taken to prevent damage during installation. Prior to application of power, each cable should be further checked to detect if damage may have occurred.

Maintenance Precautions

One major problem involves protecting a system from mechanical damage during the normal maintenance and repair of the turf area. Management must recognize the possible damage and injury that can result from shoveling, deep aerating or staking. Warning lights should indicate to workmen and users of the turf areas when the heating system is energized.

Agronomic Considerations

Turf heating offers several agronomic benefits which have not been previously mentioned. Rejuvenationn of existing turf can be accelerated, and new sod or new seedings stimulated. For example, ryegrass overseeded December 1, 1964, was 3 inches high by December 30 on heated soil covered by plastic, while unheated soil, also covered with plastic, repeatedly heaved and thawed and seed did not germinate. Heating makes rejuvenation of heavy-use areas possible where none would otherwise occur. At the Air Force Academy, for instance, hard frosts occur in the stadium before the first football game of the season is played. They will make the first installation in a football field during 1966. Another potential benefit is the possibility of combining warm-season grasses havinggreater wear resistance, with cool-season grasses for an improved turf in cooler areas of the country.

No winter irrigation of heated plots was required during the 3 years of tests at Purdue. Apparently the additional infiltration of moisture from rain and melting of snow adequately offsets any increase in evaporation which might be anticipated as the result of heating. Lebeau's heated plots also did not dry out during the winter despite a small amount of precipitation.

Certain potential difficulties must be recognized. Bluegrass plants can be over-stimulated when temperatures above 50° F. are maintained at 1-inch depth and are susceptible to frost injury in sudden severe cold weather. When surface temperatures are maintained just above freezing with little air circulation, particularly under snow cover, injury from "snow mold" is possible. Lebeau has pointed out this potential problem. He states that regulation of temperatures in conjunction with application of fungicides should insure complete protection of turfgrass from damage.

Civic Center Busch Memorial Stadium

The playing field of this new stadium will be equipped with electric soil heating cables placed approximately 8 inches below the sod and spaced 1 foot apart. Heat output of these polyvinyl-chloride insulated cables is to be 5 watts per linear foot while operating at 277/480 v AC. The system will operate "off-peak" to heat the soil when the outdoor air temperature drops below 40°F., and when the soil temperature at 4 inches falls below 50F.

A mixture of 70-80% Zoysia (Midwest and Meyer) and 20-30% bluegrass (Kentucky, Delta, Merion, Newport and Windsor) will be sodded in as turf. These grasses are expected to complement each other with the Zoysia most active in the summer and early fall, and the bluegrass predominating in the winter and early spring. The heat added will stimulate the Zoysia into early spring growth and later fall activity, while the bluegrass will remain active in the winter instead of becoming dormant.

In Conclusion

The application of heat to the rootzone of turfgrass plants involves both engineering and agronomic considerations. Research in both disciplines has led to acceptance of turf heating as a management tool in England and Sweden. The potential for use in the United States is vast, ranging from installations in golf green areas to large multiple-sport arenas. Surely other agricultural applications involving the modification of temperatures in plant-supporting mediums will be conceived. Although considerable research has been done concerning grass responses, heat transfer in soil, and soil warming, more investigations need to be made to correlate findings and define management techniques.

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SOD PRODUCTION IN THE SOUTH

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Sod production in the South is booming. A recent survey showed there is some commercial sod production in every southern state. The major sod farms in the South are located near the Gulf Coast and in peninsula Florida. These locations provide a long growing season and usually very sandy soil. The latter is important as it permits harvesting of sod in rainy as well as dry seasons.

The major turfgrasses grown for commercial sod production in the South are all warm-season species. The most important are:

Bermudagrasses	Zoysiagrasses	St. Augustine
Tifdwarf*	Meyer***,**	Common****
Tifgreen(Tifton 328)*	Emerald***	Floratine****
Tifway (Tifton 419)**		
Tiflawn (Tifton 57)***		Common Centipede****
Everglades*		
Common		

*Recommended for putting greens
**Recommended for tees and fairways
***For general turf areas and athletic fields
****For lawns only

In the upper South consideration is being given to production of certified Kentucky bluegrass and Kentucky bluegrass-creeping fescue sod.

