22ND ILLINOIS TURFGRASS CONFERENCE

DECEMBER 15-17, 1981

Arranged and conducted by

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In cooperation with

ILLINOIS TURFGRASS FOUNDATION

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This publication was compiled and edited by Thomas W. Fermanian, Assistant Professor of Horticulture, University of Illinois at Urbana-Champaign.

CONTENTS

LAWN TURF SESSION

GOLF TURF SESSION

PRESENTED AT 1980 CONFERENCE

1981 TURFGRASS RESEARCH AT THE UNIVERSITY OF ILLINOIS

Thomas W. Fermanian

The two major areas of research for 1981 were the evaluation of turfgrass cultivars, both locally and at several areas throughout the state, and the measurement of the performance of various preemergence herbicides. Additional areas of study initiated in 1981 are reported in separate articles in these proceedings.

HERBICIDE EVALUATIONS

While evaluating all of the labeled turf preemergence herbicides, several materials not previously used on turf were also evaluated. An area of 1,000 square feet of Kentucky bluegrass was overseeded in the fall of 1980 with crabgrass (*Digitaria* spp.) at the Ornamental Horticulture Research Center (OHRC) in Urbana, Illinois. Due to the limited area of overseeded turf, only 20 herbicide treatments were included in this experiment (Trial 1). An additional 10 treatments were used in a second adjacent experiment (Trial 2).

Trial 1

Trial 1 was established on 1 April 1980. Herbicides applied as a liquid were sprayed with a single-nozzle CO_2 sprayer at the rate of 37.5 gallons per acre (gpa). The granular herbicides were applied by hand. For treatments requiring a split application, a second application was undertaken six weeks after the first. The entire experiment was also overseeded with crabgrass on 9 April and 1 June 1981.

The herbicides evaluated in this trial were Lasso EC, MON 097, a plant growth regulator (PGR), Dacthal 75W, Tupersan 50W, Balan, Presan EC, and Ronstar 2.5G. Herbicides with a split rate (2+2) were applied twice. The initial applications were followed by a second application six weeks after the first applications. Evaluations of crabgrass control were taken at three months after the initial application date (13 July) and six months after the initial application (6 October). The results are shown in Figure 1.

An increase in crabgrass populations was observed at three months for both the PGR at 3+3 pounds per acre and MON 097 at 2 pounds per acre. MON 097 at 4 pounds per acre, Ronstar at 4+2 pounds per acre, Tupersan at 12 pounds per acre, Balan at 2 pounds per acre, Lasso at 3+3 pounds per acre, and Presan at both rates had very good to excellent control at six months. Dacthal at 10 pounds per acre had good control at three months; however, the crabgrass populations had increased at the six-month evaluation. The Kentucky bluegrass turf was not injured by any treatment in Trial 1.

T.W. Fermanian is an assistant professor in the Department of Horticulture at the University of Illinois at Urbana-Champaign.

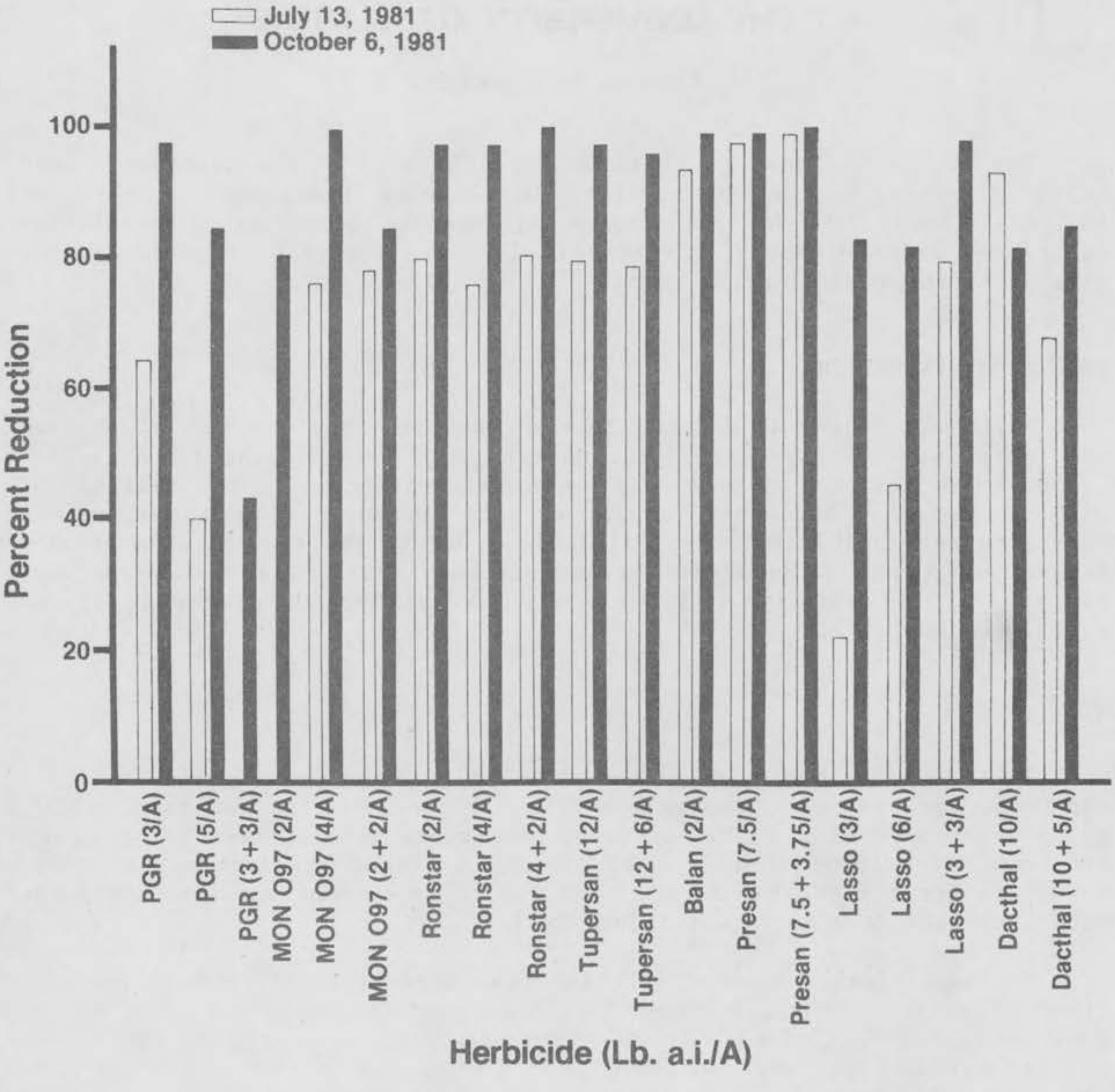

Figure 1. 1981 evaluations of preemergence herbicides for crabgrass control --Trial 1.

Trial 2

The second experiment (Trial 2) was established on 15 April 1981 on a 'Columbia-Touchdown' Kentucky bluegrass stand. Plot size was 3 x 10 feet. The whole area was overseeded twice with crabgrass seed. The first overseeding was preceded by a vertical mowing of the area. Herbicides used in Trial 2 were mostly granular formulations. All treatments were applied as in Trial 1.

The percent reductions in crabgrass populations two months after the initial applications (14 June) as compared to the check plot are shown in Figure 2. Both formulations of bensulide (Betamec and Betasan) and Ronstar exhibited excellent weed control. Unlike Trial 1, several herbicides in Trial 2 caused turf injury. A rating of phytotoxicity evaluated six (28 May) and eight (17 June) weeks after the initial application is shown in Figure 3. Both rates of Devrinol were rated phytotoxic at each date. The use of Devrinol is therefore not recommended. Ronstar showed a delayed toxic effect that persisted for several weeks. Ronstar, therefore, should be used with caution.

TURFGRASS SPECIES CULTIVAR EVALUATIONS

The University of Illinois turf program is one of 35 participants in a nationwide Kentucky bluegrass cultivar evaluation study. This study will examine the responses of 84 bluegrass cultivars to various environments and cultural regimes. Two trials have been established in Illinois. The first trial is located at the OHRC in Urbana on a silt loam soil, and a second trial is located in Kilbourne on sand.

Urbana

The Urbana evaluation was established on 15 September 1980. Plot size is 5 x 6 feet, and each cultivar is replicated three times in a randomized complete block design. Before establishment, the area was fertilized with a 12-12-12 analysis material at the rate of 1 pound of nitrogen per 1,000 square feet. After seeding, plots were covered with Soil Guard, a synthetic spray mulch, and irrigated as needed. In 1981, the area received a total of 4 pounds of nitrogen per 1,000 square feet. The turf was mowed two or three times per week at 1.5 inches. The plots were not irrigated, but excessive rainfall during the summer months prevented any drought stress from occurring until late September.

Those cultivars with average quality ratings exceeding 7.5 are judged superior. Most cultivars in the Urbana trial had medium quality as evaluated by spring green-up on 26 March 1981 (Table 1). This was also true for the drought-stress evaluation taken 25 September 1981. Generally, cultivars that rated high in overall quality were found to have medium drought tolerance.

