UNIVERSITY OF ILLINOIS
DIVISION OF UNIVERSITY EXTENSION

8th

TURFGRASS CONFERENCE

PROCEEDINGS

College of Law
Auditorium

December 7-8,1967

arranged and conducted by the

COLLEGE OF AGRICULTURE

with the cooperation of the

ILLINOIS TURFGRASS FOUNDATION

This conference is presented specifically for persons interested in turf management by the University of Illinois College of Agriculture. Abstracts in this manual bring to you up-to-date information required by those who wish to maintain high quality turf-grass area but do not constitute positive recommendations unless so stated. Statements made herein are the responsibility of either the speaker or the institution he represents.

University of Illinois
Division of University Extension

Announces the

EIGHTH ILLINOIS TURFGRASS CONFERENCE

December 7 and 8, 1967
Auditorium, Law Building
Urbana, Illinois

arranged and conducted by the College of Agriculture

with the cooperation of the Illinois Turfgrass Foundation

PROGRAM

Thursday, December 7

9:00-11:30 a.m.	Registration
10:00-11.30 a.m.	DISEASE SYMPOSIUM M. P. Britton--Fungi and how they infect C. Hodges--How do fungi cause disease D. Powell--How good is a fungicide
11:30-11:45 a.m.	Illinois Turfgrass Foundation Business Meeting John Coghill, President

Thursday, December 7---First Session

Moderator--J. Coghill, Orland Park, Illinois

1:15-1:20 p.m.	Welcome--O. G. Bentley, Dean College of Agriculture
1:20-1:50 p.m.	The stripe smut problem in turf C. Hodges Iowa State University M. P. Britton University of Illinois
1:50-2:10 p.m.	Weed Control in Turf--1967 H. J. Hopen and J. D. Butler University of Illinois
2:10-2:55 p.m.	Possibilities for Minimum Maintenance Turf R. W. Schery Lawn Institute, Marysville, Ohio
2:55-3:10 p.m.	Break

Moderator--R. Short, Peoria, Illinois

3:10-3:30 p.m.	A look at the creeping bentgrasses J. D. Butler University of Illinois
3:30-4:15 p.m.	Weed control in sod fields R. Newman University of Wisconsin
4:15-4:35 p.m.	Question and Answer Session C. F. Hodges, M. P. Britton, H. J. Hopen, R. W. Schery, J. D. Butler, and R. Newman
6:30 p.m.	Illinois Turf Foundation Banquet Urbana-Lincoln Hotel

Friday, December 8--Second Session

Moderator--C. Benck, Manhattan, Illinois

8:30-8:50 a.m.	Insects and Insecticides of Turf R. Randell University of Illinois
8:50-9:20 a.m.	Planning and Keeping a Small Nursery M. C. Carbonneau University of Illinois
9:20-9:50 a.m.	Newly Watered Fairways--Improving--Budgeting J. L. Holmes U.S.G.A. Midwest Agronomist
9:50-10:05 a.m.	Break

Moderator--T. Guttschow, Springfield, Illinois

10:05-10:25 a.m.	Factors affecting irrigation practices C. J. W. Drablos & W. R. Oschwald University of Illinois
10:25-11:10 a.m.	Importance of guttation fluid on turf diseases M. J. Healy Dow Chemical Company, Midland, Michigan M. P. Britton University of Illinois
11:10-11:30 a.m.	Question and Answer Session R. Randell, M. C. Carbonneau, J. L. Holmes, C. J. W. Drablos, W. R. Oschwald, & M. J. Healy
11:30-11:35 am.	Wrap-up and adjourn

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THE STRIPE SMUT PROBLEM IN MERION BLUEGRASS

Clinton F. Hodges and
M. P. Britton

The disease of Merion Bluegrass commonly known as stripe smut appears to be on the increase in Illinois and other midwestern states. Numerous investigators (1, 3, 9, 11, 12, 13) have reported infection of grass seedlings through their coleoptiles, and embryo infection has been reported in two grasses (4, 10), but later shown to be rather unimportant (3). Rhizome infection has been suspected, but never established (9).

Field observations indicate that the number of stripe smutted plants increases gradually over a period of years (5), with smutted plants being very difficult to find in one-year-old turf. This seems contrary to what one would expect to find if the coleoptile were the only site of infection. It has been proposed that the perennial nature of stripe smut in the crowns of infected plants is responsible for the gradual increase of smutted plants by infecting new tillers and rhizomes (10). However, it is well established that smutted plants are readily killed by high temperature and drough (2, 4, 6, 7, 8, 9). Therefore, perennial development may not account for the total increase in the number of diseased plants. On the basis of these conflicting observations, an investigation was initiated to determine if in addition to the coleoptile, other parts of the Merion variety of Kentucky bluegrass could be infected by stripe smut.

With few exceptions smut organisms are known to infect only meristematic tissues. On the basis of this characteristic an experiment was initiated to distinguish between a known site of infection, the coleoptile, and a suspected site of infection, the axillary crown buds, from which tillers and rhizomes are produced. The experiment consisted of the following treatments. Treatment 1. One thousand unsterilized Merion bluegrass seeds were placed in 200 one-inch plastic soda straws (five seeds/straw) in two flats of steamed soil (100 straws/flat). This treatment served as a control for seed-borne stripe smut. Treatment 2. Same as treatment one, but with sterilized seed. This treatment had a dual purpose. First, in the event that seed-borne stripe smut should appear in treatment one, it would function as a control for the sterilant. Second, any marked difference in germination between sterilized and unsterilized seed could be noted. Treatment 3. Same as treatment two, but with the addition of teliospores at the time of seeding. This treatment was designed to have spores present in the soil at the time of coleoptile production. Treatment 4. Same as treatment three, but with the addition of teliospores 40 days after seeding, or at the four-leaf stage. At 40 days after seeding the coleoptile has been replaced by true leaves, removing the only known site of infection, and leaving the axillary crown buds as the only meristematic structures with which the teliospores could come into contact. The plastic soda straws were used because they provided a satisfactory means of concentrating large numbers of teliospores in a small area, assuring plantspore contact.

No seed-borne stripe smut was observed in treatment 1, and there was no marked difference in germination between treatments 1 and 2. Treatment 3 revealed two distinct types of stripe smut infection on the basis of symptom development. The first type was coleoptile infection and was characterized by every leaf and rhizome of the primary crown (the crown which results from a germinating seed) being smutted. Plants displaying these symptoms were observed 34 to 36 days after seeding and ceased to appear 74 to 79 days after seeding. The second type was referred to as axillary crown bud infection and was characterized by one or more smutted rhizomes arising from an unsmutted primary crown. These smutted rhizomes appeared 61 to 75 days after seeding, or at approximately the same time coleoptile infected plants ceased to appear. Plants displaying this type of symptom development continued to appear for a period of over 5 months. Although the results of this treatment strongly indicate that axillary crown buds are infected there still exists the possibility that these plants may have been coleoptile infected, after which the fungus may have gone dormant, with symptoms expressed at a later date in the developing rhizomes. This possibility was eliminated by the results of treatment 4. All of the infected plants resulting from this treatment displayed only smutted rhizomes. The primary crowns from which the smutted rhizomes developed were not smutted. The results of this treatment clearly establish the axillary crown buds as sites of infection.

The fact that axillary crown buds could be infected led us to suspect that the axillary buds located on the nodes of rhizomes might also represent potential infection sites. In a subsequent experiment lengths of rhizomes, each of which possessed one node bud, were placed in teliospore infested soil. Of the plants that developed from these buds, 12.8% were smutted, establishing these buds as infection sites.

The results of this investigation have confirmed that coleoptiles are infected and established axillary crown buds, and rhizome node buds as sites of infection.

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WEED CONTROL IN TURF--1967

J. D. Butler and H. J. Hopen

Today whenever weed control is discussed selective herbicides usually receive major consideration. Only in recent years have selective herbicides been widely used. Not many years ago, and many in the turf industry still remember when, iron sulfate at high rates was used as a selective control for dandelions in bluegrass turf. A little over 20 years ago, the synthesis and use of 2,4-D almost overnight revolutionized weed control. Today the many uses and limitations of this common herbicide are still not fully known, and work continues. In even more recent times the organic "crabgrass" control materials have drastically changed the approach to the control of many annual grasses.

Every year new herbicides are developed, and one or two may prove satisfactory for use on turf. Of course some of the "older" materials such as 2,4-D, 2,4,5-T, DCPA, etc. are quite evident in the turf picture and will probably remain there for a long time. Quite recently MCPP, dicamba, bromoxynil, bensulide, and siduron have become quite important in the turf industry. Undoubtedly these chemicals, because of their special adaptability to turf, will remain important for turf weed control for many years.

Certainly not all of the herbicides needed for turf weed control are available. Especially needed today are herbicides which will: control weeds that are resistant to present day herbicides, have a fine line of selectivity--even between varieties--with greater safety, have longer residual action, etc.

When discussing weed control today weeds are usually classified into three groups: broadleaf (usually not divided into annuals and perennials), annual grasses, and perennial grasses. These classifications point out the facts that: (1) basically plants within each group are similar morphologically, (2) similar herbicides are used to control each group.

Broadleaf Weeds

In Illinois there are about a dozen major broadleaf turf weeds. These may be divided into those relatively easy to control with 2,4-D (A), those where 2,4-D could be expected to give at best only fair control (B) -- within this group silvex, MCPP, and dicamba would be expected to be more effective herbicides than 2,4-D and those where 2,4-D would be only a poor control (C).

A	B	C
Dandelion	Common and Mouse-ear chickweed	Field and Hedge bindweed
Buckhorn and Rugel's plantian		Red sorrel
	Prostrate knotweed	
	White clover	
	Ground ivy	

Some data (Table 1) gathered at the University of Illinois in 1967 points out several factors which should be considered when using broadleaf control materials. Although this data was gathered while working with dandelions, which, despite 2,4-D, continues to be the most common broadleaf turf weed. The considerations for herbicide usage listed below would generally be applicable for broadleaf weed control.

Consider the following before applying broadleaf herbicides:
1. material(s) to be used,
2. rate of application, and
3. method of application (i.e. --note difference in Table 1 between emulsifiable liquid and granular 2,4-D).

Table 1. Dandelion control with several herbicides on Merion Kentucky bluegrass one month after treatment

MATERIAL	LB/A	TREATED 7-31-67 REP 1	2	3	4	TOTAL	RANK
Dicamba	1/2	5	1	0	1	7*	3
MCPP	1	68	20	26	44	158	12
2,4-D (amine)	1	6	3	1	2	12	4
2,4-D (ester)	1/2	5	2	4	6	17	5
2,4,5-TP (silvex)	1/2	14	21	13	17	65	9
MCPP + 2,4-D (amine)	1 + 1/2	18	5	1	11	35	8
Dicamba + 2,4-D (amine)	1/2 + 1	0	0	0	0	0	1
**2,4-D (ester) 2,4,5-T (ester)	+1 + 1/2	32	54	24	45	155	11
2,4,5-TP + MCPP	1/4 + 2	4	18	2	0	24	6
2,4,5-TP + Dicamba	1/4 + 1/4	2	0	1	0	3	2
Bromoxynil	1/2	50	28	34	52	164	13
**2,4-D + MCPP	1 3/4 + 1 3/4	78	62	64	68	272	15
**2,4-D + MCPP	3 1/2 + 3 1/2	34	35	37	23	129	10
**2,4-D + MCPP	7 + 7	4	16	3	7	30	7
Check	- - - -	64	61	41	81	247	14

* Number of plants in 100 ft^2 (4--25 ft^2 reps).