Most southern states attempt to control sod quality, and afford protection for the buyer, by offering a certification program for commercially produced turf. These programs require that the grower start with "Foundation Stock" obtained from the original source, usually a State Experiment Station. The Foundation sod is planted on fumigated, weed-free soil and is also rogued to keep it genetically pure. The fields are inspected periodically by Plant inspectors charged with the Certified Crop Program. The grower is issued a series of certificates; he attaches one to each shipment of certified sod. In addition to guaranteeing the buyer that he is buying the "genuine article", the program protects the grower from unqualified turf producers.

Certified Sod Production in the South (does not include non-certified acreage. Texas and Arkansas will have certified turf growers in 1966).

State	Acreage in 1965	No. of growers
Alabama	30	5
Arkansas	None	None at present
Florida	249	5
Georgia	100	5
Kentucky	No data	--
Louisiana	No program	--
North Carolina	25	4
Oklahoma	--	--
South Carolina	27	7
Tennessee	1	1
Texas	None	--
Virginia	1	1

Non-certified sod production greatly exceeds certified production in most states. For example, Florida alone has thousands of acres of non-certified St. Augustine.

Bermudagrasses. Most bermudagrass sod is not sold as solid sod, but as sprigs, free of soil. This practice minimizes transportation costs and reduces transfer of weeds and nematodes. This method of sale is possible because bermudagrass is so easily established by planting vegetative material.

Zoysiagrasses. Most Zoysia is sold wholesale as sod, but the retailer or planter usually establishes these grasses by using plugs or sprigs. When used on tees or other athletic turf, it is usually solid sodded. Also, some plugs are sold.

St. Augustine and Centipede. Because of their lower cost unit area, these grasses are marketed as solid sod. They are very popular in the Deep South.

Sod producers in the South are highly mechanized. The entire operation from growing,to harvesting, to planting is made possible by use of the very latest equipment. Much of the equipment has been developed by the grower to meet a specific need. For example, one large grower in Florida has developed a throw-away cardboard pallet for transporting sod in convenient stacks from the field, to truck, to the lawn site.

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WATERING SYSTEMS - SO WHAT?

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During the past two months I have been fortunate enough to attend a number of conferences where golf course irrigation has been the main topic. Dr. Daniel has asked that I summarize the impressions made and "facts" learned during these conferences. It is obvious that considerable confusion, misunderstanding and variance of opinion exist in the industry today. The final decision as to just what type system is actually superior in the more northerly part of the country has yet to be made.

The biggest points of contention at this time are:

1. Which is superior, the combination of cement asbestos and plastic pipe, or cast iron and galvanized pipe?
2. Manually operated systems, or automatic systems?

Both pipe schools of endeavor seem to have considerable going for them and can prove to a novice's satisfaction that their stand is without doubt - right. It would seem to me that both types of piping are adequate and will produce desired results if suitable pipe, or that which meets minimum psi, size, etc., standards is used, and if it is installed properly. A big point here, of course, being the method of installation. This cannot be overstressed as I have personally seen too many irrigation systems, which have not been properly installed competely and literally "go to pieces;" but, especially the cement asbestos and plastic types. By all means, a knowledgable and qualified irrigation engineer must be consulted, and a competent contractor used if you expect to properly install a semi-trouble free watering system.

The other area undergoing considerable discussion at this time is that of complete automation vs. manually operated systems. In the southwest, or areas where a considerable amount of water is required and irrigation days are many, it seems that completely automatic systems are purely and simply all that are being installed at the present time. However, as one travels further north, or into the region where less overall water is required, and the irrigation season is shorter, it seems there are good arguments for the installation of manually operated systems. This has been quite well worked out on an economic basis which considers the number of man hours required to water the golf course compared with costs of installation of the two systems. Actually, it seems to work out about nip and tuck. It costs more to install the fully automatic system, but it costs more to operate a manually operated system. A big problem is the lack of labor to properly operate a manual system - night watering, etc.