Several cultivars exhibited excellent spring green-up in the Urbana trial. The cultivar 'K3-162' was significantly greener at the time of

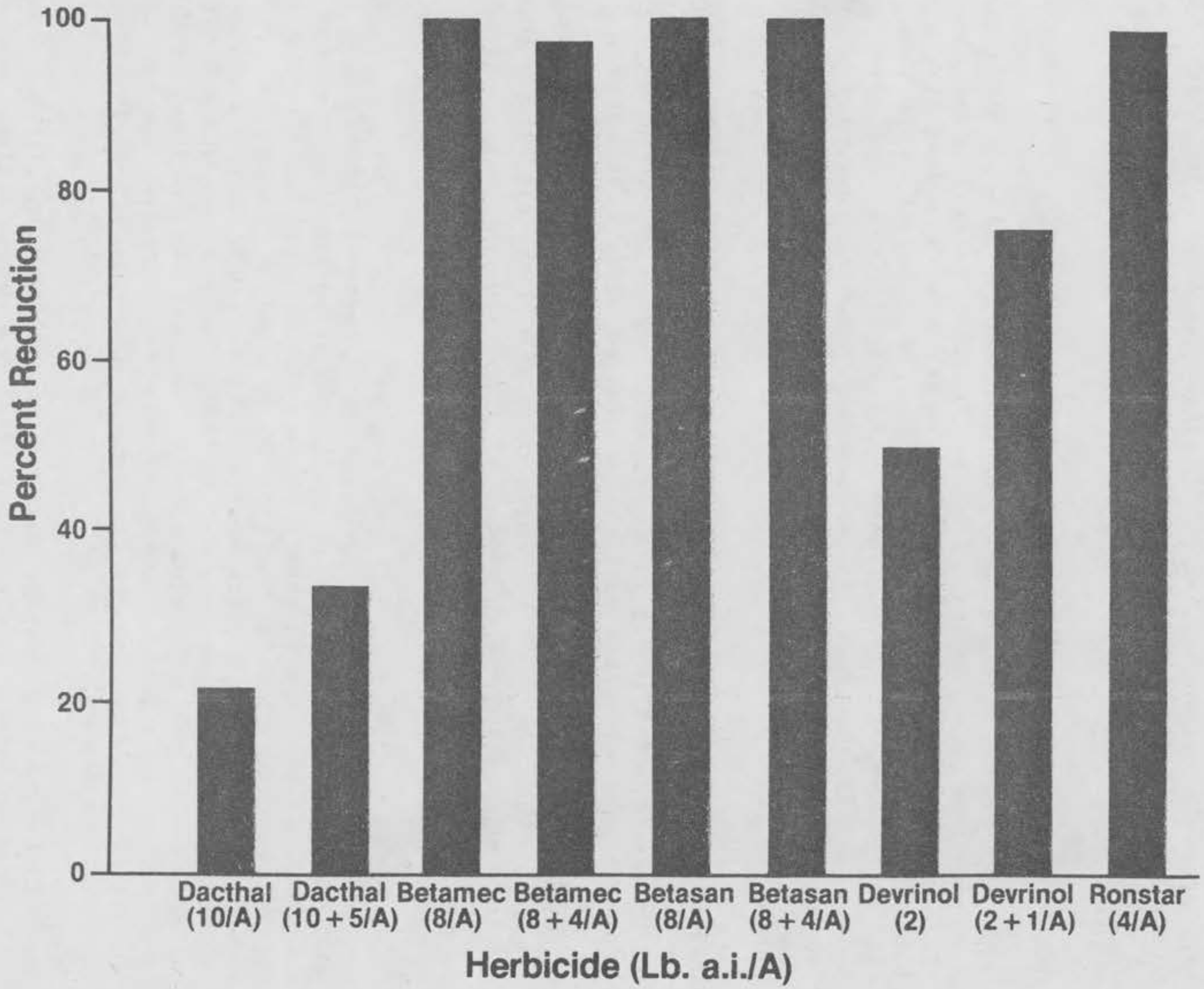

Figure 2. 1981 evaluations of preemergence herbicides for crabgrass control--Trial 2, June 14, 1981.

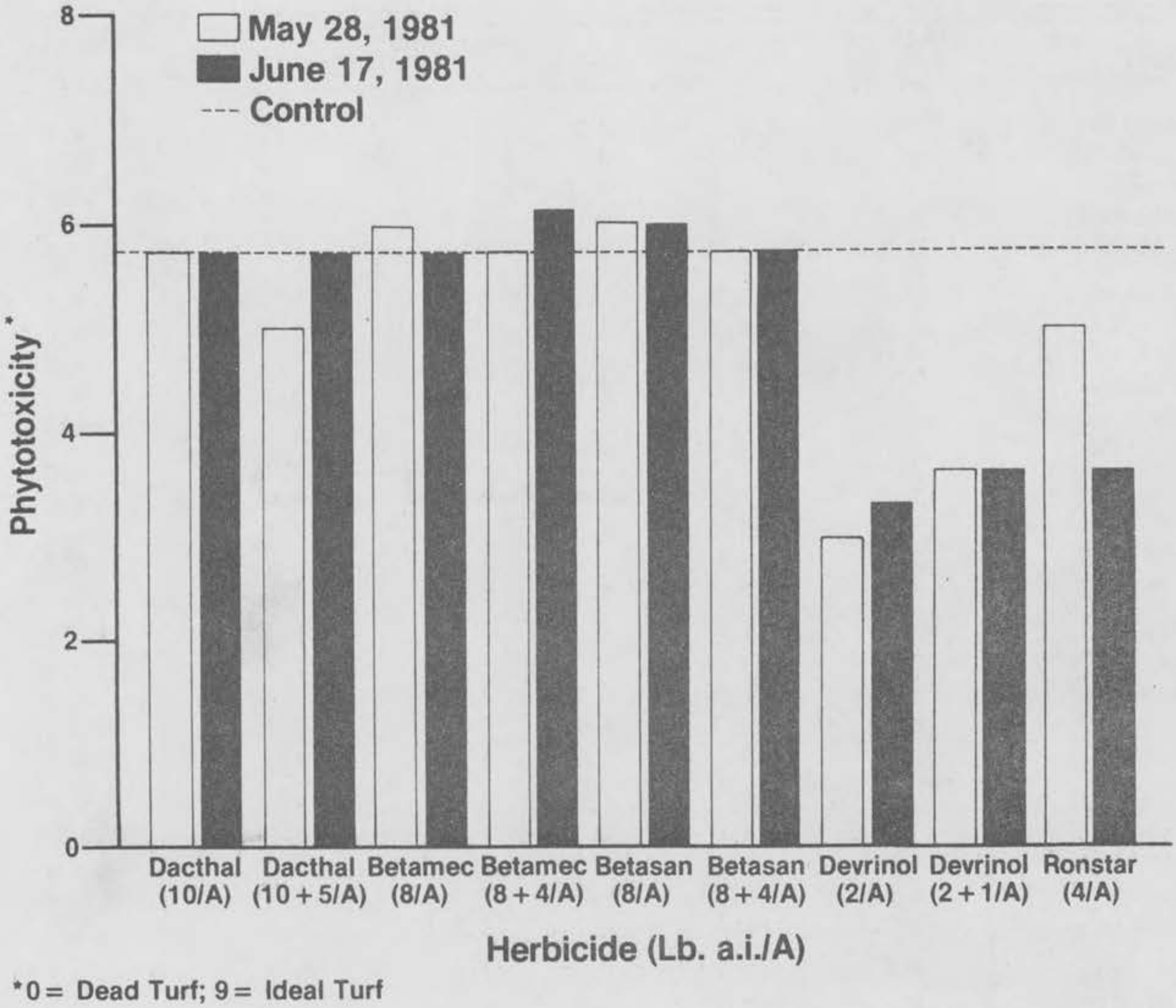

Figure 3. 1981 evaluations of preemergence herbicides for phytotoxicity--Trial 2.

Table 1. Evaluation of Kentucky Bluegrass Varieties during the 1981 Growing Season at Urbana

Cultivar	Green-up* 3/26/81	Quality† 5/7/81	Quality† 7/8/81	Quality† 10/8/81	Quality† Overall dates	Drought** 9/25/81
Adelphi	7.0	7.7	7.7	7.7	7.7	9.0
Glade	6.7	7.3	8.7	7.7	7.6	9.0
Birka	7.0	8.7	9.0	6.3	7.8	7.7
Monopoly	6.7	9.0	8.7	8.0	8.3	9.0
RAM-1	7.0	7.3	8.0	8.0	7.4	9.0
Fylking	7.0	7.3	7.3	6.3	6.8	9.0
Cheri	6.7	7.7	7.7	7.0	7.4	9.0
243	7.0	6.7	6.3	7.0	6.5	9.0
Wabash	7.0	9.0	8.0	8.3	8.1	9.0
Nugget	3.3	5.0	7.3	6.7	6.0	6.3
239	7.0	7.7	7.3	7.0	7.1	9.0
S-21	7.7	7.7	5.7	5.3	6.0	9.0
PSU-190	7.0	8.0	8.3	7.3	7.6	9.0
PSU-150	7.0	9.0	8.3	7.7	8.2	6.3
PSU-173	7.0	8.3	8.7	8.0	8.1	9.0
Kimono	6.3	7.0	8.3	7.3	7.7	9.0
Baron	7.0	7.0	7.7	8.7	7.6	9.0
Enmundi	7.0	7.3	8.3	8.3	7.8	9.0
Plush	6.7	7.3	6.7	8.0	7.3	9.0
Parade	7.0	8.3	7.3	7.7	7.5	9.0
Trenton	7.0	8.7	8.0	8.3	8.0	9.0
Rugby	6.7	8.0	7.3	7.7	7.7	9.0
SV-01617	7.0	7.3	7.3	7.3	6.9	9.0
Banff	6.7	8.7	8.7	7.7	8.1	9.0
Dormie	7.7	6.3	7.7	4.3	5.8	5.0
Holiday	6.0	7.7	7.3	7.0	7.3	7.7
Geronimo	7.0	8.0	7.3	6.3	7.2	7.7
Aspen	7.0	7.0	7.0	7.7	7.0	9.0
MLM-18011	7.3	7.3	7.0	8.0	7.1	9.0
CEB VB 3965	7.0	7.3	7.7	8.7	7.9	9.0
Touchdown	7.0	7.0	8.0	7.7	7.6	9.0
Welcome	7.0	7.7	7.3	8.3	7.5	9.0
WW AG 463	6.7	8.0	8.0	8.0	7.9	9.0
WW AG 480	6.3	6.7	8.0	8.3	7.8	9.0
Bono	7.7	8.3	8.7	6.7	7.7	7.7
Kenblue	8.0	5.7	4.3	5.7	5.1	5.0
Harmony	5.7	6.3	7.0	6.3	6.6	7.7
America	7.0	6.7	7.7	7.7	7.3	9.0
Vanessa	6.3	7.3	8.3	7.0	7.7	7.7
Mosa	6.3	7.3	8.7	7.7	7.8	9.0
Cello	6.7	8.0	8.7	8.0	8.0	9.0
WW Ag 478	6.0	6.3	8.7	9.0	8.0	9.0
Piedmont	7.7	8.3	6.7	7.7	7.2	9.0
Majestic	8.0	7.3	6.0	6.7	6.5	9.0
Bonnieblue	7.0	7.0	8.0	9.0	7.8	9.0