** Applied granular without pre-wetting foliage--others 5 gal. water/1000 ft^2.

Annual Grass Weeds

In Illinois only crabgrass (both species) and the foxtails are common annual grass weeds in turf. The preemergence "crabgrass" materials used on turf today work exceptionally well for their control. A few annual grasses, silver crab, lovegrass, etc., may persist even after the use of a preemergent herbicide that controls crabgrass and foxtail.

Table 2 gives some counts of crabgrass present in plots after using several preemergent herbicides at the University of Illinois in 1967. The preemergent crabgrass herbicides generally available and recommended have been sufficiently tested and proven through wide usage. Table 2 is included to call attention to several factors which should be considered before applying these preemergence herbicides.

Consideration and proper answers to the following questions are important in getting best results with the use of preemergence crabgrass herbicides.

1. Is the material for use on the grass to be treated?
2. When should the material be applied for best total results?
3. Is this material the one recommended?
4. Is the material formulated to suit the need?
5. How much should be applied per acre, etc.?

Table 2 Control of crabgrass with several pre-emergent herbicides.

Trade Name	Common Name	Lb/A	Applied 5-8-67 Rep 1	2	3	4	Total
Check		----	77	24	11	8	120[a]
*Treflan	trifluralin	1.5	1	0	0	0	1
*Betasan (Prefar)	bensulide	15	0	0	0	1	1
*Zytron	DMPA	15	0	2	8	0	10
*Balan	benefin	1.5	0	2	1	6	9
*TOK		8	0	12	6	1	19
**Tupersan	siduron	8	1	0	3	0	4
**Dacthal	DCPA	15	0	0	1	0	1
***Calcium arsenate	calcium arsenate	650	3	10	5	0	18

a Number of Crabgrass Plants per 100 ft^2 (4--25 ft^2 reps)
* Liquid concentrate
** Wettable powder
*** Granular

Postemergence "crabgrass" materials are frequently used under less than desirabl conditions. Number and timing of applications, temperature, maturity of weeds, etc. determines the control obtained with these materials. DSMA, AMA, and other organic arsenicals have generally given satisfactory control in Kentucky bluegrass turf. PMA at light (fungicidal) rates has given good postemergence control of crabgrass in bent grass turf.

Perennial Grass Weeds

Certainly the most pressing weed control problems today occur with the perennial grasses. Bentgrass, tall fescue, quackgrass, nimblewill, redtop, Bermudagrass, and Zoysia constitute major weed problems in Illinois. Successful mechanical control (stripping of sod, dry fallowing, etc.) is often difficult to achieve due to the growth habits of these grasses. The use of non-selective herbicides (including fumigants) have received a lot of attention for control of these weeds; however, they have not always proven successful.

More attention should be given to keeping these weeds from coming in as contaminants in grass seed, soil, etc. More care should be taken in destroying these weeds in areas to be established in turf.

MINIMUM MAINTENANCE TURF

Robert W. Schery
The Lawn Institute

"Minimum maintenance" varies with circumstance. For the golf course superintendent it is probably at a higher level than for the home owner, and with the home owner at a higher level than with the roadside landscaper. Also, some facets of maintenance weigh more heavily than do others, depending upon the turf. Low and slower growing grasses which require less frequent mowing may afford "minimum maintenance" even though their fertility and thatch-control requirements may be high. Winter-seeding a golf green with fine-textured species may be preferable to ryegrass, or fine fescues to tall fescue in the better highway medians. Or expenditure of effort at a season when time is available might constitute "minimum maintenance", while at another season not; in southern Illinois, where either bluegrass or bermuda is possible, the choice well might be bluegrass because attentions in automn rather than summer suit its growing cycle. Even natural conditions have a determining influence. The soils in most of Illinois, even with little supplementary attention, are "luxurious" compared to those of southern Missouri or southeastern Indiana and Ohio.

Thus, I believe we must regard "minimum maintenance", not as ignoring the planting, but in terms of a reasonable savings of time and effort for the particular circumstances. "Minimum maintenance" would not seem to demand seeding a new turf without fertilization (or lime if the soil required it), for example. It is only sound economics to supply a soil reserve of necessary minerals (especially phosphorus) at the time of seeding, when the planting costs far overshadow the slight additional charge for fertilizer; yet that fertilization can do much to guarantee the perpetuation of the planting, and thereby is a saving rather than an expenditure. On the other hand, "minimum maintenance" would let the clippings lie, recycling nutrients which can be the equivalent of a fertilization or two annually. What "minimum maintenance" boils down to is common-sense lawn tending, at a level sufficient to maintain thriving even if not the most luxuriant turf. With well-adapted varieties, minimum needs are not exorbitant. Considerate mowing, occasional timely fertilization, and perhaps a modicum of weed control are the main requirements.

MOWING - Mowing height varies with the grass, which for Illinois will most often be Kentucky bluegrass or fine fescue (or combinations of these species). Tests have repeatedly shown for bluegrass lawns that relatively high mowing has many maintenance advantages. Grass mowed at two inches generally shows only about one-tenth as many weeds as that mowed at one inch. Moreover, taller grass "shakes off" disease, is deeper rooted, and recovers from injury more readily. Unless some of the newer varieties adapted to low mowing are planted, such as Fylking, a mowing height of between 1-1/2 and 3 inches would be suggested for Illinois, the taller range where conditions are more difficult (such as in the southern part of the state during summer). In general, rotary mowers are better suited to high mowing with bluegrass turfs than are reels, contributing versatility and economy to mowing maintenance.

FERTILIZATION - Heavy fertilization (especially nitrogen) brings rewards in color and density, but hazards of greater disease incidence, thatch buildup, etc. Even "Minimum maintenance" turf should not be without fertilization, though this might be restricted to only one or two applications a year, each of about one lb. N/M Requirements vary from soil to soil, but in general a balanced fertilizer high in nitrogen is suggested, and autumn applications are emphasized. The fine fescues, noted shadegrasses are well adapted to infertile soils, often surviving with nothing more than a seedbed fertilization. But even natural Kentucky bluegrass or the less luxurious varieties persist with little fertilization, and on reasonably good soils soon dominate the plant population. Quite frequently the well-fertilized turf succumbs to disease, while a less-fertilized one persists.

WEEDING - Standards for acceptable turf have so risen in recent decades, that even "minimum maintenance" lawns must not be weed patches. Highway experience has shown that the public tolerates weeds similar in appearance to the grass. Thus, crabgrass and other weed grasses are overlooked (unless they become coarse clumps with a differential growth pattern), but coarse broadleaf weeds (Dicotyledons) are objectionable if contrasting with the grass (especially things like milkweeds, Silphium and "brushy" types. Fortunately spraying with non-volatile 2, 4-D formulations is widely accepted, reasonably fast and economical with modern apparatus One would recommend for "minimum maintenance" turf a 2,4-D spraying from time to time after the planting is well established.

OTHER MAINTENANCE - Irrigation, thatch removal, disease prevention, insect control, etc., add luster to a turf, but they are seldom practical for minimum maintenance lawns. The local situation will have to determine which, if any of these, is demanded. Fortunately, well-adapted varieties of such species as Kentucky bluegrass and fine fescues are self-reliant, and require little pampering.

Most turf is more self-reliant than one would suppose from listening to the dos and don'ts at a turf conference, where attention is mostly directed to professionally-managed, high quality turf. Much of the public is willing to sacrifice a bit of luster for convenience and economy. If someone does want a golf green, or a lawn like a golf green, he must expect to pay the added effort, cost, and risk of hazards.

A Few Grass Possibilities for Minimum Maintenance

KENTUCKY BLUEGRASSES - Genetically mixed populations such as natural, Kenblue, Arboretum, Park, Nudwarf, etc.; selections such as Fylking, Delta, Prato, etc., may turn out to be of lower maintenance.

CANADA BLUEGRASS - Seed supplies uncertain, and usually Kentucky bluegrass preferred.

FINE or RED RESCUES - All varieties, including well-known Chewings, Illahee, Pennlawn, Rainier; and newer releases such as Highlight, Ruby, Golfrood and Oasis.

BENTGRASSES - Field-evolved colonial types such as Highland; Redtop where eventual coarseness is acceptable.

TALL RESCUES - Kentucky-31 and other varieties for hot locations and where coarseness is not too objectionable; mainly in the Upper South.

LEGUMES - Clover is often a good companion for bluegrass, contributing N; alfalfa as "starter" in blends; Korean lespedeza for temporary summer cover, non-competitive; vetches where acceptable (can't stand 2,4-D).

A LOOK AT THE CREEPING BENTGRASSES

J. D. Butler

In the northern United States there is no grass more widely praised nor strongly criticized than creeping bentgrass. In the cool humid regions of the U.S., the bentgrasses would rate just behind the bluegrasses in importance as turfgrasses. Creeping bentgrass certainly deserves close scrutiny, for indeed this grass is of primary concern to the golf course superintendent.

In the U.S., four introduced species of Agrostis (bentgrass) are used as cultivated turf. The very fine-textured velvet bentgrass (A. canina L.) is found in the Northeast over a rather limited range. Redtop (A. alba L.) is a rather coarse, open growing grass used for pasture, erosion control on poor soil, and as a "nurse" grass for other fine turf grasses. Colonial (A. tenuis Sibth.) and creeping bentgrass (A. palustris Huds.) have proven themselves for use on golf courses, home lawns etc. The growth habits and general appearance of the colonial and creeping bents may be quite similar. Visible vegetative differences of strains within these two species today seem to be as great as the difference between the species.

Use.

The high maintenance required for creeping bentgrass to look well has limited its use on home lawns. Without the technical ability, equipment, etc. necessary to keep creeping bentgrass at its finest, other grasses will be substituted by the homeowner. Creeping bentgrass maintained with Kentucky bluegrass will do poorly--green up too late in the spring, disease more readily, scalp, etc. The creeping bentgrasses are found primarily on golf greens, with more limited use on tees, fairways, estates, etc.

Range.

Creeping bentgrass extends well into Canada and the deep South. Diseases have been a limiting factor in the southern extension of the creeping bents. With more effective nematocides and fungicides, the creeping bents can be expected to increase in the South. The selection of strains adapted for growth in colder, warmer, and more xerophytic regions will further increase the range of this grass.

The Plant.

Creeping bentgrass typifies a stoloniferous (runner) plant that only rarely has a rhizomatous growth habit similar to that of Kentucky bluegrass. This growth habit contributes to the many problems such as thatching, scalping, recovery from chemical injury, etc. associated with this grass. The prostrate stems of this grass are fine textured (rarely over 1 mm in diameter) with long equi-length internodes. The leaves, which number as many as 700 per square inch, are characterized by pointed tips, prominent veins (for the size of the leaf), prominent ligules and rather inconspicuous midribs. The leaves of the bentgrass are more succulent than those of most other grasses. This characteristic is important from a standpoint of drought tolerance and pesticide injury. Bud formation and rooting at the nodes (joints) are valuable turf qualities of this grass. As the fiberous roots develop along the stolons they will knit the turf to the soil (promoted by topdressing) and provide a firm, fast turf. Pruning the turf (scalping, thinning, or mowing) will promote stem development at the nodes.