All fully automatic systems are new. The most knowledgable authorities in irrigation are not cognizant of all the facets and angles, when comparing the economics of fully automatic and manual systems in the more notherly part of the country. I have personally talked to approximately 10 golf course superintendents who have fully automatic systems in the northern area. They have reported that automatic systems are quite difficult to get into full operation - many bugs must be worked out. But, after the system is operable, they much prefer to maintain the golf course with the automatic system than with the manual system and labor supply they had in the past.

To add all this up, it seems to me that further improvements are necessary with automatic systems before they will be completely acceptable in the more northerly parts of the United States. One constantly hears rumbles that new automatic valve ideas are being tested and will be marketed shortly. Such things as heat and radio controlled valves are discussed. Certainly, if systems could be developed which do not contain the many miles of copper wiring or plastic tubing currently necessary in automatic systems, a great advancement would be realized.

In any event, it is apparent that considerable advancements are currently taking place in the irrigation industry and they are needed. Certainly more use of turf can be expected and automatic irrigation is making great strides.

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DESIGN AND ECONOMY COMPARISONS OF TURF SYSTEMS

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SPRINKLER IRRIGATION COST ANALYSIS

COMPARATIVE COST DATA FOR SPRINKLING TEN ACRES OF LAWN AREA BASED ON THE USE OF FOUR METHODS OF WATERING AS FOLLOWS:

1. FULLY AUTOMATIC SPRINKLER SYSTEM
2. MANUALLY OPERATED SPRINKLER SYSTEM
3. QUICK COUPLER SYSTEM
4. HOSES AND PORTABLE SURFACE SPRINKLERS

THE FOLLOWING COST DATA IS PATTERNED AFTER AND BASED ON INFORMATION COMPLIED BY THE TWELFTH NAVAL DISTRICT IN CALIFORNIA. THEIR REPORT WAS BASED ON ACTUAL TESTS AND COSTS OF THE VARIOUS TYPES OF SYSTEMS ON NAVAL INSTALLATIONS THROUGHOUT THE WEST COAST AREA. THE FIGURES PRESENTED HERE HAVE BEEN ADJUSTED SOMEWHAT TO REFLECT AVERAGE COSTS AND WATERING REQUIREMENTS OVER THE ENTIRE UNITED STATES. THE COST OF WATER AND LABOR AS WELL AS THE COST OF INSTALLATION WILL OF COURSE VARY IN EACH INDIVIDUAL CASE.

THE COMPARATIVE COST DATA TABULATED BELOW ARE BASED ON THE FOLLOWING ASSUMPTIONS:

1. WATER SUPPLY SUFFICIENT TO UTILIZE 3'' VALVES
2. LARGE ROTARY SPRINKLER HEADS (64' TRIANGULAR SPACING)
3. WATER COST $0.25 PER 1000 GALLONS
4. LABOR COST $1.60 PER HOUR
5. AVERAGE INSTALLATION COSTS APPROXIMATELY 10% HIGHER THAN CALIFORNIA

EXAMPLE TABLE - 10 ACRE AREA

	INSTALLATION COST	WATER COST PER YEAR	LABOR COST PER YEAR	TOTAL ACCRUED COST AFTER 3 YEARS	COST PER YEAR 30 YEAR LIFE AMORTIZATION	SAVINGS PER YEAR AUTOMATIC OVER OTHERS
AUTOMATIC SYSTEM	$24,000	$1,629	$ 30	$28,977	$2,459	
MANUAL SYSTEM	$22,000	$2,444	$1,536	$33,940	$4,713	$2,254
QUICK COUPLER SYSTEM	$14,500	$2,933	$2,073	$29,518	$5,489	$3,030
HOSE SYSTEM	$ 9,000	$3,520	$3,110	$28,890	$6,930	$4,471

SINCE THE ABOVE FIGURES ARE BASED ON A 10 ACRE AREA, RELATIVE COSTS MAY BE DETERMINED BY MOVING THE DECIMAL POINT ONE PLACE TO THE LEFT TO OBTAIN A COST PER ACRE, THEN MULTIPLYING THAT RESULTS BY THE NUMBER OF ACRES DESIRED. PLEASE NOTE THAT THIS APPLIES TO ACREAGE ONLY THE PER ACRE COST WILL BE DISTORTED CONSIDERABLY ON SMALL ACRES OF LESS THAN 2 TO 3 ACRES.