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Table 1. Evaluation of Kentucky Bluegrass Varieties during the 1981 Growing Season at Urbana (continued)

Cultivars	Green-up* 3/26/81	Quality† 5/7/81	7/8/81	10/8/81	Overall dates	Drought** 9/25/81
Vantage	7.0	8.3	7.0	7.0	7.0	9.0
Merit	7.0	6.7	7.3	7.0	7.1	9.0
Argyle	8.0	7.3	5.7	6.0	5.8	7.7
Charlotte	7.0	7.3	6.3	6.3	6.7	7.7
A20-6	6.3	7.0	8.7	8.7	8.3	7.7
A20	7.0	8.0	8.3	7.7	8.1	7.7
H-7	6.3	6.0	6.7	7.7	6.7	9.0
I-13	6.7	7.0	8.0	9.0	7.9	9.0
A20-6A	6.7	7.7	8.7	9.0	8.3	9.0
N535	7.0	6.7	7.3	8.0	7.1	9.0
I528T	7.0	6.0	6.7	8.7	6.8	9.0
Shasta	7.3	7.0	7.3	8.0	7.4	9.0
Columbia	7.0	8.0	7.7	8.0	7.9	9.0
Apart	7.0	6.0	5.0	5.3	5.3	9.0
A-34	7.0	8.0	7.0	7.3	7.2	9.0
Sydsport	6.3	8.0	9.0	8.7	8.3	9.0
Mer pp 300	6.3	7.0	7.7	7.7	7.3	9.0
Mer pp 43	7.0	7.0	7.3	5.3	5.9	5.0
Mona	6.7	8.0	8.3	8.0	7.8	9.0
Lovegreen	7.0	7.3	8.0	5.7	6.6	7.7
Bristol	7.3	7.0	7.0	8.0	7.3	5.0
Victa	7.0	7.7	8.7	8.3	8.0	9.0
Enoble	5.7	7.3	7.3	7.3	7.2	7.7
SH-2	6.3	8.3	8.0	8.3	7.8	9.0
NJ 735	6.3	7.0	7.0	7.0	6.9	9.0
S.D. Common	7.3	8.0	5.3	5.0	5.8	5.0
Merion	7.0	8.0	7.3	6.0	7.2	7.7
BA-61-91	7.0	6.7	7.7	8.7	7.5	9.0
Bayside	7.0	7.7	6.7	6.7	6.8	7.7
225	7.0	8.7	8.0	8.3	8.1	9.0
Mystic (P-141)	8.0	7.0	8.3	7.3	7.7	9.0
Admiral	7.0	7.3	6.7	8.3	7.3	9.0
Eclipse	7.0	8.0	6.7	8.0	7.4	9.0
Escort	6.3	9.0	8.0	8.7	8.3	5.0
K3-162	9.0	8.3	7.0	7.3	7.6	9.0
K3-179	7.0	8.3	7.7	8.3	7.9	9.0
K3-178	7.0	8.7	8.3	8.0	8.2	9.0
K1-152	7.0	8.3	7.7	8.0	7.9	9.0
Barblue	8.0	9.0	6.3	7.3	7.3	9.0

*Green-up ratings are made on a scale of 1 through 9; 9 represents early green-up and 1 represents dormancy.

†Quality ratings are made on a scale of 1 through 9; 9 represents ideal turf quality.

**Drought ratings are made on a scale of 1 through 9; 9 represents resistance to drought stress.

evaluation than any of the other 83 entries. 'Bristol', 'Dormie', 'Kenblue', and South Dakota Common were judged superior in both spring green-up and drought tolerance. However, their overall quality was rated only fair (Table 1).

Kilbourne

The trial at the Illinois River Valley Sand Field, Kilbourne, was established 6 April 1981. Dolomitic limestone was applied to the area at 1.5 tons per acre in the fall of 1980. Prior to seeding, fertilizer was applied as 34-0-0 (1.6 pounds of nitrogen per 1,000 square feet), 0-44-0 (110 pounds per acre), 0-0-6 (280 pounds per acre), and potassium magnesium sulfate (180 pounds per acre). Both complete-analysis fertilizers (water-soluble nitrogen source) and slow-release nitrogen fertilizers were applied throughout the year, totalling 6.5 pounds of nitrogen per 1,000 square feet. Granular Tupersan, a preemergence crabgrass herbicide, was applied at seeding at a rate of 6 pounds of active ingredient per acre. A second application of Tupersan WP was made on 18 May at a rate of 6 pounds of active ingredient per acre. Basagran at the rate of one quart per acre was applied on 19 September and 28 September to control nutsedge. Irrigation is essential for turf growing in a pure sand soil. Although excessive rainfall characterized the 1981 growing season, plots were still irrigated to prevent moisture stress.

Cultivars differed widely in rate of establishment (Table 2). On 15 July the plots were infected with Pythium blight, a disease more frequently seen on perennial ryegrass in Illinois. Environmental conditions at this time were ideal for a Pythium outbreak (i.e., hot, wet, humid); and air movement over the plot was poor, thus contributing to the severity of the disease. Recovery from this disease varied with the cultivar (Table 2).

Crabgrass (*Digitaria* spp.) and nutsedge (*Cyperus* spp.) proved to be major weed problems following the Pythium infection. No post-emergence crabgrass control was applied, but two applications of Basagran made in the fall successfully controlled the nutsedge. October quality ratings reflect disease susceptibility and weed infestation (Table 2).

Future Work

Both the Urbana and Kilbourne plots are relatively immature stands. Cultivar evaluations taken at these sites over the next several years will provide a better picture of individual cultivar performance.

These Kentucky bluegrass evaluations are also part of a larger regional study which will include cultivars of other turf species. Data collected from all regional trials will be used to formulate establishment recommendations for individual sites in the state. This program will not replace statewide recommendations for turfgrass but should supplement them. Other factors, such as weather, soil type, and intended use, will also be used in formulating these recommendations.

Table 2. Evaluation of Kentucky Bluegrass Varieties during the 1981 Growing Season at Kilbourne

Cultivar	Percent Cover 70 Days after Seeding* (6/19/81)	Percent Cover 21 Days after Pythium Outbreak (8/5/81)	Quality† (10/26/82)
WW AG 463	71.7	83.3	6.7
Banff	68.3	80.0	7.0
Barblue	66.7	55.0	5.0
Columbia	66.7	60.0	5.7
Mona	66.7	70.0	5.3
K3-162	65.0	71.7	4.7
K3-178	63.3	75.0	5.3
Plush	63.3	68.3	5.0
Charlotte	61.7	58.3	3.7
K1-152	61.7	75.0	6.0
PSU-190	61.7	65.0	3.7
Rugby	61.7	60.0	4.7
Welcome	60.0	58.3	4.0
Bayside	58.3	65.0	4.3
Kenblue	58.3	50.0	3.7
Trenton	58.3	60.0	6.0
Escort	56.7	60.0	4.7
SV-01617	56.7	51.7	4.0
Vantage	56.7	43.3	3.3
225	56.7	65.0	5.3
239	56.7	66.7	5.0
Argyle	55.0	60.0	4.0
S.D. Common	55.0	50.0	3.7
WW AG 478	55.0	50.0	3.7
Fylking	53.3	58.3	4.7
PSU-173	53.3	53.3	3.3
Admiral	51.7	53.3	4.3
America	51.7	61.7	4.0
N535	51.7	63.3	5.0
Vanessa	51.7	66.7	4.0
A-34	50.0	63.3	4.0
A20-6A	50.0	60.0	5.0
Mer pp 300	50.0	41.7	3.0
Touchdown	50.0	53.3	4.0
Monopoly	48.3	53.3	3.7
PSU-150	48.3	63.3	4.0
Sydsport	48.3	65.0	4.7
Bonnieblue	46.7	55.0	4.0
Bono	46.7	53.3	3.0
Holiday	46.7	58.3	3.3
Merion	46.7	48.3	3.3
Mosa	46.7	56.7	4.0
Wabash	46.7	56.7	5.0
WW AG 480	46.7	46.7	4.3
Majestic	45.0	48.3	4.0

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Table 2. Evaluation of Kentucky Bluegrass Varieties during the 1981 Growing Season at Kilbourne (continued)