Propagation.

Creeping bents are propagated either by seed, or vegetatively (stolons, sod pieces, etc.). Two varieties, Penncross and Seaside, are grown primarily from seed, while others such as Toronto (C-15), Cohansey (C-7) and Arlington (C-1) are stolonized. The progeny from seeded bents are quite variable and may present a patchwork appearance. With vegetative propagation the resulting turf should be perfectly uniform. However, in order to have uniformity the bentgrass must not be allowed to seed, nor any off types allowed in the nursery.

The creeping bents are seeded at 1 pound per 1000 square feet. As there are 6-8,000,000 seed per pound this allows 40-50 or more seed per square inch. With proper care and warm weather the bent seedlings will be up in 5-7 days. The usual rate of spreading stolons is 8-10 bushels per 1000 square feet. Certainly adequate plant populations are provided at these rates of establishment. Post-planting care is especially important in getting a playable putting surface. With optimum care only a very few months (as little as 3-4) of warm weather are required to get a putting green.

Strains.

In most cases a strain of creeping bentgrass is used because of: availability, personal preference (often through experience), general usage and acceptance in the area, and/or recommendations of other turf people.

Several individual traits--texture, color, vigor, temperature effects on color loss, thatching, disease tolerance, shade tolerance, etc., etc., etc. -- may be considered in choosing a creeping bentgrass. On golf greens fungicides are widely used--thus thatching, coarse texture, color, etc. may be considered more important than disease susceptibility. Not all of the desirable characteristics are to be found in any one strain. The strains widely available today have stood the test of time and have proven successful. Extensive testing of a new strain is necessary before giving it wide usage. No more than 6 or 8 strains of creeping bentgrass are being used to any extent in Illinois today. It should be noted that certain vegetative materials sold under the same or different names may not necessarily be the same. This is not new as North and Oldland in 1934 noted "Flossmore is probably identical with Washington." They also reported with Seaside "differences among lots of seed with regard to the quality of turf." Also strains perform and look quite differently under different management practices and at different locations. The variables mentioned have helped to produce some widely diverse opinions concerning different strains. In fact, when reading and talking with others about a given strain one often wonders if he is thinking of the same grass.

Below is a rather broad generalization for the most common creeping bentgrass strains found in Illinois. These strains have been used rather widely and have, in most cases, proven satisfactory for use on greens.

Seaside is not used much today for greens, although it is common on older greens in Illinois, but finds common usage on fairways and tees. It forms a turf that is not as dense as most other strains with a tendency toward being grainy and patchy (plant variability). It is quite susceptible to dollar spot, leaf spot, and certain other common turf diseases.

Penncross is used widely for greens with some usage for tees, fairways, etc. This grass forms a dense, relatively fine, vigorous turf. Although this bent is usually established by seeding, the resulting turf is rather uniform. Penncross has a fair to good general disease resistance; however, stripe smut may present a problem.

Toronto (C-15) is a vigorous, dark yellowish green grass, and appears today to be the most widely used vegetative propagated grass in northern and central Illinois. It has done especially well under high management levels.

Washington (C-50) forms a dark green, medium textured turf with fairly good disease resistance. This grass is found on many of the older golf courses and is still in fairly common usage.

Cohansey (C-7) is a light green, aggressive bent which has consistently been ranked at or near the top in comparative bent tests. However, it has not been very widely used--probably because of its color.

Old Orchard (C-52) is a dark green, moderate textured grass that has performed well in Illinois.

Arlington (C-1) and Congressional (C-19) are dark green, moderately textured bents. C-1 and C-19 are frequently mixed to form a good turf. This mixture has performed very well in southern Illinois.

Pennlu is a moderate textured, strong bluish green bent selected for vigor, disease resistance, etc.; however, stripe smut may be a problem.

Other varieties such as Evansville, Twin Orchards, Springfield, etc. are of interest; however, they are not within the scope of this paper.

Maintenance.

The maintenance requirements of creeping bentgrass under greens conditions are quite unique. Greens maintenance is one of the most intensive forms of agriculture. Maintenance practices, although general in nature, are certainly not standardized.

The mesophytic creeping bents under greens conditions require rather large amounts of water. During hot, dry periods as much as 3-5 inches of water may be used weekly to irrigate golf greens. Where the turf is kept higher (tees, fairways, etc.) less water will be needed.

Fertility requirements of the creeping bents have not been fully investigated. Generally 8-12 pounds of nitrogen per 1000 square feet are considered adequate for greens, with less needed for taller turf. Need for the other essential elements is not to be neglected. Consider, as with water requirements, that frequently grass is grown under a hydroponic system and fertility programs must be adjusted to take care of such situations.

Tolerance to low mowing has been the reason for creeping bent being considered the greens grass. Within limits, the higher a grass is kept the easier it is to maintain. Frequent mowing of growing grass is a must when the grass is kept low. For greens, bent is usually maintained at around 1/4 inch.

Diseases are a constant problem with creeping bents. The multitude of diseases which infect these bents, plus the environmental conditions under which the bents are grown, greatly magnify this problem. Preventative fungicidal programs are commonplace on bent greens.

Thatch and insect control, aerification, etc. are other maintenance considerations associated with creeping bentgrass.

The time limitation has not allowed as thorough an examination of the bents as should be made. A thorough understanding of the creeping bents should make our job easier and more enjoyable.

WEED CONTROL IN NURSERY SOD

Robert Newman
University of Wisconsin

Wisconsin's 8000+ acres of nursery sod are produced on both muck and mineral soils. The largest acreage is on muck soils. The smallest acreage is on mineral soil and is generally in the hands of landscape contractors or used for local market purposes. Our largest concentration of nursery sod is in the Wind Lake marsh area located 65 miles north of Chicago in Racine County.

Weed problems in most nursery sod cannot be considered serious in Wisconsin at this time, however there are exceptions. Weed problems are brought to our attention from time to time by sodgrowers, landscapers and the public. Grasses such as quackgrass, annual bluegrass, bentgrasses and various coarse grasses present the most serious weed problems; while in the broadleaf category common chickweed is troublesome along with white clover, biennial thistles and a scattering of others. Rough pigweed, lambsquarter and purslane appear during the seeding year but are eliminated by the first few frosts.

We know from past experience that weed infestations can become serious in a "one crop" farming system. Present day herbicides give us a very effective method of dealing with most weed problems, but we should give equal attention to the non-chemical aspect of prevention of weed invasion and halting the spread of existing weeds.

A weedy sod field is of little or no value to the grower, and sooner or later he must bear the expense of weed control if he expects to remain in business.

The source of weeds is hardly any secret.

1. Muck soil is notoriously good for the preservation of weed seeds from previous years. White clover is more of a problem on mineral soils, especially if they are spring seeded. Quackgrass has an amazing ability to spread vegetatively by rhizome growth. The rhizome pieces are easily dragged around with the quackdigger or springtooth harrow. Bentgrass is just as easily spread as stolons are dragged from place to place.

2. Wind and water carry weed seed into the often low lying sod fields from unattended canal banks, fence rows, windbreaks, and neighboring weed infested fields. Thistle and dandelion seed arrives via air from waste places. We have small sod operations in the state that are on former low land pasture soil. The surrounding area often remains as pasture land where redtop and reed canarygrass seeds profusely and the seed moves into the sod field by wind and water.

   Redtop, nimblewill, quackgrass, bromegrass and reed canarygrass are found on canal banks. Common chickweed is often found within the shade line of willow windbreaks. As Merion becomes infested with powdery mildew in fall common chickweed begins to take over in these areas.

3. Growers plant a few weeds that come in their bluegrass seed. According to the recent report by Dr. Robert Schery, Director of the Lawn Institute, 20% of 777 lots of Kentucky bluegrass seed analyzed by professional seed

technologists contained annual bluegrass. Cool, moist muck provides an ideal environment where this pest prospers and reproduces. Bentgrass seed was found in 8% of the 777 lots of Kentucky bluegrass seed checked. Several Agrostis species are common to muck soils. Current seed laws and regulations that permit these pests in seed lots as crop seed are hardly the protection sod growers need.

There is a distinct difference in the weed number and damage in spring and late summer seedings of sod crops. With a spring seeding clover, annual grasses such as barnyardgrass and fall panicum are present in sufficiently large numbers and sizes so as to impair sod quality. Late summer seedings take advantage of frost to kill many annual weeds before they reach the size where they impair quality and before they mature to produce seed. Spring seedings don't have the advantage of nature's free annual weed control -- FROST.

Winter annuals of the mustard family do some damage to summer seedings due to their prostrate, rosette type growth habit.

Certain practices are being followed or can be followed which will help to eliminate and prevent further weed infestations:

1. Selection of fields
   a) Cleanest possible from standpoint of weed not controllable with selective herbicides such as the perennial grasses like quackgrass.
   b) If possible, avoid areas adjacent to or that drain from neighboring weed fields you have no control over.
   c) Select a field which is not subject to surface flooding. Surface flooding is a prime source of weed seeds.
   d) Select a field which is or can be well drained.

2. Management of ditch banks, windbreaks, fence rows and waste places
   a) Remove unnecessary windbreaks.
   b) Do not allow the weeds in these areas to go to seed by either mowing or by the use of contact-type herbicides.
   c) Develop a fallow strip or barrier between weed infested areas and the sod field.
   d) Grade down ditch banks and sow to Kentucky bluegrass.

3. Elimination of perennial grasses before sowing by:
   a) In extreme cases a two-year program including the use of atrazine, fallowing and an atrazine-tolerant cover crop such as sudangrass is necessary to eradicate perennial grasses.
   b) Short residue herbicides such as amitrol in combination with fallowing in July and early August are sometimes successful.
   c) Long time fallowing gives good control.

4. Check for all undesirable seeds present in the bluegrass seed sown
   a) Annual bluegrass and bentgrass may be present under " other crop" seed -- this information is available from the seed analyst.
   b) Used high bushel weight seed with good germination.

5. Seed in late summer
   a) Germination and establishment are more rapid than with spring seedings.
   b) Annual weeds will provide protection against wind erosion and will be killed by frost before going to seed or becoming too competitive.

c) Crabgrass will not be the problem that it usually is on mineral soils.

6. Provide adequate fertility for optimum growth

7. Use selective herbicides for broadleaf weed control
   a) Apply in spring when broadleaf weeds are small but growing actively.
   b) The combination of 2,4-D and dicamba eliminates a broad spectrum of broadlwaf weeds.

8. Spot treat perennial grasses
   a) Treat with amitrol when perennial grasses appear. Perennial grasses are most vulnerable to amitrol during their early stages of growth and will only spread if left unchecked.
   b) Repeat spot treatments will usually be necessary if the area can't be cultivated within several weeks.

9. Don't allow weeds to become established in the cut areas, cultivate the area.

10. Education of sod users

Nursery sod producers are often being unjustly blammed for weedy turf. The consumer must be informed that weed control is his job also. Too much or too little water and/or fertilizer along with close clipping contribute to weed problems.

Landscapers contribute their share to this problem when top soil isn't added to subsoil or fill, when soil structure is destroyed, and when extreme compaction before laying sod results from their activities.