COST BREAKDOWN - EXAMPLE TABLE I

WATER COST - AUTOMATIC (NIGHT TIME OPERATION)

UNDER AVERAGE SUMMER TIME CONDITIONS LAWN AND TURF AREAS WILL REQUIRE A MINIMUM OF ONE INCH OF WATER PER WEEK. DURING A NORMAL YEAR WATERING WILL BE REQUIRED FOR AT LEAST 24 WEEKS

1'' OF WATER/WEEK X 24 WEEKS = 24'' PER YEAR
24'' ÷ 12 = 2 FEET X 10 ACRES = 20 ACRE FT/ YEAR
20 ACRE FT/YR X 43,560 SQ.FT./ACRE = 871,200 CUBIC FT/YR.
871,200 CU.FT. X 7.48 GAL/CUB.FT. = 6,516,576 GAL/YR.

THE AVERAGE WATER RATE IS APPROXIMATELY 0.25/1000 GAL. THEREFORE:
6,516,576 GAL./YR. X $0.25/1000 GAL. = $1,629 PER YEAR

WATER COST - MANUAL (DAY TIME OPERATION)

DUE TO THE HUMAN ELEMENT AND 30 50% LOSS DUE TO EVAPORATION AND WIND A FIGURE OF 1.5 INCHES OF PRECIPITATION PER WEEK IS AN AVERAGE EXPERIENCE RATING

$1 629 X 1.5 = $2,444 PER YEAR

WATER COST - QUICK COUPLERS (DAY TIME OPERATION)

DUE TO INCREASED HANDLING AND ADJUSTING OF SPRINKLERS PLUS THE NEED FOR TIMING EACH INDIVIDUAL SPRINKLERS WATER USE WILL INCREASE AT LEAST 20% OVER A MANUAL SYSTEM.

$2 444 X 1.2 = $2.933 PER YEAR

WATER - COST - HOSE SYSTEM (DAY TIME WATERING)

DUE TO THE DIFFICULTY IN MEASURING THE AMOUNT OF WATER APPLIED THE LACK OF UNIFORMITY IN SPRINKLER SETTINGS AND THE HUMAN ELEMENT IN TIMING EACH INDIVIDUAL SPRINKLER WATER CONSUMPTION AVERAGES 20% MORE THAN WITH A QUICK COUPLING SYSTEM

$2 933 X 1.2 = $3.520 PER YEAR

LABOR COST - AUTOMATIC

AN AUTOMATIC SYSTEM REQUIRES NO LABOR FOR OPERATION THE SYSTEM WILL BE TURNED ON AT THE BEGINNING OF THE SEASON AND OFF AT THE END. IT MAY ALSO BE DESIRABLE TO TURN IT OFF DURING PERIODS OF EXCESSIVE RAIN. LABOR SO SPENT IN FLIPPING A SWITCH COULD NOT CONCIEVABLY COST MORE THAN $30.00 PER YEAR

LABOR COST - MANUAL

TEN ACRES OF TURF WILL REQUIRE BETWEEN 180 AND 200 ROTARY SPRINKLERS. AT 9 TO 10 HEADS PER VALVE, 20 VALVES ARE REQUIRED. TIME REQUIRED FOR COMPLETE OPERATION OF THE SYSTEM WEEKLY WOULD BE 4 HR. PER VALVE X 20 VALVES = 80 HOURS / WEEK

80 HOURS/WEEK X 24 WEEKS = 1920 HOURS/YEAR
ASSUMING THAT 50% OF THIS TIME CAN BE USED ON OTHER WORK
1920 HRS. X .5 = 960 HRS. @$1.60 = $1.536/ YEAR.