Cultivar	Percent Cover 70 Days after Seeding* (6/19/81)	Percent Cover 21 Days after Pythium Outbreak (8/5/81)	Quality† (10/26/82)
Cheri	43.3	66.7	3.7
Geronimo	43.3	46.7	3.3
MLM-18011	43.3	61.7	4.3
Parade	43.3	45.0	3.7
Apart	41.7	40.0	4.3
Kimono	41.7	51.7	3.3
Mer pp 43	41.7	28.3	1.7
Piedmont	41.7	41.7	4.0
S-21	41.7	41.7	3.0
Shasta	41.7	45.0	3.3
1528 T	41.7	50.0	4.0
Aspen	40.0	51.7	4.7
Merit	40.0	60.0	3.7
Adelphi	38.3	50.0	5.0
K3-179	38.3	50.0	3.3
Bristol	36.7	36.7	3.7
Enoble	36.7	48.3	3.3
Lovegreen	36.7	48.3	3.0
NJ 735	36.7	41.7	3.0
RAM-1	36.7	50.0	4.0
Glade	33.3	53.3	4.0
Harmony	33.3	46.7	3.3
Baron	30.0	45.0	3.3
H-7	30.0	31.7	3.0
Dormie	28.3	33.3	2.7
Eclipse	28.3	48.3	3.7
Victa	26.7	31.7	2.7
243	25.0	41.7	3.3
A20-6	23.3	36.7	2.7
BA-61-91	23.3	36.7	2.3
Birka	23.3	38.3	2.7
Mystic (P-141)	23.3	28.3	2.0
A20	21.7	26.7	3.3
Cello	21.7	33.3	2.7
I-13	21.7	33.3	3.3
CEB VB 3965	20.0	30.0	2.0
Enmundi	20.0	40.0	3.3
SH-2	13.3	30.0	2.7
Nugget	11.7	16.7	1.7

*Data are the mean percent cover of the plots with Kentucky bluegrass 70 days after seeding (19 June).

†Quality ratings are made on a scale of 1 through 9; 9 represents ideal turf quality.

Regional cultivar trials were established at two sites the past fall: at the Rock Island County Extension Office and at the Cantigny Grounds and Museum in DuPage County.

ACKNOWLEDGMENTS

I wish to acknowledge the generous assistance of Richard Hentchal, Justin "Chub" Harper, Jesse Felix, Cisco Felix, and Jim Schuster in the establishment and maintenance of these plots.

ILLINOIS RESEARCH UPDATE

David J. Wehner

In this paper, I would like to cover four topics. First, I will present the results of our research on the decline of 'Toronto' creeping bentgrass. Second, I wish to present results from an herbicide trial conducted on broadleaf weeds. Third, I will introduce a research project that I hope to start in 1982 on water use in turfgrass management. Fourth, I will present some information on a topic we usually ignore at our research conference--our undergraduate program in turfgrass management at the University of Illinois at Urbana-Champaign.

DISEASE CONTROL RESEARCH

During 1980 and 1981, I conducted research in Illinois to determine the efficacy of antibiotics and standard turfgrass fungicides for controlling the decline of 'Toronto' bentgrass. This disease, which first appeared in the Chicago area in the fall of 1979, has caused such extensive damage that several golf course superintendents have abandoned 'Toronto' and replaced their greens with 'Penncross' or 'Penneagle' bentgrass. The disease occurs during cool, moist weather and is particularly severe when rain is followed by a bright, sunny day. The symptoms of the disease resemble those of the disease dollar spot; however, the spots have an orange cast to them in contrast to the bleached appearance of dollar spot. The disease can spread rapidly through a bentgrass putting surface, leaving behind patches of annual bluegrass. The end result is an unplayable area.

1980 Studies

Studies during 1980, conducted at Medinah Country Club in Medinah, Illinois, included a broad spectrum of standard turfgrass fungicides (chlorthalonil, Daconil 2787; iprodione, Chipco 26019; benomyl, Tersan 1991; triadimefon, Bayleton; propamocarb, Banol; metalaxyl, Subdue). None of these materials controlled the decline of 'Toronto' bentgrass. The rates used for the trial were chosen from the upper end of the recommended label rates.

In August of 1980, a cooperative research project was initiated and sponsored by the Golf Course Superintendents Association of America (GCSAA), the United States Golf Association (USGA), and the Chicago District Golf Foundation. Turfgrass researchers from the University of Illinois at Urbana-Champaign (UIUC) were given the task of conducting field trials of pesticides aimed at controlling the decline of 'Toronto' bentgrass.

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1981 Studies

The experiments conducted by UIUC researchers in 1981 concentrated on the use of fungicides and antibiotics for disease control. Several fungicides were tested again in case a fungal organism was responsible for the disease. Antibiotics were included on the premise that the disease organism is not a fungus but rather a bacteria or bacteria-like pathogen. Researchers at Michigan State University (Roberts et al. 1981) reported evidence in 1980 that bacteria or bacteria-like organisms were found in the water-conducting tissue of infected 'Toronto' bentgrass plants. This evidence, combined with the lack of disease control with standard fungicides in 1980 and the failure of several pathologists to isolate a fungal pathogen from diseased plants, formed the basis for the testing of antibiotics.

The majority of testing by UIUC researchers in 1981 was done at Silver Lake Country Club in Orland Park, Illinois, with smaller trials at Medinah Country Club and St. Charles Country Club in St. Charles, Illinois. In early April, a replicated trial with 21 different treatments was started on the bentgrass nursery at Silver Lake. As sometimes happens, the disease did not occur on the nursery that year. To increase the chance of getting some useful data, a series of smaller nonreplicated trials was established on two putting greens at Silver Lake, two at Medinah, and one at St. Charles. These trial plots consisted of four 60-foot-long sprayed strips, one strip each of chlorthalonil, metalaxyl, tetracycline (Mycoshield), and streptomycin (Agri-Strep), and an untreated check strip.

The disease pressure on these greens varied. There was, however, an indication that the antibiotic tetracycline showed promise for disease control on three of the five greens treated. The most striking observations were made on 20 May 1981 on the #11 green at Silver Lake. These observations are characterized by the 20 May disease ratings, which are presented in Table 1. They indicate a reduction in disease severity with the tetracycline (25 percent disease on tetracycline plot versus 50 percent disease on check plot) but not complete control and no control with chlorthalonil, metalaxyl, or streptomycin.

Table 1. Effects of Antibiotics and a Fungicide on 'Toronto' Creeping Bentgrass Disease Ratings

Treatment	Rate* (formulated product/ 1,000 sq ft)	Percent Disease	
		4/30/81	5/20/81
Streptomycin (Agri-Strep)	1.9 oz	30	40
Chlorthalonil (Daconil 2787)	11.0 fl oz	30	50
Tetracycline (Mycoshield)	2.4 oz	30	25
Metalaxyl (Subdue)	4.0 fl oz	30	60
Check		30	50

*All treatments were applied in 5.3 gallons of water per 1,000 square feet. Plots received three sprays from 4/30/81 to 5/20/81.

Based on the results of the nonreplicated trials, a second replicated study was established on 3 June 1981 on two putting greens (#1 and #11) at

Silver Lake. This trial concentrated on using tetracycline at several rates in an attempt to get better disease control. Prior to the start of the test, the plots on #1 had an average disease rating of 15 percent, and the plots on #11 had an average disease rating of 36 percent. The application rates and results for these studies are presented in Table 2. The higher rates tested (3.6 and 4.8 ounces per 1,000 square feet) were effective on #1 where there was minimal disease pressure, but they were ineffective on #11 where the disease was more severe before the start of the test. This study indicated that low rates may provide preventative control while higher rates would be needed for curative control.

Table 2. Effects of Tetracycline on 'Toronto' Creeping Bentgrass Disease Ratings

Treatment	Rate* (formulated product/ 1,000 sq ft)	Percent Disease on 6/17/81†	
		#1 green	#11 green
Tetracycline	1.2 oz	20 AB	40 A
Tetracycline	2.4 oz	17 BC	28 A
Tetracycline	3.6 oz	13 BC	21 A
Tetracycline	4.8 oz	5 C	16 A
Check		33 A	40 A

*All plots except those receiving 4.8 oz were sprayed on 6/3/81 and 6/10/81. Plots receiving a 4.8-oz rate were sprayed on 6/3/81.

†Means within a column followed by the same letter are not significantly different at the 5% level of confidence by the Duncan's Multiple Range Test.

The need for high rates of tetracycline for curative control was clearly demonstrated at St. Charles Country Club in an experiment started on the #16 green on 28 May 1981. Two sets of plots were established by Superintendent Peter Leuzinger. One set of plots was treated with the strips of chlorthalonil, metalaxyl, streptomycin, and tetracycline at the rates mentioned in Table 1. The second set of plots was treated with materials supplied to Superintendent Leuzinger by the researchers from Michigan State University. These treatments consisted of a copper-based fungicide (Kocide), tetracycline, and streptomycin applied at high rates in a heavy-drench treatment. By mid-June, it was apparent that plots receiving the high rates of tetracycline (40-60 ounces of Mycoshield in 50 gallons of water per 1,000 square feet) were free of disease, while plots receiving low rates of tetracycline showed no improvement.

Further research is needed to refine the tetracycline treatment procedure. Two major questions needing to be answered are: (1) how many applications are needed to prevent the disease from developing, and (2) can this material be used at rates lower than the heavy-drench treatment that was successful at St. Charles. I established a third set of plots at Silver Lake in an attempt to answer the question concerning rates of tetracycline. This study was established on 9 July 1981 and consisted of plots treated with various rates of tetracycline in 5, 10, or 20 gallons of water per 1,000 square feet. Shortly after establishing the plots, a change in the weather allowed the test area to improve and no useful information was gathered. Additional field work on this disease will be conducted in 1982 with the hope of answering these two major questions.