TURF INSECTS AND INSECTICIDES

Roscoe Randell

Sod webworms were not a serious problem during the past year. There were the usual number of reports of other insects such as cutworms, leafhoppers, etc. As new insecticides are being developed and labeled, their effectiveness is often evaluated in comparison to other new ones or established chemicals. Also, there is often some concern by the user of an insecticide as to its possible damage to a crop such as turf. Insecticides for control of turf insects should give a high degree of control and also not be damaging to the grass. During 1967, two projects were conducted in relation to insecticide use on turf insects.

Insecticide phytotoxicity: The first experiment was a phytotoxicity screening of various insecticides used on bentgrass at five times the recommended rate of application. Table 1 shows the various insecticides used on various strains of bentgrass and the rating of damage which occurred.

Rates as high as those used in this experiment are not normally used by home-owner or commercial people such as golf course superintendents, but it is very possible for such high rates to be used. Overlapping of spray swath or improper calibration of equipment may result in excessive rates of insecticide or any pesticide. Conclusions which were made on this experiment are as follows:

1. No phytotoxicity occurred when any of the chemicals were used, regardless of formulation, at the recommended rate.

2. Only emulsifiable concentrate formulations caused burning to the leaves of bentgrass, therefore, it was the insecticide carrier which probably caused leaf damage.

3. There were some differences in degree of damage between strains of bentgrass.

4. Although chemical burn was severe in 1 or 2 insecticide plots, all plots recovered.

5. Chemical burn, if present, occurred within a two-hour period after application.

In summary, all insecticides suggested for turf insect control are not phytotoxic when used at the recommended rate. All insecticides suggested by us for webworm control will give adequate control at the recommended rate. If you are in doubt about your own ability or that of your help to calibrate your sprayer, then we suggest you use either granular or wettable powder formulations.

Sod Webworm Insecticide Screening: These insecticide plots were established on bentgrass at the University of Illinois turf plots and at three other locations. We want to thank the superintendent at Edgewood Valley Country Club, Evanston Golf Course, Elmhurst Country Club, and Thorngate Country Club for cooperating in this work.

Ten insecticides were used in sod webworm control trials. In some instances there was more than one formulation used for a chemical. The chemicals were applied at the rate suggested on the label. All chemicals are either labeled for use on turf or will be labeled. All chemicals used have a low to moderate toxicity rating.

Sod webworm eggs were seeded on replicated plots at the rate of 5 eggs per square foot on June 21. All plots except check were treated with insecticides on July 21. Sampling of plots for effectiveness of control was done on July 31 to August 2.

Table 2 shows the chemical with the trade name in parenthesis, the amount of actual ingredient used per 1000 square feet and the number of larvae per square foot remaining 10 days after treatment.

All chemicals used gave effective control of sod webworms at the suggested rate. Carbaryl (Sevin), diazinon and trichlorfon (Dylox) have been the insecticides which were suggested for sod webworm control during 1967. These insecticides will remain on the suggested list for 1968.

TABLE 1. Phytotoxicity of various insecticide formulations to creeping bentgrass strains when applied at five times the suggested rate.

Insecticide and formulation	Active ingredient suggested for use per 10,000 sq. ft.	Strains of bentgrass and damage rating		
		Penncross	Toronto	Seaside
Diazinon 2%G	1 lb.	-	-	-
Diazinon 25% E.C.	1 lb.	0	0	0
Trichlorfon (Dylox) 5%G	20 oz.	-	-	-
Trichlorfon (Dylox) 50% W.P.	20 oz.	-	X	X
Fenthion (Baytex) 5%G	20 oz.	-	-	-
Fenthion (Baytex) 4 lb. E.C.	20 oz.	X	X	XX
Carbaryl (Sevin) 5%G	2 lbs.	-	-	-
Carbaryl (Sevin) 80% W.P.	2 lbs.	X	-	-
SD 8447 (Gardona) 75% W.P.	20 oz.	-	-	X
Durshan 2% E.C.	5 oz.	X	-	-
Ethion 4 lb. E.C.	2 lbs.	-	-	-

- No visible damage
X Slightly off color
XX Slight burn
0 Severe burn

TABLE 2 Comparative effectiveness of several insecticides for sod webworm control, Urbana, Illinois, 1967

Insecticide and formulation	Ounces actual ingredient per 1,000 sq. ft.	Average No. Larvae per Sq. Ft.
Ethion 4 lbs. E.C.	3	0
Trichlorfon (Dylox) 5%G	2	0
Trichlorfon (Dylox) 50% W.P.	2	0
Fenthion (Baytex) 5%G	2	0
Fenthion (Baytex) 4 lbs. E.C.	2	0
Durshan 2 lbs. E.C.	0.5	0
Diazinon 2%G	2	0
Diazinon 25% E.C.	2	0
Diazinon 50% W.P.	2	0
Carbaryl (Sevin) 5%G	3	0.12
Carbaryl (Sevin) 80% W.P.	3	0,12
SD 8447 (Gardona) 75% W.P.	2	0
Sarolex 4 lbs. E.C.	2	0
G. A. 445 25% W.P.	2	0
Mobam 50% W.P.	2	0
Check	-	1.50

RR:
11/6/67

PLANNING AND KEEPING A SMALL NURSERY

M. C. Carbonneau

There are several important points to consider when planning a small nursery for a golf course, park or recreation area.

It is most important to consider the purpose of having the nursery area in your over-all plan of operation. Nursery stock is available in quantity and variety today so this is usually not the problem. However, the problem can be having the material available when planting crews are ready to do their work. Many operators prefer to have plant materials on hand to make replacements for those that died.

In newly established or expanding operations it is often desirable to have a small nursery in order to have a supply of shade trees and evergreens available for use. The above are important reasons for having a "holding" or "finishing" nursery on a recreational or non-commercial operation.

It is important to point out that costs involved in producing landscape sized plant materials in small quantities is an expensive proposition. The quality of the plant material produced in many of these operations is not up to that which can be purchased. Commercial nurserymen are familiar with the special requirements necessary to produce the plants growing in their nursery. For this reason it is recommended that production costs and quality of plant material be considered before starting a "production" nursery.

It is possible, however, to purchase large liners or small sized planting stock for "growing-on" to a more desirable landscape size. This esentially is a "holding" or "finishing" nursery which can be a valuable asset. A nursery of this scope should be designed to provide plant material for expansion of facilities, replacements or for re-landscaping existing areas.

Land for use as a small nursery should be in good tilth, relatively high in organic matter and well drained. Attention should be given to weed populations on the land. If the area is infested with quackgrass, Canada thistle or bindweed, these should be eradicated before planting.

An ample supply of water is important for best growth of ornamental plants. The nursery should be incorporated into the irrigation program of a park or golf course. The water is especially necessary at planting time and for maximum growth during periods of extended drought.

The lay-out of the nursery is important for fast and efficient upkeep of the area. Blocks of one basic kind of plants (eg. evergreens, deciduous trees, etc.) should be incorporated in one area. The cultural reasons for this are as follows: spacing of the plants, cultivation, herbicide application, insecticide application and digging operations.

Proper spacing of the plant material cannot be stressed enough. The distance between the rows and between the plants in the rows is governed mainly by the desired size of the plants at harvest. The kind and size of equipment available for cultivating and spraying also has a bearing on the spacing. There should be plenty of room for the equipment to move in the rows so the operator will not damage the plants. The best recommendation to be given would be to over-space in a small nursery so that the men have plenty of room to operate their equipment.

Selection of material to be grown will certainly depend on the landscape or long-ranged plan developed for the area. Several varieties of shade trees, flowering trees and evergreens should probably be considered for the area. Be sure to know all of the pests associated with the plant material grown. If insects and diseases are known to be a problem on specific varieties avoid planting them or take the necessary measures to prevent damaging infestations. Prevention of infestations of insects and diseases will be necessary for success of the operation.

Weed control is one of the most pressing problems in the nursery industry today. We cannot as yet recommend any herbicide to effectively control weeds in all types of ornamentals (trees, deciduous shrubs and narrowleaf evergreens). Most narrowleaf evergreens are tolerant to low rates of application of simazine. Deciduous shrubs are less tolerant than evergreens to most of the herbicides on the market today.

Since applications of the materials available today are limited to special crops (we recommend that cultivation and hoeing be the main methods of weed control in a small nursery).

In summary, keep these points in mind when planning a small nursery.

1. Select large liners for "finishing" in the nursery.
2. Be sure to plant the material on well drained land.
3. Additional organic matter should be added to the soil by manuring or growing green manure or sod crops.
4. Have irrigation available for use at planting times and during dry spells.
5. Do not crowd the plants in the rows and allow space between the rows for ease of cultivation.
6. Plant only for your needs in the immediate future. Overgrown plants are expensive to maintain and expensive to move.
7. Remove blocks of plants at one time so you can keep a rotation in progress.
8. When the time comes to cease the nursery operation do not hesitate to do so. Planting without a plan can do more harm than good.

MCC:
11-15-67

INCREASES AND DECREASES FOLLOWING FAIRWAY WATERING

James L. Holmes
USGA Green Section
Mid-Western Agronomist

Numerous estimates have been made concerning the increase in golf course operational costs following the installation of a fairway watering system. However, no specific figures nor exacting data could be located by the author. Consequently, the following questionnaire was sent to 35 golf course superintendents in the north Midwest, and other Green Section agronomists were asked to submit questionnaires to superintendents who had recently installed watering systems.

WATERING QUESTIONNAIRE

1. Installation Cost
2. Annual cost for water
3. Cost for seeding or overseeding after installation
4. Cost for:
   a) Labor to operate the system
   b) Electricity or power
   c) Repair or replacement
5. Increased cost for:
   a) Weed control
   b) Fertilizer
   c) Insecticide
   d) Fungicide
   e) Mowing or grass cutting
   f) Drainage
   g) Labor for above
6. Increased damage to turf from carts and play
7. Extra equipment needed such as fairway verticutters, aerators, seeders, mowers and so forth
8. Wear and tear on mental and physical condition of the superintendent
9. Members' comments and opinions on improvement or damage to playing conditions

Seventeen replies were returned from superintendents in the Midwest, two from New England, and three from the West Coast prior to the time data was extracted. Since then, five other questionnaires have been received and checked. Information contained in these five almost exactly corresponded to the 22 used for extracting data. Therefore, it would seem that the information derived from the 22 returns is accurate.

The entire watering system was considered, which included greens and tees. So, cost estimates, especially for: 1) Labor to water, 2) Cost of installation, and 3) Cost for repair and replacement, are not for fairways alone and some adjustments are in order.

RESULTS AND COMMENTS

The information obtained from the questionnaire, with author's comments in small Roman numerals, is as follows:

1) Installation Cost

Manual system, average (17 clubs)	$ 65,000.00
Manual system, low	36,000.00
Manual system, high	90,000.00
Automatic system, average (5 clubs)	117,000.00
Automatic system, low	80,000.00
Automatic system, high	150,000.00

2) Annual Cost For Water

Average (7 clubs)	$ 3,985.00
Low	1,200.00
High	7,700.00

i. One club from Florida reported $12,000 cost for water. This figure was not used as this was the only report from this area. Other reports were from more northern sections of the United States.

3) Cost for Seeding or Overseeding After Installation

Average (9 clubs)	1,530.00
Low	500.00
High	2,400.00

i. Cost of Sod (not figured in annual increase as this should be on a one-time, pipe line scar repair basis).