LABOR COST - QUICK COUPLERS

QUICK COUPLER SYSTEMS REQUIRE A GREAT AMOUNT OF HAND LABOR. A VERY CONSERVATIVE ESTIMATE IS AN INCREASE OF 35% OVER THE COST OF OPERATING A MANUAL SYSTEM

$1 536 X 1.35 = $2 073

LABOR COST - HOSES

THE HANDLING SETTING MOVING AND TIMING OF SPRINKLERS AND HOSES IN MOST CASES BECOMES A FULL TIME JOB FOR ONE MAN WHENEVER SEVERAL ACRES ARE INVOLVED TO BE CONSERVATIVE LABOR COSTS MAY BE ESTIMATED AT AN INCREASE OF 50% OVER THE COST OF OPERATION OF A QUICK COUPLER SYSTEM

$2 073 X 1.5 = $3 110

COST DETERMINING TABLE - ACRE AREA

	INSTALLATION COST	WATER COST PER YEAR	LABOR COST PER YEAR	TOTAL ACCRUED AFTER 3 YEARS	COST PER YEAR 30 YEAR LIFE AMORTIZATION	SAVINGS PER YEAR AUTOMATIC OVER OTHERS

COST ANALYSIS

WATER COST - AUTOMATIC (NIGHT TIME WATERING)

___" OF WATER /WEEK X ___WEEKS = ___" PER YEAR
___" ÷ 12 = ___FEET X ___ACRES = ACRE FT./ YR.
____ ACRE FT/ YR. X 43,560 SQ. FT. /ACRE = ______CUBIC FT. / YR.

__________ CUBIC FT. @ $ _____/100 CU FT. = $ ______ PER YEAR
OR

__________CUBIC FT. X 7.48 GAL./ CU. FT. = _______ GAL /YR.
__________GAL/YR X $ ________ /1000 GAL = ____________ PER YR.

WATER COST - MANUAL (DAY TIME OPERATION)

$ ________ X 1.5 = $ __________ PER YEAR

WATER COST - QUICK COUPLER (DAY TIME OPERATION)

$ ________ X 1.2 = $ __________ PER YEAR

WATER COST - HOSES (DAY TIME OPERATION)

$ ________ X 1.2 = $ ______ PER YEAR

LABOR COST - AUTOMATIC

$ __________ PER YEAR

LABOR COST - MANUAL (APPROX. 2 VALVES / ACRE)

2 VALVES X ___ ACRES = _______VALVES X ______ HRS. / VALVE / WEEK = ______ HRS / WEEK
_______ HRS. / WK. X _____ WKS. = ___HRS/ YR. _____ (PERCENT OF TIME ACTUALLY USED IN WATERING) =
_________ HRS. CHARGED TO WATERING ALONE.
HRS. X $___ PER HOUR = $ ______________ PER HOUR

LABOR COST - QUICK COUPLER

$ ______ X 1.5 = $ ______ PER YEAR

LABOR COST - HOSE

$ __________ X 1.5 = $ _______ PER YEAR

CRABGRASS AND GOOSEGRASS PREVENTION - 1966

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Wide choice is available for pre-emergence control of annual grasses. Numerous formulations of each chemical may be available. Turf Managers should decide on the extent of the program to be afforded. Then, choose the preferred chemical for either single or multi-purpose needs.

For further information see Midwest Turf Leaflet No. 29. Always read and follow the label directions. Normally treat for crabgrass, then as goosegrass is expected re-treat at one-third normal rate in addition.

Chemical	Active ingredient 1,000 sq.ft. lbs.	Active ingredient 1 acre lbs.	Residual %	Apply next season %	Comments
Calcium arsenate	3	120	75	25	Toxic to *Poa annua*, grubs
Lead arsenate	5	150	80	20	Toxic to *Poa annua*, grubs
Zytron	.3	15	50	50	May prevent knotweed
Benefin	.04	1.5	0	full	Good on goosegrass
Bandane	1.0	40	50	half	Replacing chlordane
Chlordane	2.0	80	50	half	Grub control also
Betasan	.3	10	0	full	Bentgrass is very tolerant
Tupersan	.2	9	0	full	Bluegrass seedlings are tolerant
Dacthal	.3	10	0	full	Bentgrass is quite tolerant
Azak	.3	10	0	full	-

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