I would like to thank the GCSAA, USGA, and Chicago District Golf Foundation for their support of this project and Dudley Smith and Tom Hildreth of Silver Lake Country Club, Don Pakkala and Kip Tyler of Medinah Country Club, and Pete Leuzinger of St. Charles Country Club for their cooperation with the field testing program.

BROADLEAF WEED CONTROL

The high cost of pesticide development has prohibited the introduction of new herbicides that are used only for weed control in turfgrass stands. Manufacturers are evaluating new formulations of standard turfgrass herbicides or seeking data to expand the labels of products that have proven efficacious on large-scale crops. The purpose of this research was to evaluate the herbicides 2,4-D, MCPP, dicamba, bromoxynil, and Glean for control of broadleaf plantain (*Plantago major* L.), buckhorn plantain (*Plantago lanceolata* L.), and white clover (*Trifolium repens* L.) in a mixed Kentucky bluegrass-tall fescue (*Poa pratensis* L.-*Festuca arundinacea* Schreb.) turfgrass stand. Treatments consisted of sprays containing individual herbicides or combinations of herbicides applied in 28 gallons of water per acre, or herbicide-fertilizer combinations applied in 172 gallons of water per acre.

Weed population ratings taken eight weeks after herbicide application indicated that the best control of broadleaf plantain was afforded by the herbicide 2,4-D alone or in combination with other herbicides. Equal control was found on plots treated with a combination of bromoxynil and MCPP. The herbicides Glean and dicamba did not control broadleaf plantain. The results for buckhorn plantain closely paralleled those for broadleaf plantain. The best control of white clover was found on plots treated with the herbicides MCPP and dicamba either alone or in combination with other materials. Neither 2,4-D nor Glean adequately controlled this weed species. Weed control was not affected when fertilizer was combined with herbicides and applied in a large volume of water.

WATER USE IN TURFGRASS MANAGEMENT

The supply of water available for use by the turfgrass manager will decrease in the future. In some states and communities, there already are restrictions on irrigation of turf areas. I think that all turfgrass managers should be aware of this trend and be prepared to implement water conservation practices when and if water use is restricted in their locale. We hope to start some research at the University of Illinois on water use by turfgrass stands. Our research project will include basic research on the water-use patterns of Kentucky bluegrass, creeping bentgrass, and annual bluegrass as well as applied research to demonstrate our current knowledge on water use. Today, I wish to explain the nature of the applied studies and alert you to the fact that I may be calling on some of you to cooperate in this research project.

The purpose of the applied research project is to demonstrate that water savings can be realized without sacrificing acceptable turfgrass quality. No research is needed to demonstrate that water is necessary for turfgrass growth--without water, the plants go dormant or die. It is possible, however, to reduce the amount of irrigation without causing a deterioration in turfgrass quality. Water savings can be realized by implementing sound irrigation management practices that are based on an understanding of plant-soil-water relationships. By knowing the factors that affect the amount of water available for plant growth and the rate at which water is being used by the turfgrass stand, the needs of the plant can be met without wasting water.

The major factors affecting the amount of water available for plant growth are the amount of irrigation or rainfall, the rate of precipitation, the infiltration rate of the soil, and the water storage capacity of the soil. We are interested in maximizing the amount of water available for plant growth in ways other than simply applying more water via long, frequent irrigations. The turfgrass manager generally has control of only two of the factors that determine the amount of water available for turfgrass growth--the amount and rate at which irrigation water is applied. Turfgrass managers should start to plan their water conservation programs by determining the infiltration rate of the soil. This is done with a device called a double ring infiltrometer that in reality is nothing more than two steel rings pounded into the soil. The infiltrometer is placed into the soil, and water is added to both rings. After the soil has been saturated, the rings are refilled with water and the rate at which the level drops is determined. This rate is called the infiltration rate, indicating the maximum rate at which irrigation water can be applied without causing runoff from the site. This procedure may have to be repeated in different locations according to changes in topography and soil characteristics.

The turf manager must know the soil moisture status on the area to be irrigated. Soil moisture can be monitored with the aid of an instrument called a tensiometer, which gives readings as to the wetness or dryness of the soil. This instrument has a porous ceramic tip that is connected by a column of water to a gauge that gives a numerical reading. The tensiometer is inserted into the soil, and the water column in the instrument equilibrates with the soil solution. If the soil is dry, the gauge will indicate a high reading; if the soil is wet, the gauge will indicate a low reading. The readings in the gauge must be correlated with plant performance to establish when irrigation water is needed. By allowing the turf to dry out, taking a reading, and then irrigating until the tensiometer gives a low reading, the manager will know approximately how much water the soil can store.

The turfgrass manager can now plan to irrigate when the tensiometer gives a specific high reading until the tensiometer gives a specific low reading. By knowing the amount of rainfall, the manager can supply what is needed to keep the amount of water stored in the soil at the desired level. Irrigation water should be applied at a rate that is lower than the infiltration rate of the soil. Through refinement, the manager can construct a program that supplies the needs of the turf and results in a savings of water, through both the elimination of runoff and the application of only what water the root zone can store.

The usefulness of this type of irrigation program has been demonstrated in California by Dr. Gibeault (1978). He determined the amount of water used on turfgrass plots that were irrigated either on a set schedule or when tensiometers gave a reading that indicated the soil had dried out. The amount of water used to irrigate the turf on a set schedule was considerably higher than that used on the plots with tensiometers. Turfgrass quality was equal under both irrigation treatments.

Water savings can also be realized by modifying irrigation systems so that they apply water only to the areas that absolutely require irrigation. Dr. Augustin (1981) from Florida has illustrated in a recent trade journal article how this concept would work on a golf course. He suggests discontinuing irrigation on the area between the fairway and tee and also installing part-circle heads around the greens. The part-circle heads are set so that they apply water only to the putting surface and not to the surrounding bunker area.

TURFGRASS EDUCATION

We often neglect an important topic at our turfgrass research conferences--the undergraduate program in turfgrass management at the University of Illinois at Urbana-Champaign (UIUC). I would like to tell you more about our program since you often come into contact with students who are interested in turf management but do not know how to pursue their interest.

The program at the UIUC leads to a bachelor of science degree in ornamental horticulture. In this program, students take courses from three major areas. The first area is the humanities and social sciences. Courses such as English, music, sociology, and psychology help develop the communication skills of the students as well as make them aware of their surroundings. The second area consists of courses, such as plant pathology, soil science, entomology, and chemistry, that provide a foundation on which students can build their knowledge of plant science. The third area consists of courses from the horticulture core such as arboriculture, plant propagation, turfgrass management, woody ornamentals, landscape design, and bedding and foliage plants. These courses provide the information needed to manage plants in the environment.

After completing courses in all three areas, students are prepared to pursue any type of career from golf course superintendent to landscape contractor. Students will not be discouraged by being trained in a narrow area that may or may not be in demand at graduation time.

I encourage anyone interested in the UIUC program to contact me for further information.

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SOUTHERN ILLINOIS RESEARCH UPDATE—1981

Herbert L. Portz, J.E. Preece, and B. Joon Ahn

CULTIVAR EVALUATION AND MANAGEMENT LEVELS

Kentucky Bluegrass versus Tall Fescue for the Transition Zone

The location of southern Illinois in the transition zone (Plant Hardiness Zones 6 and 7) makes it difficult to maintain most cool-season turfgrasses. The most-wanted turfgrass in southern Illinois is Kentucky bluegrass; but summer heat, drought, dormancy, and diseases allow crabgrass to overtake this delicate queen of the cool-season grasses. Tall fescue, however, has good drought, heat, and wear tolerance and is the preferred cool-season turfgrass as far south as north Georgia and as far west as Kansas. A coarse leaf texture, bunch growth habit, and seedling frost-heaving susceptibility are disadvantages of this otherwise rugged king of the cool-season turfgrasses.

Research with Kentucky bluegrass at Southern Illinois University at Carbondale (SIU-C) indicated that, in 1976, cultivars such as 'Adelphi', 'Brunswick', 'Merion', and 'Sydsport' had very good heat and drought tolerance compared to the poor tolerance or early dormancy of 'Aquila', 'Touchdown', 'Birka', and 'Common'.

Results of a management study including irrigation and cutting height are shown in Table 1.

In 1980, with severe summer stress and Fusarium blight, 'Touchdown' was the most severely thinned under conditions of no irrigation and low cut, whereas 'Vantage' and 'Parade' survived the best of all cultivars under conditions of both low and high cut. In 1981, a late infestation of crabgrass appeared in the low-cut, irrigated plots, and there was an average quality rating of 4.1 as compared to a high rating of 7.8 for the high-cut plots. Similar advantages were shown for high-cut with no irrigation; however, the difference was not as great as in the irrigated plots.

Kentucky bluegrass cultivars were evaluated from 1975 to 1978. Table 2 summarizes their performance characteristics for different maintenance levels and indicates their relative drought-stress tolerances.

Recommendations for yearly fertilizer applications on home lawns in southern Illinois (Table 3) are based on the results of several years of fertilizer experiments on Kentucky bluegrass.

H.L. Portz and J.E. Preece are professors, and B.J. Ahn is a graduate research assistant, in the Department of Plant and Soil Science at Southern Illinois University at Carbondale.