Average (3 clubs)	3,170.00
Low	2,000.00
High	5,000.00

ii. One club reported $14,000.00 for seed and labor. Not figured in the average

iii. One club reported $1,000.00 per year for 3 years.

iv. In the author's experience, this must be considered a continuing expense as fairway turf either consists primarily of *Poa annua* or becomes *Poa annua* shortly after watering system installation.

4) Cost For:

A) Labor To Operate The System

Manual system, average (16 clubs)	2,900.00
Manual system, low	350.00
Manual system, high	6,500.00

Automatic labor operational cost, 4 clubs, each reporting $1,000.00 per year.

B) Electricity or power

Average (16 clubs)	$ 1,510.00
Low	250.00
High	2,500.00

One club reported $288.00 for natural gas. Not figured.

C) Repair or replacement

Annual Average (12 clubs)	440.00
Annual Low	100.00
Annual High	600.00

i. Five clubs reported no money spent for repair or replacement.

ii. One club reported $2,500.00 over estimate??? Not figured.

iii. One club reported $247.50 per year after third year.

iv. One club reported $15,600.00. (Must have been some faulty installation here - not figured.)

v. The question allowed no way to determine between manual and automatic systems, but experience indicates that repair and replacement cost for automatic is higher.

5) Increased Cost For:

A) Weed Control

Average (15 clubs)	877.00
Low	120.00
High	3,800.00

i. Three clubs anticipated less for weed control because of better turf.

ii. One club reported the use of 12 tons of calcium arsenate at 16¢, or $320.00 per ton, or $3,840.00. They further reported that this would be a continuing cost at between $1,500.00 and $2,000.00 per year for a number of years.

iii. Other increases in herbicide costs were primarily for broadleaf weed control.

B) Fertilizer

Average (16 clubs)	$ 1,370.00
Low	500.00
High	2,200.00

i. Perhaps the club reporting an increase of over $2,000.000 never fertilized before the installation of the watering system.

ii. One club reported a 30% increase in fertilizer cost, which should be just about right.

C) Insecticide

Average (4 clubs)	$ 485.00
Low	75.00
High	1,000.00

i. Eighteen clubs reported no change, but there has to be an increase as adult insects are known to search out lush, watered turf in which to lay eggs.

D) Fungicides

Average (11 clubs)	$ 1,120.00
Low	100.00
High	2,500.00

i. All clubs reporting no increase has bluegrass fairways and no transition to other turf planned. All clubs with Poa annua - bentgrass fairways reported the increased use of fungicides. The author's personal experience would indicate that the $1,120.00 average is somewhat low for this type of fairway turf.

E) Mowing Or Cutting Fairways

Average (18 clubs)	$ 900.00
Low	350.00
High	3,500.00

i. The increase of $3,500.00 must mean that these people never cut fairways before.

ii. No doubt, a shorter height of cut is demanded after watering; so, most cut more often to keep grass shorter, as well as the fact that watered turf grows better during periods of drought.

F) Drainage

Average (6 clubs)	$ 900.00
Low	100.00
High	2,000.00

i One club reported it necessary to install over $10,000.00 worth of tile which was not necessary when the watering system did not exist. Not figured.

ii. Others reported it necessary to purchase ditchers, considerable gravel, etc. Still others reported drainage a continuing problem as "wet" spots develop, especially following periods of prolonged drought. Apparently uneven water distribution causes development of wet spots when the system is used extensively. Slit trenches are constantly being installed. Even so, this drainage cost must be figured as a one-time proposition rather than on an annual basis. Arbitrarily, let's figure annual increase budget expenditure for drainage at $200.00 after installation of the watering system for a course located on heavy, non-draining soil.

G) Labor For All Items in Number 5

i. Impossible to arrive at any conclusions here. Most superintendents reporting indicated labor was included in itmes A, B, C, D, E and F above.

6) INCREASED DAMAGE TO TURF FROM CARTS AND PLAY

Nineteen superintendents reported that turf improved as a result of the fairway watering system rather than damage increasing.

Three superintendents, quoted below, reported increased damage as follows -- "Compaction and lack of drainage big problem" -- "Cart wear serious in wet spots, must increase cart paths" -- "Damage to turf double since system installed, cart fleet doubled, play increased". It would appear that increase in play and cart use is the prime problem here and not fairway watering.

7) EXTRA EQUIPMENT NEEDED SUCH AS FAIRWAY VERTICUTTERS, AERATORS, SEEDERS, MOWERS AND SO FORTH

Of the 22 questionnaires used, the following was purchased as a direct result of watering fairways:

13 - 7 gang fairway mowing machines
7 - aerotillers or slicers
5 - fairway spray machines
3 - seeders
5 - tractors
3 - triplex mowers
5 - fairway aerators

i. The kind or make of equipment purchased was not specified. Therefore, it is impossible to accurately estimate annual increase to budget for this item. But, it would seem conservative to estimate $500.00 per year for as long as the watering system is amortized.

8) WEAR AND TEAR ON MENTAL AND PHYSICAL CONDITION OF THE SUPERINTENDENT

The comments made by those who answered are of such an informative nature they are all quoted verbatum:

"Adds another responsibility. He must see that it is used and used properly."

"Plenty - labor hardest to control."

"Plenty - $10,000.00."

"Doubled."

"Considerable more concern since water is thought by many to provide perfect turf regardless of wear and tear on turf."

"Having a manual watering system and a labor problem, wear and tear on the superintendent has become, at times, almost unbearable."

"With no excuses, it has to be done and is usually overdone. It does cause considerable concern for the superintendent until system is completely automated; then concern is reduced considerably as superintendent is in full control."

"Terrific - o.k. - when every thing works fine, but brother when it doesn't. It would take about 12 years of electrical engineering to understand."

"More pressure - for you to determine how much water to use. More evening work - setting and checking clocks."

"The biggest problem I've had is that the controllers for automatic system have not worked and I've had to run it manually, far too many times."

"Since I was not here when the system was installed, I do not know from that standpoint; but the high percentage of Poa annua worries me."

"Amen. It never fails - it never rains until the watering is finished."

"They are building a new mental and health center here and I have already made my reservation."

"This new system has reduced the wear and tear on my mental and physical condition. It is a 100% improvement over what we had here."

"Pleasure of better course compensates for added personal wear and tear."

"I no longer have to look at sick, ratty-looking fairways in mid-summer. My mental and physical condition improved with the fairways."

"An automatic watering system is a great asset to any golf course, due to better control of watering turf, and enables the superintendent to do a better job because of complete control and dependability."

"We have a very well-engineered automatic system. Less strain on superintendent than with manual system."

"Less trouble from labor, more trouble from increased play."

9) MEMBERS' COMMENTS AND OPINIONS ON IMPROVEMENT OR DAMAGE TO PLAYING CONDITIONS

All comments were favorable. However, the degree of favorability varied. Such quotes as, "there always are a certian per cent of the membership who want no change", and "the course plays longer, thus certian of the members, expecially the older ones, occasionally make unfavorable comments", were included. But, for all intents and purposes, everyone seemed happy with fairway irrigation.

ITEMIZED SUMMARY

For complete summarization or annual cost increase as a result of fairway irrigation, the following seems to be in order:

1)	Amortize manual system, 30 years	$2,170.00 per year
	Amortize automatic system, 30 years	3,900.00 per year
2)	Annual cost for water. (This is for clubs which must purchase from municipality.)	3,985.00
3)	Average cost for overseeding. (This is considered by the author as an annual increase in budget in the north Midwest where bentgrass is cultured or attempts are made to culture.)	1,530.00
4)	Annual increased cost for:	
	Labor to operate manual system	2,900.00
	Labor to operate automatic system	1,000.00
	Electricity	1,510.00
	Repair or replacement	440.00
5)	Increased annual average cost for:	
	Weed control	877.00
	Fertilizer	1,370.00
	Insecticides	485.00
	Fungicides	1,120.00
	Mowing	900.00
	Improvement in drainage	200.00
6)	Amortize extra equipment (per year)	500.00
	Annual increase necessary in budget for manual system if water is purchased	17,987.00
	Annual increase necessary in budget for automatic system if water is purchased	17,817.00
	Manual, without purchase of water	14,000.00
	Automatic, without purchase of water	13,830.00

CONCLUSIONS

It is of note, from these questionnaires and the author's interpretation thereof, that annual increase in budget is somewhat greater for a manual system than for an automatic; though it must be remembered this does not take into account an automatic system may require greater expenditure in electricity and parts. Also, the annual increase in budget is somewhat greater than anticipated.

Occasionally, it is necessary to construct a large reservoir, in excess of 1 million gallons capacity, to store water if an adequate water supply can not be maintained throughout the hours of irrigation. Cost for construction of reservoirs would range anywhere from $10,000.00 to $250,000.00. Naturally, when increase in budget is considered, this must be amortized. Further, the kind and supply of water has not been considered. If a dirty, silty, mucky water is all that is available, it is a foregone conclusion that after a relatively short period of time soils will become sealed and extra aerifications and/or aerotillings will be a must.

After irrigation has become a reality, most clubs, except those located on sandy, well-drained soils, find it necessary to improve both surface and subsurface drainage. Tiles are installed in low, water-holding areas as necessary. In addition to this, slit trenches, 3 inches wide and approximately 3 feet deep, filled to the surface of the soil with pea gravel, are excellent for draining low, water-holding pockets. No soil is to be placed over the gravel or a perched water table will result. Rather, bring the gravel to the surface of the soil. In a short time, turf will grow over the gravel and should not be a hindrance to play. As many drain trenches as considered necessary can be placed. The cost for installing tile and slit trenches is a local item, and one which can be pretty well determined prior to the time that work starts.

Constant watering through artifical irrigation is known to cause soils to puddle, reduce infiltration rates, and result in excess cart damage in over-wet areas. This means that aeration, aerotilling and other loosening operations are simply a must if you expect to maintain good, playable conditions at all times. When the membership becomes excited about the installation of their fairway watering system and figure all their problems will be solved, a few of these items should be pointedly brought to their attention.

Labor is an extremely big factor in golf course irrigation today. As a matter of fact, it is the author's opinion that the trend toward automation results from the fact that not only is labor expensive, but it has been difficult to obtain and keep competent water men the past couple of seasons. Further, it can be determined from remarks in the "wear and tear" section that water control is superior with automation and superintendents are generally in favor of it. It would seem the old proverb fits, that "automation is here to stay", even in northern areas where the fairway watering season is short.

Of real significance is the rapid encroachment of weeds, primarily Poa annua, following irrigation, along with reduced height of cut. Poa annua is extremely difficult and expensive to control. Arsenicals are effective when used properly. However, the author has repeatedly observed that rapid and complete surface drainage must be a reality before they can be used where bentgrass is to be grown. Therefore, if you wish to attempt a Poa annua control program with arsenicals, it is an absolute must that all low pockets, or any areas which do not drain rapidly, be drained. This program has been well outlined in numerous papers and exacting methods for use of Poa annua control materials are currently available.

It is the author's opinion that superintendents south of Chicago and to the Bermudagrass belt, simply can not trust Poa annua any given year. Further, it is extremely difficult to maintain bentgrass in a good, healthy condition at all times in this location. The people in this particular area should be vitally interested in selections of Kentucky bluegrass currently being tried at land grant colleges and by private enterprise, as well as considering some of the better strains currently available, such as Merion.

One of the problems that worries agronomists active in the turf field, as well as golf course superintendents, is that the paying membership firmly believes all their fairway problems are magically solved once the fairway watering system is installed. Indeed, nothing could be further from the truth, as is repeatedly pointed out in the "wear and tear" section, and the following quote from one of the questionnaires, "at first very good; but as Poa crept in and they haven't gone to bent or spent any more money on maintenance or labor (in fact budget is down from before watering system) comments are and have been bad". The important point here is that if the budget is not increased after fairway watering becomes a reality, turf deteriorates rather than improves.

Obviously, a fairway watering system is a great asset and after all is said and done, the paying membership pretty much get what they want, or are willing to pay for.

FACTORS AFFECTING IRRIGATION PRACTICES

C. J. W. Drablos and
W. R. Oschwald

The age old question of when and how much water to apply to agricultural crops has been with us since irrigation began. This same question also applies to the irrigation of turf and the answer has an influence on the design and management of the system. The objective of watering turf is to maintain a sufficient moisture level in the soil for satisfactory growth and performance of the grass. Therefore the designer and operator of the irrigation system must be familiar with those factors that influence when and how much water to apply. The purpose of this paper is to review a number of these factors and discuss their relationships in the irrigation management scheme.

Soils

Water Holding Capacity

The ability of a soil to store and supply water for use by plants depends upon its water holding capacity and the ease with which water moves into and thru the soil profile. Plant growth is favored on soils that have a high capacity for holding plant available water - from irrigation or precipitation - but permit excess water to drain away. Removal of excess water is necessary to prevent water logged conditions that limit plant growth due to lack of oxygen (5).

Soils consist of solid particles (organic matter and mineral matter) that are separated by soil voids or soil pores. Water is stored in the soil in the smaller pores and as a film around the soil particles. It is held by the forces of cohesion (attraction of water molecules for each other) and adhesion (mutual attraction of water molecules and soil particles). Surface tension exerts a pull on the water to hold it in the soil as a film. Gravity causes water to drain from the larger soil pores if the water table is low enough. (1)

Fine textured soils - sandy clay, silty clay, clay - have a high percentage of soil particles that are small in diameter. This results in small pores, a large surface area and a high water holding capacity. Coarse textured soils have large pores, small surface area and low water holding capacity. Organic matter, structure, and texture determine the size distribution of soil pores. Texture largely determines the amount of surface exposed.

When a soil is saturated with water - the soil water includes gravitational, plant available and unavailable water. Gravitational water is free to drain from the soil and is not generally used by plants. Plant available water does not drain from the soil with gravity but may be removed by plants. Unavailable water does not drain from the soil and is held too tightly by the soil for use by plants. (5)

The amount of water that a soil can hold depends primarily on soil texture although the effect of texture may be modified by organic matter. The amounts of available water that can be held by soils with varying textures and verying amounts of organic matter are shown in Table 1. (9)

Table 1. Soil Texture, organic matter level and available water holding capacity.

	Inches of available water per foot of soil material		
Texture Group 1)	Low and Very low org. mat.	Medium organic matter	High organic matter
Fine (sc, sic, c)	1.8	2.0	2.2
Moderately fine (scl, cl, sicl)	1.9	2.2	2.5
Medium (vfsl, si, sil, l)	2.0	2.4	2.8
Moderately coarse (fsl, sl)	1.2	1.5	1.8
Coarse (gravel, s, ls)	.3	.5	.7
Peat & Muck (organic)	---	---	3.0

1)
Abbreviations: s: Sand or Sandy; si: Silt or Silty; c: Clay; l: Loam; f: Fine; v: Very

Table 1 can be used to estimate the water holding capacity of the root zone. First, estimate the texture and organic matter of each soil layer; next, refer to Table 1 to estimate the available water holding capacity for that texture - organic matter combination; finally, determine the total for the root zone by summing the individual values.

Natural Internal Drainage and Aeration

Natural internal drainage and aeration relate to the downward flow of water thru the profile. They indicate the amount of time that a soil is saturated with water under natural conditions. Surface color, surface layer thickness and subsoil colors are indicators of the natural internal drainage and aeration of a soil.

Oxygen is necessary for the decomposition of organic matter. Under saturated conditions, little oxygen is present. As a result organic matter accumulates and the surface soil is thicker and darker than under conditions where oxygen is plentiful. Poorly drained soils in Illinois that developed under prairie grass vegetation have thick, black or very dark brown surface layers.

Subsoil color is a good clue to possible wetness problems. Subsoils that are bright in color - brown, yellowish brown, reddish brown - are naturally well drained. Subsoils that are dull - gray or olive gray - are naturally poorly drained and the water table is at or near the soil surface during wet periods. Improved drainage is necessary before most plants will grow satisfactorily and before irrigation will be very effective. The success of drainage improvements will be determined to a large extent by the permeability of the soil. (5)

Soil Permeability

Permeability refers to the rate of water movement thru the soil profile. Excess water moves in the larger soil pores due to the force of gravity. Movement in the small pores is restricted. Thus, soil permeability is influenced by the size distribution of the soil pores. Soils with very slow and slow permeability have a high proportion of pores that are small enough to restrict or slow the downward flow of excess water. Soils with a higher proportion of large pores, are moderately or rapidly permeable and excess water drains readily thru the profile.

If permeability is very slow, water movement is restricted to the extent that under drainage by tile drainage systems is not satisfactory. Soils with slow permeability can be tile drained but require closer spacing of tile lines than moderately permeable soils that tile drain readily.

Soil permeability influences the rate at which a soil can absorb water from irrigation or rainfall. As permeability decreases, less water can drain thru the profile in a given period of time. If the soil is sloping, run off will occur resulting in lower efficiency of irrigation. If the soil is bare or protected by only a weak vegetative cover, as with a newly established turf, erosion may be a serious problem. (5)

Infiltration Rate

Water from irrigation or rainfall enters the soil, runs off the surface, or collects in depressions on the soil surface. The fate of the water is determined by factors that influence the rate at which water enters the soil - that is the infiltration or intake rate. The infiltration rate is influenced by (a) surface characteristics, (b) water content of the soil and (c) permeability of the soil profile. (4)

Surface characteristics that influence infiltration rate include texture, structure, amount of vegetative cover and slope gradient. Water can enter coarse textured soils readily and will move farther in a given amount of time than the same quantity of water applied to a soil with finer texture. Structure - the arrangement of the soil particles - may be compact or porus. When a soil is compacted, the soil solids are "pushed" closer together with a reduction in pore size. Compaction may be especially significant in reducing infiltration rates in heavy traffic areas particularly if the heavy use occurs when the soil is wet. Freezing and thawing over winter, the use of aerators, and increasing organic matter content aid in improving compacted turf grass areas. Slope characteristics - especially slope gradient - influence the length of time water will "stick around" while "waiting" to enter the soil. As slope gradient increases - the "waiting period" decreases and increased runoff results. (6)

The amount of vegetative cover on a soil also influences its infiltration rate. A bare soil is likely to seal due to soil particles that are loosened by the impact of falling irrigation or rain drops. A slower infiltration rate results. (8) In turfgrasses, thatch may accumulate and compact to the extent that it impedes the entrance of water into the soil. (6)

Water movement and retention in a soil are influenced by the water content of the soil. Water moves thru soil as a "front " due to surface tension or suction. The movement is film movement - around the soil particles and in the small pores of the soil. Some soils exhibit swelling or wetting with the result that the pores become smaller and water movement slows as the soil becomes wetter. The initial intake rate may be fast but the rate will slow as the moisture content increases due to reduction in pore size. (8)

Permeability of the soil profile influences the rate that water will move into as well as thru a soil. Texture and structure are important factors that influence soil permeability. Pore size distribution, as discussed above, determines the rate of flow in saturated soils. If a soil is stratified - has layers or strata that vary in texture - water retention and movement in unsaturated soils may be more affected by the stratification than by the textural class. Any change in porosity -- coarser textured to finer textured or vice versa csn increase the retention and slow movement of water. For example, a layer of coarse gravel underlying finer textured soil material will result in a significant increase (50% or more) in the amount of water retained in the unsaturated, finer textured soil. However, fast movement into the coarse layer will occur when the saturation point is reached. (1)

Direct and Indirect Soil Influence on Irrigation

The soil has both direct and indirect influences on the effectiveness at irrigation. The direct influence is due to water holding capacity, natural drainage and aeration, soil permeability and infiltration rate. These soil characteristics have a direct effect on irrigation efficiency because they determine how fast water enters a soil, how much is retained in the soil and how fast the excess drains thru the soil profile.

Indirectly, the soil also has an influence on irrigation efficiency. The capacity of a soil to supply nutrients may enable plants such as turf grasses to make full use of soil water from irrigation. Soil characteristics may limit the capacity of a soil to provide nutrients, reduce the availability of applied fertilizer materials, or restrict rooting depth of plants. Any of these factors may effectively limit the growth of turf grasses and decrease the effectiveness of irrigation. (5)

Rooting Depth

The depth of the grass rooting system is an important consideration in the design of a sprinkler irrigation system. The amount of moisture in the soil available to the plant increases as the root depth increases. Research in California has indicated that the rooting depth on a heavy soil can vary from 8 inches for Chewing fescue to 36 inches for Merion bluegrass. (2) The rooting depth recommended in the Irrigation Guide in Illinois for turf grasses is from 8 inches for fine and medium textured soils to 12 inches for course textured soils. (4)

Consumptive Use

The frequency of irrigation is governed not only by the quantity of water available to the plant but also by the rate at which the available water is depleted. Climate conditions such as high wind movement, intense sunlight, low humidity and higher temperatures all contribute to higher water use rates. Such conditions dictate more frequent watering than the reverse set of conditions. Consumptive use and evapo-transpiration are terms used to express the combined water lost by evaporation from the soil and leaf surface plus the water lost by plants through transpiration. The irrigation guide recommends that the average consumption use rate for turf grasses under average summer temperatures in Illinois is 0.20 inches per day. (4) This value will vary to some extent with a change in conditions.

Amount of Water to Apply

The amount of water to apply at any given time will depend upon how much is present in the soil when irrigation is started, the water holding capacity and the drainage characteristics of the soil. Enough water should be applied to insure that the entire root zone will be wetted.

If the soil is considered as a storage reservoir, the storage capacity within the root zone is determined by a difference between the amount of water retained by the soil after free water has drained off (Field Capacity), and that remaining at the time when the plants can no longer obtain enough water to meet transpiration requirements (wilting point). The water held between field capacity and wilting point is called available water for plant growth. For most vigorous and healthy growth, watering should begin when approximately 40 to 60 percent of the available water has been depleted. Most plants show a marked growth response when soil moisture is maintained between this level and field capacity.

The decision about when to irrigate should not be a set irrigation every day, neither should it be a fixed time interval of any other periodic nature because water use rates vary. The decision to initiate irrigation should be based upon observations, both of the turf and of the soil. Observation of the turf alone may be too late to accomplish a needed irrigation for good turf maintenance or it may cause an observation of a condition brought about by another cause which would result in irrigation when not needed.