Table 1. Effects of Irrigation and Cutting Height on Turfgrass Quality of Cultivars of Kentucky Bluegrass in 1980 and 1981 at Southern Illinois University at Carbondale*

	Irrigated		Nonirrigated		
Cultivar	Low Cut (1-1/4 inches)	High Cut (2-1/4 inches)	Low Cut (1-1/4 inches)	High Cut (2-1/4 inches)	Ave.
		10 September 1980†			
Adelphi	6.0	7.0	3.3	4.7	5.2
Baron	6.0	6.0	3.0	3.3	4.6
Bensun	6.0	6.3	3.7	4.3	5.1
Bristol	6.7	7.0	3.0	4.3	5.2
Common	5.3	5.7	3.7	4.3	4.8
Parade	6.3	7.0	4.7	6.0	6.0
Touchdown	5.3	6.0	1.7	3.3	4.1
Majestic	6.7	7.0	3.7	4.7	5.5
Vantage	5.7	6.7	5.3	5.3	5.8
Ave.	6.0	6.5	3.2	4.5	
		18 November 1981†			
Adelphi	5.3	9.0	8.0	8.3	7.6
Baron	4.2	7.7	6.5	7.0	6.4
Bensun	3.2	8.0	6.7	8.0	6.5
Bristol	4.2	8.0	6.5	8.7	6.8
Common	2.5	7.0	5.7	8.0	5.8
Parade	5.2	7.5	7.2	8.3	7.0
Touchdown	5.7	7.5	5.2	6.8	6.3
Majestic	4.5	8.0	6.5	7.7	6.7
Vantage	2.3	7.5	7.5	8.0	6.3
Ave.	4.1	7.8	6.6	7.9	

*9 = excellent quality, no weeds; 1 = all dead, many weeds

†1980 = combination of Fusarium and drought; 1981 = crabgrass enroachment

Table 2. Performance Characteristics of Kentucky Bluegrass Cultivars at Southern Illinois University at Carbondale, 1975-1978

Medium to high maintenance	Drought-stress tolerance
Adelphi	Very good
Parade	Medium
Touchdown	Medium
Brunswick	Very good
Sydsport	Very good
Bensun (shade tolerant)	Very good
Baron	Good
Glade (shade tolerant)	--
Low to medium maintenance	
Majestic	Good
Aquila	Poor
Vantage	Good
Rugby	--
Common types (Park, etc.)	Poor (but early dormancy)
Victa	Good
Not recommended (disease, etc.)	
Merion (mildew, rust, Fusarium blight)	Very good
Windsor (stripe smut, poor fall color)	--
Fylking (Fusarium blight, mildew)	Medium
Nugget, Pennstar, Common, etc. (dollar spot, Fusarium blight, leafspot, or stripe smut)	Medium to poor

Table 3. Recommended Yearly Fertilizer Applications on Home Lawns in Southern Illinois

Date	Pounds of Nitrogen per 1,000 square feet	Fertilizer
Mid-May	1 - 1.5	Slow Release (IBDU or similar)
September	1 - 1.5	Complete Analysis (12-12-12 or similar)
Mid- to late November	1.5	Fast Release, Soluble Nitrogen (34-0-0 or 46-0-0)

The advantages for a fertilizer program of late fall nitrogen and mid-May slow-release nitrogen as compared to predominantly early-spring applications have been shown to be the following:

1. better winter color
2. enhanced photosynthate production
3. earlier spring green-up
4. increased root growth with minimum top growth
5. less excess spring growth
6. better turf density
7. less disease (with slow-release fertilizer in May)

This program and its advantages have been reported previously with the exception of the last one (less disease). In 1980, however, severe drought stress and Fusarium blight resulted in lower September turf quality when ammonium nitrate was applied on 15 May than when IBDU was applied, regardless of what the previous fall fertilization had been (see Table 4).

Table 4. Effects of Fusarium Blight and Drought on Kentucky Bluegrass after Ammonium Nitrate and IBDU Fertilization

Previous Late Fall Fertilization	15 May 1980 Application	Sept. 1980 Quality*
Ammonium nitrate	Ammonium nitrate	4.0
	IBDU	5.0
IBDU	Ammonium nitrate	3.4
	IBDU	4.2
Check (only 12-12-12 in Sept.)	Ammonium nitrate	3.0
	IBDU	4.3

*9 = full stand and excellent quality; 1 = all dead

Tall fescue cultivar evaluation was begun in 1975 and included mixtures with Kentucky bluegrass. Several new cultivars at that time, 'Kenwell' and 'Kenhy' from Kentucky and 'Galway' (then 'K-108') from Northrup King, were slightly better than 'Kentucky 31' ('Ky 31'). Mixtures of 'Ky 31' and several Kentucky bluegrass cultivars and blends performed better than tall fescue alone. A 90:10 ratio of 'Ky 31' to 'Baron' or 'Majestic' gave better quality than 'Common' or 'Nugget' mixtures (7.0 and 6.9 as compared to 6.2 and 6.3, respectively). Results of a tall fescue experiment begun in 1977 are shown in Table 5. 'Rebel' had the best average quality from 1978 to 1981, both alone (6.5) and in a 90:10 mixture with Kentucky bluegrass (6.6). Results from a Southern Regional Tall Fescue Trial at Wichita, Kansas, indicated that the top three cultivars in visual quality for 1979-80 were 'Rebel', 'Beltsville Synthetic 16-1', and 'Falcon'. The first two cultivars are also finer textured than 'Ky 31', a major selection criterion for newer tall fescue cultivars. 'Belt Syn 16-1' is being released as genetic material to be used in breeding programs.

Table 5. General Quality of Tall Fescue Cultivars and Mixtures with Kentucky Bluegrass at Southern Illinois University at Carbondale*

Cultivar/ Mixture	1978 19 July	1979 24 May	1980 15 July	1981 7 April	1978-81 Average
I-96 (MO)	5.0	4.7	5.7	5.7	5.3
Ky 31	5.7	5.7	6.3	6.3	6.0
Galway (NK)	5.7	6.0	7.0	6.3	6.2
Surprise (MO)	5.0	4.0	6.0	6.3	5.3
V-11 (MO)	6.0	5.0	6.3	6.7	6.0
Rebel (NJ)	6.3	6.7	6.0	7.0	6.5
				Ave.	5.8
I-96/KB†	6.0	4.7	6.7	6.0	5.8
Ky 31/KB	5.7	6.3	7.0	7.0	6.5
Surprise/KB	5.3	4.0	6.7	6.7	5.7
V-11/KB	6.3	5.3	7.0	6.3	6.2
Rebel/KB	6.3	6.0	7.0	7.3	6.6
				Ave.	6.2

*9 = excellent quality; 1 = no stand
†KB = Kentucky bluegrass, 90/10 ratio by weight

Bermudagrass versus Zoysiagrass

Selection of these two warm-season turfgrasses has been ongoing at SIU-C since 1975. Presently there are 25 cultivars or breeding selections of bermudagrass and 35 of zoysiagrass. The latest 15 of the zoysiagrass selections are from Korea and were brought to the United States by Dr. D.Y. Yeam. Both turfgrasses have certain desirable qualities, but the most important single requirement for use in our transition zone is cold tolerance. Cold-tolerance tests have been conducted at SIU-C since 1977 in a cold chamber, because winter field conditions in the past few years have been mild or the ground has been snow-covered (hence very little winter damage). Cold tolerances for cultivars of bermudagrass and the several species of zoysiagrass are noted in Table 6.

A major malady that has been increasing in zoysiagrass lawns is "neglectitis." High, infrequent cutting and too much nitrogen causes thatch buildup. Consequently, in the dry, hot summer of 1980, considerable Fusarium blight and nematodes took advantage of the thatchy, stressed zoysiagrass and severely reduced stands. Lower cutting height, dethatching, and less nitrogen are recommended.

ZOYSIAGRASS SEED PHYSIOLOGY

Dr. Yeam and coworkers in Korea developed a seed-treatment technique for enhancing zoysiagrass seed germination. Dr. Yeam further refined this

Table 6. Cold Tolerance of Bermudagrass and Zoysiagrass Cultivars

Very good (<-11°C)	Good (-10 or 11°C)	Fair (-7 or -8°C)	Intermediate ----------	Poor (>-7°C)
		Bermudagrass		
--	C-53*	Midiron* Westwood* T-4* A-8* P-1*	Tiffine* Tifgreen* Common* (naturalized)	Tufcote* Tiflawn* U-3* Common (Arizona seed)
		Zoysiagrass		

Z. japonica (Medium to coarse texture)	*Z. matrella* (Fine to medium texture)	*Z. tenuifolia* (Very fine to fine texture)
Meyer* Midwest Korean	Z-102* Matrella Emerald (*japonica* x *tenuifolia*)	Most new† California selections

*Tested in cold chamber at Southern Illinois University at Carbondale (SIU-C) in 1978, 1979, 1980.

†Field tested at SIU-C; mostly killed in 1979-80, but poorly established; replugged in 1980; fair survival in 1981.

technique while on sabbatical leave at SIU-C and USDA-Beltsville (USDA-B) in 1979-80. It consists of treating seed with a 30-percent KOH- or NaOH-water solution for 25 minutes, followed by light treatment for 36-48 hours, and may include a presoaking for 24 hours before seeding. Germination is increased from 5 to 10 percent in 10 to 15 days to 80 to 90 percent in 4 to 7 days.

What happens to the seed that helps break dormancy and hasten germination? Seeds first must imbibe water, and it has been shown that KOH or NaOH scarifies the seed coverings and allows water to enter the seed. Previous research has also shown the effect of red and far-red light on the phytochrome system; red light triggers germination, whereas far-red light reverses the reaction. Once certain inhibitors are reduced and promotors increase, germination can proceed.