The feel and appearance method provides an estimate of the soil moisture condition. With this method soil samples are taken from appropriate locations and depths and compared with descriptions in Table 2 to estimate available moisture content for different soil textures and conditions. (7) The feel and appearance method is not the most accurate method, however, with experience and judgement the irrigator should be able to estimate the moisture level within 10 to 15 percent of the amount determined with more sophisticated techniques.

Various instruments such as tensiometers and electrical - conductivity measuring devices are available commercially for measuring soil moisture. If the instruments are well located and if the irrigator reads them consistently and interprets the results according to his knowledge of both crop and soil, it is possible to closely predict the time to irrigate.

Table 2 -- Practical interpretation chart of soil moisture for various soil textures and condions

Available moisture in soil	Feel or appearance of soil			
	Coarse-textured soils	Moderately coarse textured soils	Medium-textured soils	Fine and very fine textured soils
θ percent - Wilting Point	Dry, loose, and single-grained; flows through fingers.	Dry and loose; flows through fingers	Powdery dry; in some places slightly crusted but breaks down easily into pwd.	Hard, baked, and cracked; has loose crumbs on surface in some places.
50 percent or less	Appears to be dry; does not form a ball under presure.[1]	Appears to be dry; does not form a ball under presure[1].	Somewhat crumbly but holds together under pressure	Somewhat pliable; balls under pressure.[1]
50 to 75 percent	Appears to be dry; does not form a ball under pressure.[1]	Balls under pressure but seldom holds together.	Forms a ball under pressure; somewhat plastic; slicks slightly under pressure	Forms a ball; ribbons out between thumb and fore-finger.
75 percent to field capacity	Sticks together slightly; may form a very weak ball under pressure.	Forms weak ball that breaks easily; does not slick.	Forms ball; very pliable; slicks readily if relatively high in clay	Ribbons out between fingers easily; has a slick feeling.
At field capacity (100 percent).	On squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as for coarse-textured soils at field capacity.	Same as for coarse-textured soils at field capacity.	Same as for coarse-textured soils at field capacity.
Above field capacity	Free water appears when soil is bounced in hand	Free water is released with kneading.	Free water can be squeezed out.	Puddles; free water forms on surface.

[1] Ball is formed by squeezing a handful of soil very firmly.

Effect of Various Properties on Design of Sprinkler Irrigation Systems

To better understand how the various soil, water and plant factors are related to the design and management of an irrigation system, let us work through a typical example problem. The ultimate objective is to determine (1) frequency of application, (2) amount of water to be applied at each application and (3) the total amount of water required. To solve this problem, it is necessary to make the following assumptions:

1. Area to be irrigated - 40 areas
2. Soil type - Sandy loam - 0.19 inches of water per inch of soil
3. Maximum intake rate - 1.0" per hour
4. Crop - turf
5. Depth to irrigate - 12 "
6. Design moisture use rate - 0.20"/ day
7. No natural precipitation during this period
8. Irrigation to begin when 40% of available moisture has been depleted (60% remaining)
9. Irrigation to be completed prior to when the available moisture has been depleted to the 20% level.

Step 1. Net moisture replaced at each Irrigation.
(Depth to irrigate x waterholding capacity x percent of moisture to be replaced)

(1) Depth = 12"
(2) Waterholding Capacity for this soil is 0.18'/inch of soil
(3) Percent moisture to be replaced - 40%

Net moisture to be replaced at each irrigation = 12 x 0.18 x 0.40 = 0.86 inches

Step 2. Design Irrigation Frequency
(How often to irrigate when crop is using maximum amount of moisture.)

$$\frac{\text{Amount to be replaced}}{\text{Design Moisture use rate}} = \frac{0.86}{0.20} = 4 \text{ days}$$

Step 3. Gross depth of water to be applied at each irrigation

$$\frac{\text{Net Moisture Replaced}}{\text{Efficiency}} = \frac{0.86}{0.70} = 1.2 \text{ inches}$$

Step 4. Maximum Application time
(Length of time each lateral must operate to apply 1.2 inches at a rate of 0.40"/hour)

$$\frac{\text{Gross Depth Applied}}{\text{Application Rate}} = \frac{1.2}{0.40 \text{ "/hour}} = 3 \text{ hours}$$

Step 5 Number of settings per day vs hours of operation
1 setting per day = 3 hours of operation
2 settings per day = 6 hours of operation
3 settings per day = 9 hours of operation
4 settings per day = 12 hours of operation
5 settings per day = 15 hours of operation
6 settings per day = 18 hours of operation
7 settings per day = 21 hours of operation

Step 6. System Capacity Requirements

$$Q = 453 \frac{Ad}{FH}, \text{ where}$$

Q = Discharge in gallons per minute

A = Acreage of design area

d = Gross depth of water application in acre inches per acre

F = Number of days allowed for completion of one irrigation

H = Average number of hours of operation per day.

In above formula, "A" and "d" are fixed.
A = 40 acres, d = 1.2 inches
"H" can be varied depending upon the optimum time for the system to be in operation, availability of labor etc.

The water supply requirements will vary inversely with the number of settings planned per day.

(1) One setting per day, $Q = \frac{453 \times 40 \times 1.2}{4 \times 3} = 1812$ gpm

(2) Two settings per day, $Q = \frac{453 \times 40 \times 1.2}{4 \times 6} = 906$ gpm

(3) Three settings per day, $Q = \frac{453 \times 40 \times 1.2}{4 \times 9} = 604$ gpm

(4) Four settings per day, $Q = \frac{453 \times 40 \times 1.2}{4 \times 12} = 453$ gpm

(5) Five settings per day, $Q = \frac{453 \times 40 \times 1.2}{4 \times 15} = 362$ gpm

(6) Six settings per day, $Q = \frac{453 \times 40 \times 1.2}{4 \times 18} = 302$ gpm

It can be noted in the above example that the frequency and amount of water to apply at each irrigation does depend upon soil characteristics and type of crop to be grown. In this example the tract of land is irrigated every four days during the peak season. Where you have a minimum number of settings per day, there will be less demand for labor but an increased requirement for equipment and a larger water supply. As the number of settings are increased per day, there will be a greater demand for labor but a lower requirement for equipment and a smaller water supply.

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THE IMPORTANCE OF GUTTATION FLUID ON TURF DISEASES

M. J. Healy and M. P. Britton

Samples of turf from 52 golf course putting greens (Figure 1) were collected in the fall of 1965, the spring of 1966, and again in the summer of 1966. While most of the putting greens sampled were predominantly creeping bentgrass, many contained some annual bluegrass. Samples from each green consisted of five 3/4 inch diameter plugs collected from the same area at each of the three sampling dates. Ten leaves from each sample were selected. Five of these leaves were primarily green, but with some dead or yellowed tissue, and the other five were completely brown. Isolations of fungi were made from each leaf. The fungi obtained were identified and then used to inoculate detached leaves of both annual bluegrass and creeping bentgrass.

Guttation fluid was collected from both annual bluegrass and creeping bentgrass plants grown in quartz sand in a growth chamber; in soil in flates in the greenhouse, and from established field plantings after fertilizing them with either urea, ammonium nitrate, or ammonium chloride. The guttation fluid was collected several hours later and analyzed for glutamine.

Results: Brown or yellow leaf tips accounted for the majority of injury observed in "healthy" turf (Figure 2). Leaf-Spotting was infrequently noticed in both the spring and fall. Table 1 shows that species of *Curvularia*, *Fusarium*, *Helminthosporium*, and *Alternaria* accounted for the majority of fungi isolated. Innoculation tests showed that almost all of the pathogenic isolates were species of either *Helminthosporium*, *Fusarium*, or *Curvularia*. In general *Curvularia* and *Fusarium* were more pathogenic on annual bluegrass than creeping bentgrass while the reverse was true with *Helminthosporium* (Table 2). The average pathogenicity rating of isolates of *Helminthosporium*, *Curvularia*, and *Fusarium* species on both grasses was higher in all cases when plant extract was used instead of water in inoculations (Table 3). The following species were pathogenic: *Helminthosporium sorokinianum*, *Curvularia geniculata*, *Curvularia pallescens*, *Fusarium roseum*, and *Fusarium tricinctum*.

Guttation fluid collected from annual bluegrass and creeping bentgrass plants grown in quartz sand, in soil in the greenhouse, and from established plantings after the addition of any of the fertilizers used yielded glutamine in every case. Guttation fluid from control plants receiving no fertilizer contained no trace of glutamine. No other amino acid was found in any of the samples tested. It is apparent that the production of glutamine in response to nitrogen fertilization is a phenomenon common to both annual bluegrass and creeping bentgrass, not only when the plants are fertilized under controlled conditions in the laboratory but also under natural conditions in the field.

After the production of glutamine was positively established, an experiment was designed to test its effect on germ tube growth and appressorium formation of isolates of *Curvularia geniculata*, *C. pallescens*, and *Helminthosporium* sorokinianum. A positive correlation between increasing appressorium development and increasing glutamine concentration was observed for all the fungi tested (Figure 3).

In summary this investigation provided the following information:

1. The genera of fungi most frequently isolated from leaves collected from annual bluegrass or creeping bentgrass putting-green turf were Curvularia, Alternaria, Fusarium, and Helminthosporium.

2. Detached leaf inoculation tests indicated that of the fungi commonly isolated, only species of Helminthosporium, Fusarium, and Curvularia were pathogenic. Helminthosporium sorokinianum, Curvularia geniculata, Curvularia pallescens, Fusarium roseum, and Fusarium tricinctum were identified from pathogenic isolates of these three genera.

3. Annual bluegrass and creeping bentgrass are not equally susceptible to all fungi found to be pathogenic. Isolates of Curvularia and Fusarium generally were more pathogenic on annual bluegrass than on creeping bent while the reverse was true with Helminthosporium.

4. The exudation of glutamine by annual bluegrass and creeping bentgrass in response to nitrogen fertilization can be an important factor contributing to the severity of disease outbreaks. There is no doubt that both glutamine and wounding fluids produced by mowing play an important role in increasing the infection of plants by fungi associated with diseased putting-green turf.