The precise role of seed coverings on the dormancy of zoysiagrass is being investigated by Mr. Joon Ahn. In one experiment, KOH-scarified seed and seed mechanically decoated after KOH scarification were subjected to red-light irradiation times from 10 seconds to 60 minutes. Results (shown in Table 7) indicate that KOH-scarified seed required a longer light exposure to germinate 50 percent or better than did the decoated seed. This and other experiments indicate that waxy seed coverings may screen out light or contain inhibitors. KOH scarification, therefore, changes the seed coverings so that water can be imbibed, light can penetrate, and/or inhibitors can be reduced.

Table 7. Percent Germination of Zoysiagrass after Different Seed Treatments and Various Red-Light Irradiation Times

Seed Treatment	Red-Light Irradiation Time					
	0 sec	10 sec	1 min	5 min	30 min	60 min
Untreated	0.0	---	---	---	---	0.3
KOH-scarified	6.6	14.0	19.0	37.6	60.6	57.0
Decoated	29.6	57.6	59.0	70.6	76.6	68.8

ZOYSIAGRASS ESTABLISHMENT AND MANAGEMENT

Major efforts in the last several years have been to establish zoysiagrass by stolons and seeds. Methods for seeding into a prepared seedbed were further studied in 1981 with NaOH-scarified Korean zoysiagrass seed (S) and NaOH-scarified plus light-treated seed (SL). Seed was dropseeded at rates from 0.5 to 1.5 pounds per 1,000 square feet and rolled with a smooth roller or Brillion seeder. A preemergence application of eight pounds active ingredient per acre of siduron was followed by postemergence treatments of 2,4-D/dicamba and bentazon. There was no difference in ground cover between smooth and Brillion rolled. Results shown in Table 8 indicate that, on the average, a better ground cover was achieved with SL seeds than with S seeds. A 0.75-pound seeding rate of SL seed appears adequate, providing over 90 percent ground cover in 12 weeks.

Alternative methods of establishing zoysiagrass seed were tested in 1981. A Kentucky bluegrass sod located at the Dixon Springs Agricultural Center in Illinois was treated with glyphosate or the growth retardant mefluidide (Embark) three weeks prior to seeding and again just before seeding. One pound per 1,000 square feet of scarified plus light-treated seed was dropseeded, and then plots were vertical mowed or flex-harrowed two times. Two other treatments were implemented with John Deere and Moore grassland drills. Two post-treatments with DSMA were applied at 7 and 8-1/2 weeks. Results shown in Table 9 indicate successful establishment in glyphosate-killed sod with either the flex-harrow or vertical mowing method of seed incorporation.

Seeding cool-season grasses with zoysiagrass was tested at both SIU-C and USDA-B. Results of the USDA-B experiment are shown in Table 10. Very low seeding rates of cool-season grasses such as perennial ryegrass and tall fescue must be used in order to insure successful zoysiagrass seedling establishment. With only one-half pound of ryegrass, 58.9 percent of the

Table 8. Effects of Seeding Rate and Seed Treatment on Seedling Establishment of Zoysiagrass after 12 Weeks*

Seeding Rate (pounds per 1,000 sq ft)	Percent Ground Cover †	
	NaOH scarified	NaOH scarified and light treated
0.5	83.0 d	85.0 cd
0.75	88.3 bcd	90.8 ab
1	83.3 d	92.5 ab
1.25	90.8 ab	92.5 ab
1.5	89.2 abc	95.0 a
	Ave. 87.0 B	91.0 A

*This experiment was carried out in 1981 at Southern Illinois University at Carbondale.

† Means within columns followed by the same letter and between columns followed by the same capital letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

Table 9. Effects of Kentucky Bluegrass Sod and Seeding Method on Resulting Ground Cover of Zoysiagrass*

Sod Treatment	Seeding Method	Seeding Rate (pounds per 1,000 sq ft)	Percent Ground Cover †	
			7 weeks	12 weeks
Glyphosate	Flex harrow	1	58.8 a	66.0 a
	Verticutter	1	56.2 a	67.5 a
	Moore drill	0.25	13.8 b	20.0 b
	John Deere drill	0.25	12.5 b	17.5 b
Embark	All methods		< 10	< 10

*This research was performed at the Dixon Springs Agricultural Center, University of Illinois, in 1981.

† Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

total stand was zoysiagrass, whereas with two pounds only 24.4 percent of the total stand of 92.2 percent was zoysiagrass. These cool-season grasses can provide early erosion control, some winter seedling protection, late fall and early spring green color, and earlier use of the turf.

Hydroseeding and hydromulching were also tested; results indicated that only a light straw or turf-fiber mulch should be used.

Table 10. Effects of Seeding Rates of Zoysiagrass* and Cool-Season Grasses on Ground Cover**

Cool-Season Grass	Seeding Rate (pounds per 1,000 sq ft)	Percent Ground Cover in 7-1/2 Weeks†	
		Total with cool-season grasses	Zoysiagrass only
Perennial	0.5	77.2 b*	58.9 a
Ryegrass	1	94.3 a	33.3 b
'Citation'	2	92.2 a	24.4 b
Tall	1	80.0 b	62.1 a
Fescue	2	85.5 ab	52.8 b
'Rebel'	4	88.3 a	48.3 b
Kentucky	0.25	68.3 b	80.6 a
Bluegrass	0.5	86.4 a	74.4 a
'S.D. Com.'	1	88.8 a	60.0 b

*Korean zoysiagrass seed (NaOH scarified and light treated) was planted at 1/2, 1, and 1-1/2 pounds per 1,000 sq ft. The data are an average of three seeding rates and represent percent of total ground cover of zoysiagrass.

†Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's Multiple Range Test.

**This research was performed at USDA-Beltsville in 1981.

SAND-BASED GREENS

Sand-based greens have been increasing in popularity and are of special interest where the many clay-loam soil greens in southern Illinois need to be improved or replaced. Deeper rooting was found in medium sands than very fine sands in the greenhouse. Sand-based greens are being established at the Horticulture Research Center at Carbondale. The objectives are:

1. to compare sands of different particle sizes for use in root zones for bentgrass and zoysiagrass
2. to compare different sand root-zone depths over native soil up to a full 12-inch sand depth
3. to compare two organic materials (sawdust and peat moss) for shallow surface modification of sand
4. to test three seeded bentgrass cultivars and several fine-leaved zoysiagrass cultivars for their adaptation to sand-based greens
5. to determine irrigation and fertilization needs for bentgrass growing in various sand root zones

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CURRENT RESEARCH ON FUSARIUM BLIGHT OF KENTUCKY BLUEGRASS

Richard W. Smiley

Fusarium blight continues to receive specific research emphasis in New York. Investigations are balanced among four major disease-control approaches, including chemical controls, genetic controls, soil and plant management, and the etiology (cause) of the disease. A brief review of the research at Cornell University follows.

FUNGICIDES

The efficacy of fungicides for controlling Fusarium blight was evaluated on 'Merion' Kentucky bluegrass turf established from sod in early 1979. The plot is maintained as a fairway at The Mill River Club, Oyster Bay, New York. Fungicides were applied on 8 June, 29 June, and 22 July 1981. Treatments were composed of 4 x 15-foot test areas replicated four times in a randomized complete block design. The fungicides included Bayleton (triadimefon), F-8411 (triadimefon plus fertilizer), Vangard (etaconazole, CGA 64251), Chipco 26019 (iprodione), Tersan 1991 (benomyl), Subdue (metalaxyl, CGA 48988), and Terraclor (quintozene, PCNB). Applications of F-8411 were made by broadcasting through a drop spreader. All other chemicals were applied as foliar sprays with a self-powered boom sprayer that delivered five gallons per 1,000 square feet at 100 pounds per square inch (psi). Each plot received the golf course's complete fairway maintenance program, including application of fungicides for control of other diseases. Fusarium blight symptoms were first observed in late July, and the percentages of turf killed were assessed on 13 August. Data were evaluated for statistical significance by use of Duncan's Multiple Range Test at the 0.05 level of significance.

The disease severity was relatively light on the plot during 1981. Nontreated control plots had 17 percent of their areas affected by Fusarium blight. As is typical, good control was achieved with the three applications of Bayleton at a 2-ounce rate (1 percent blight), Vangard at 2 fluid ounces (1 percent), Chipco 26019 at 8 ounces (2 percent), and Tersan 1991 at 8 ounces (4 percent). Most important, however, was the significant reduction of disease by applications of Subdue at 15 ounces (5 percent blight). Terraclor 75 at 3 ounces failed to provide significant control. Since Subdue is rather specific as a toxicant against *Pythium* and related fungi, and since similar results had been achieved at this location previously, a review of our past fungicide evaluation studies was necessary.

Results similar to those of 1981 were achieved at The Mill River Club in 1978 and 1980, where the nontreated controls contained only 11 percent and 5 percent blighted turf, respectively. However, on another fairway of

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the same golf course during 1979 and 1980, where controls had 40 percent and 33 percent diseased turf, Subdue and Terraclor were totally ineffective in reducing the level of disease.

Chemical screening studies are useful tools for studying disease complexes. Pesticides that affect different groups and species of microorganisms may be used to determine the possible roles of these different organisms in a disease syndrome. This approach is commonly used to study complex diseases on many types of crops, and it is yielding important new information about Fusarium blight on Kentucky bluegrass. Only after eight years of study at one location with as many as eight individual plots at that location each year, and only after a series of technologically advanced fungicides has been developed, can we deduce that more than one pathogenic fungus is apparently involved in the Fusarium blight disease in New York.