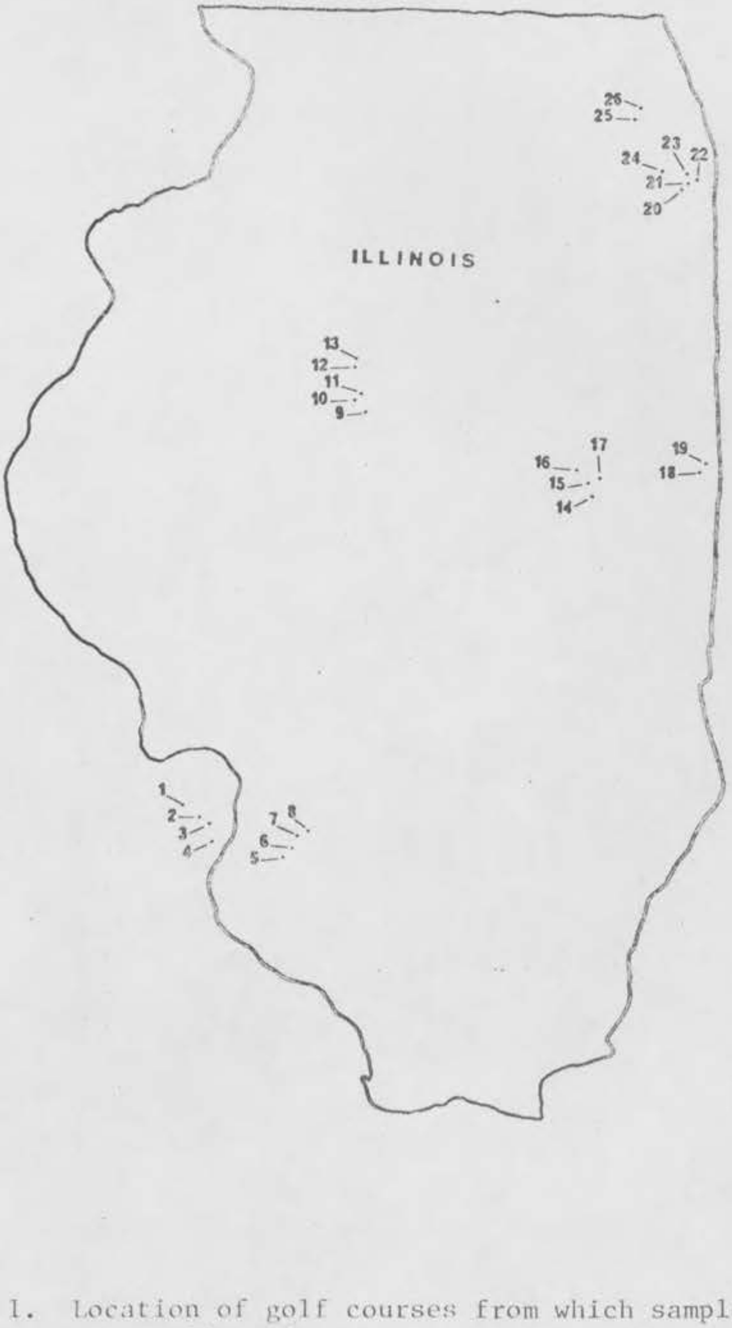

FIGURE 1. Location of golf courses from which samples were collected.

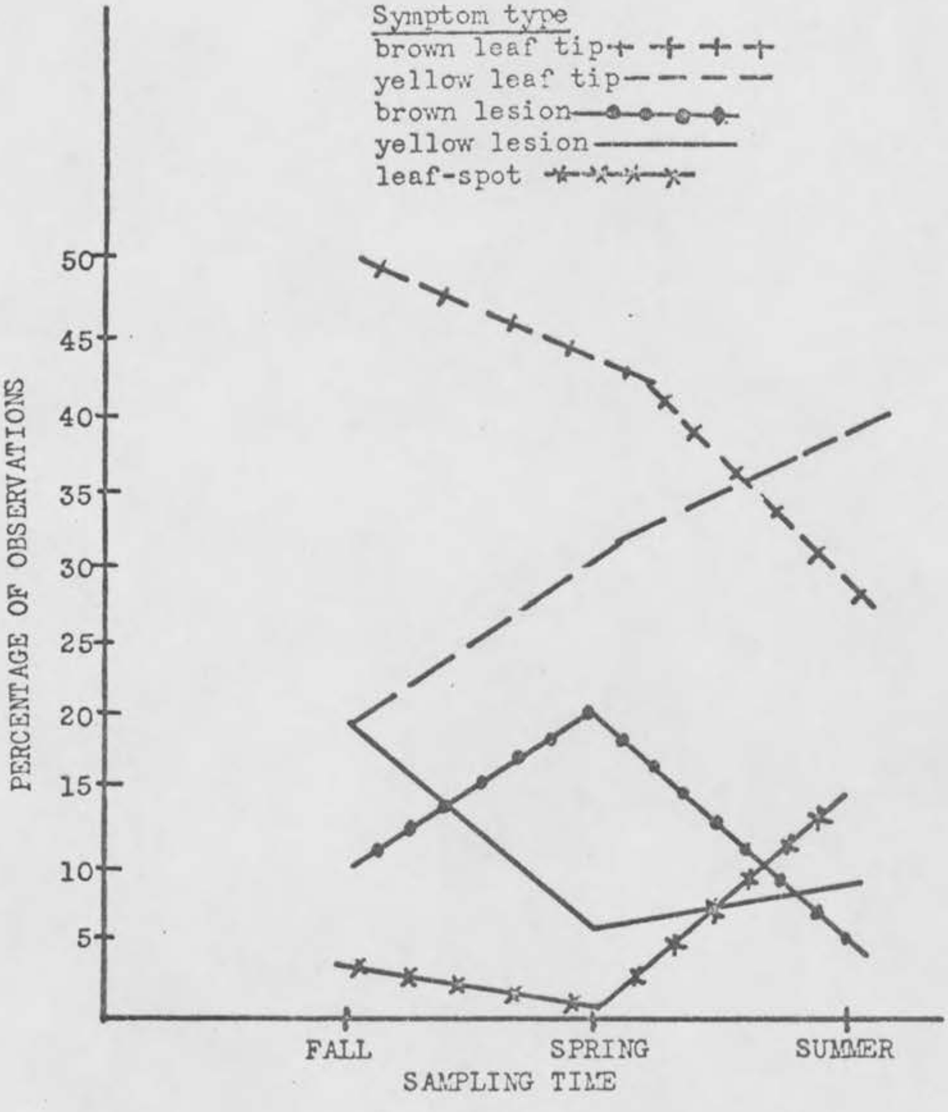

FIGURE 2. Frequency of observation of leaf symptom types from "healthy" putting-green turf.

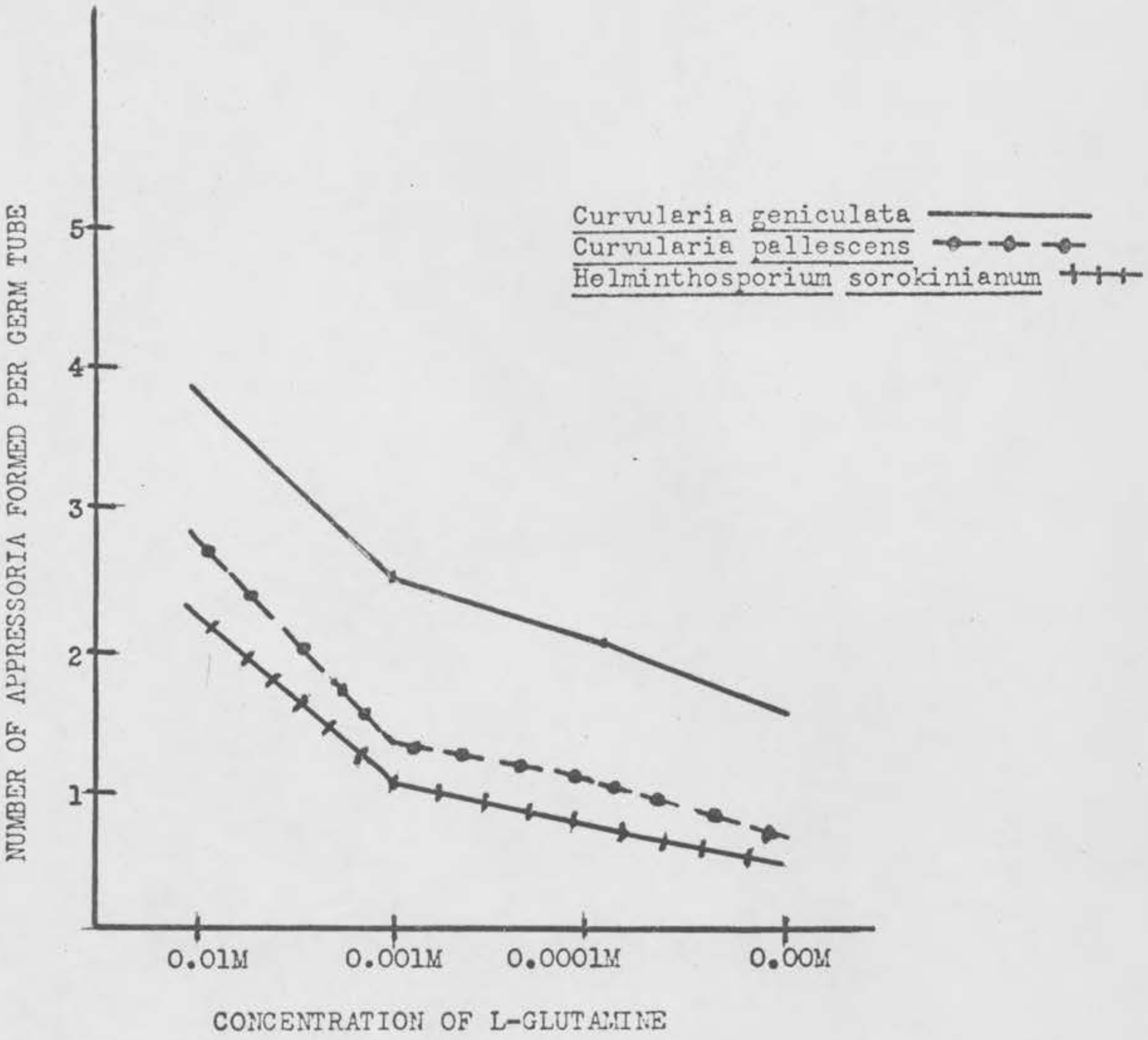

FIGURE 3. Effect of L-glutamine on appressorium formation by three species of fungi isolated from leaves of putting-green turf.

Table 1. Frequency of isolation of genera of fungi from brown and green leaves of samples from 52 putting greens collected in the fall of 1965 and spring and the summer of 1966.

Genus	Percentage of total isolations: Fall %	Spring %	Summer %
Curvularia	20	0	35
Fusarium	16	14	10
Helminthosporium	1	2	11
Alternaria	26	29	9
Penicillium	6	tr[a]	10
Trichoderma	4	2	1
Mucor	2	tr	tr
Aspergillus	1	tr	tr
Gliocladium	tr	0	tr
Rhizopus	tr	tr	2
Botrytis	tr	0	0
Blastomyces	tr	0	0
Cladosporium	tr	7	tr
Chaetomella	tr	tr	0
Verticillium	tr	tr	0
Papulaspora	tr	0	0
Cunninghamella	tr	0	0
septate[b]	18	41	19
nonseptate[c]	tr	0	tr

a - tr signifies less than 1% of total isolations

b - isolates having regularly septate mycelium but producing no spores and unidentified.

c - isolates having nonseptate mycelium and unidentified.

Table 2. Percentage of isolates of *Curvularia*, *Fusarium*, and *Helminthosporium* showing a differential pathogenicity rating to annual bluegrass and creeping bentgrass.

	Percentage of isolates		
Pathogenicity rating	Curvularia	Helminthosporium	Fusarium
equal or higher on creeping bent than annual bluegrass	9%	84%	22%
equal or higher on annual bluegrass than creeping bentgrass	25%	6%	33%
nonpathogenic	66%	10%	45%

Table 3. Average pathogenicity rating of pathogenic isolates of three genera of fungi to two grass species, using two inoculation substrates.

	Annual bluegrass		Creeping bentgrass	
Genera	H_2O	Plant extract	H_2O	Plant extract
Curvularia	1.7	3.5	0.7	1.5
Helminthosporium	3.2	3.8	6.2	7.3
Fusarium	3.2	3.9	3.9	4.3