The disease complex appears to include species of *Fusarium* and *Pythium*, but the nature of the contributions of these and possibly other fungi to the disease process remains uncertain. Also unknown are the reasons why (1) some fungicides ineffective against *Pythium* nearly always control the disease; (2) some fungicides that affect groups of fungi other than *Fusarium* are sometimes quite effective when the disease severity is low; and (3) the responsiveness of the disease to these fungicides varies from site to site and from year to year.

Six granular formulations of triadimefon (Bayleton) were evaluated for Fusarium blight control on a 'Fylking' Kentucky bluegrass fairway at the Village Green Golf and Country Club near Syracuse and on a 'Merion' fairway at The Mill River Club on Long Island during 1980. All of these formulations completely controlled the disease on Long Island, and none of them was effective at Syracuse. Since all triadimefon formulations normally provide excellent control of Fusarium blight at all other test locations, the test near Syracuse was repeated in 1981 to determine if an application timing problem had been responsible for the failure during 1980. The 1981 test included sprays of Bayleton 25W and broadcast applications of Bayleton 5G (not commercially available). Application rates of 0.5, 1.0, and 2.0 ounces of active ingredient per 1,000 square feet, repeated at 20, 30, or 60 days, respectively, were started on 1 May, 1 June, and 2 July. The disease appeared in July, and none of the preventive triadimefon programs suppressed the disease. The timing and rate of application do not appear responsible for failure of Bayleton to control the disease at Syracuse. The nature of the fungi involved in the disease is being investigated.

Another component of our chemical control program involved the completion of a Master of Science degree by Mr. Randall T. Kane (B.Sc., Turf Agronomy, Purdue; M.Sc., Turf Pathology, Cornell). His program was financed by grants from the Sod Grower's Association of Mid-America, the American Sod Producer's Association, and The Musser International Turfgrass Foundation. This research examined the influence of systemically translocated fungicides and related growth-regulating chemicals on Fusarium blight. The studies developed from our observations that the best controllers of this disease appeared to be fungicides that caused the highest level of changes in growth and appearance of the treated plants. His objective was to determine whether the growth-regulatory activity or the fungitoxic activity exhibited by these fungicides is of greater importance for control of this disease.

During two years of field, greenhouse, and laboratory research, Randy Kane determined that growth-regulatory activity alone is unable to control Fusarium blight. Yet, since the best compounds for controlling the disease are not all highly toxic to *Fusarium* species, the precise value of fungitoxic activity alone is also in question. Randy Kane concluded that a balance of fungitoxicity and growth modification appears necessary for optimum disease control. The growth parameters studied included changes in leaf production rate, root weight, chlorophyll content and retention, and concentrations of total nonstructural carbohydrates (TNC). His research showed that fungicides such as Bayleton, Chipco 26019, and Tersan 1991 can reduce growth of bluegrass leaves and roots, delay the natural senescence of leaves, and increase the TNC content. Each of these can in turn be expected to modify a plant's tolerance to stressful conditions, and most of the changes could assist plants to survive conditions that are deleterious to unprotected plants. These studies contributed much to our understanding of disease control mechanisms and are applicable to many phases of turfgrass management. Randy Kane is continuing to work closely with our turfgrass research program as he embarks upon a Ph.D. degree, with emphasis on *Fusarium* diseases of wheat. He has submitted manuscripts on his research for publication in *Agronomy Journal* and *Phytopathology*.

RESISTANT VARIETIES

The susceptibilities of 76 Kentucky bluegrasses, blends, or mixtures to Fusarium blight at New Brunswick, New Jersey, was reported by Dickson and Funk (1976). Similar data were then obtained by scientists in Texas, California, and Illinois as well. These reports stimulated me to determine whether the adaptation of a bluegrass to its particular site of origin could become useful for predicting the potential severity of Fusarium blight. Such information would be very useful to plant breeders. An international survey of 16 plant breeders was conducted in 1978 and 1979. A questionnaire sent to each breeder requested information regarding the location where each variety's parental clone had been selected or bred and the environmental and management characteristics for that site of origin.

The data for 49 varieties were analyzed statistically, using the following as variables: the percent disease at four locations, the variety's apomictic percentage, latitude and altitude, average July temperature and rainfall, shade, slope and slope aspect, mowing or grazing height, soil fertility, texture, pH, and irrigation. It was found that none of these variables or their combinations adequately predicted a variety's susceptibility to Fusarium blight. Nevertheless, the varieties selected from areas of highest summer temperature or of lowest latitude tended to be least susceptible. Environmental parameters at the four test sites (New Jersey, California, Texas, Illinois) were also compared with varietal performances. The average combined disease ratings for all varieties at each location was highest at locations with the highest July temperature or highest altitude, but the individual varieties had variable responses. Although general trends were clearly present, it was concluded that the environmental factors we studied were less important than untested and unidentified variables (such as plant growth characteristics or heat tolerance) for predicting the susceptibility of specific varieties to Fusarium blight. Results of this two-year study were published (Smiley et al. 1981).

MANAGEMENT AND PLANT RESISTANCE

Herbicides

Variety selection studies of Dickson and Funk (1976) illustrated that Kentucky bluegrass varieties differed in susceptibility to Fusarium blight if they had previously been treated with calcium arsenate herbicide. Dr. C.R. Funk graciously shared with me their more voluminous unpublished data which showed that some varieties had the same amount of blight in treated and untreated plot areas but that others exhibited up to tenfold increases in blight when they had been treated with the herbicide. Gibeault et al. (1977) then reported very similar results on a linuron-treated plot in California.

I therefore established a test in 1980 to examine the effects, if any, of seven herbicides that are or were commonly used for controlling crabgrass and annual bluegrass. The study included granular formulations of Balan, Betasan, calcium arsenate, Dacthal, Ronstar, Scott's *Poa annua* Control (linuron), and Tupersan; it consisted of 28 different treatments, each replicated four times at three different sites. These tests are on old turfs that are regularly blighted ('Merion'), are only occasionally blighted ('Fylking'), or have never been blighted ('Fylking'). 'Merion' and 'Fylking' are moderately to highly susceptible to Fusarium blight. The herbicides were applied during 1980 and 1981. Disease was light and nonuniform among replicates during both years at the two sites where disease had occurred previously. Results at both sites are confounded by summer death of *Poa annua*. Fusarium blight was not induced by two years of herbicide use on the turf that has had no history of this disease. At this time, we are unable to detect any increases in Fusarium blight after applying the herbicides at low- or high-labelled rates.

Parallel herbicide studies were conducted on sod. The herbicides were applied in April 1980 to 'Fylking' sod and a blend of 'Merion' plus 'Fylking' plus 'Adelphi'. The sods were harvested and moved to my sod research nursery at Pinelawn Memorial Park at Farmingdale, Long Island, during early June 1980. Although the turf was intentionally kept rather dry after initial rooting was completed, no thinning or other deleterious effects of the herbicides were noted on these sods during their first two seasons at the installation site. A smaller study of a similar nature was also conducted with sods of 'Fylking', 'Merion', 'A-34', or 'Adelphi' bluegrasses. Again, no adverse effects of the herbicides have been noted through the first two seasons. In fact, these studies with herbicides have resulted in only favorable effects to date. Nevertheless, our use of calcium arsenate in other plots in a blight-prone area during 1978 caused a very strong amplification of Fusariam blight, compared to untreated areas. Results consistent with those from the studies in New Jersey and California were anticipated from our recent studies. Such inconsistencies are no longer surprising in Fusarium blight research. These studies are being continued through 1982 or 1983.

Water and Water Management

Mr. David Thompson (B.Sc. and M.Sc., Plant Pathology, Cornell) recently completed an investigation to test an earlier hypothesis (Smiley 1980) that excessive water in a soil profile, or excessive humidity in the plant canopy, can predispose turf to infection by *Fusarium* species. It has been widely recognized that drought causes an increase in the potential for Fusarium blight to occur. However, in 1977 the landscape gardeners on Long Island asked me why the disease was also very severe during years of record high rainfall. My survey of field notes and weather data substantiated their observations for that area and led me to hypothesize that both extremes in moisture were harmful. David Thompson's in-depth research in the greenhouse and in the field showed that drought is more conducive to predisposition than is excess moisture but that both conditions predispose turfgrass plants to higher levels of infection. He studied the accumulation of toxic gases, the depletion of oxygen in soil, and the resultant physiological stress in plants to make his determinations.

Overall Management

The pesticide and varietal origin studies described above are balanced by a large number of cultural management and varietal evaluation studies. Current investigations emphasize sodded turf and center upon long-term plots that are located at The Mill River Club and at Pinelawn Memorial Park on Long Island. These study areas were established on specially sodded areas maintained as a fairway and rough or as a commercial lawn, because previous studies of Fusarium blight in the United States have been conducted on seeded stands. Results of tests on seeded turf are not necessarily applicable to turf established as sod. Eight sod producers in southeastern New York provided sod for these studies.

At The Mill River Club, early in 1979, 12,000 square feet of existing sod were removed and replaced by new sod over a fairway that had been severely damaged by Fusarium blight for several years. The cultural variables on this study area include three varieties ('Adelphi', 'A-34', or 'Merion'), two mowing heights (5/8-inch fairway or 1-1/2-inch rough), two liming materials (dolomitic granular or hydrated sprayable), gypsum, core cultivation, and excess nitrogen. Half of each management variable on each variety is also treated with linuron herbicide. Additionally, some of the studies described later in the Etiology section are located on this sod, as is one of the fungicide programs described earlier. In 1980, disease occurred at very low levels (6 percent blighted grass) on the 'Merion' (equal disease on sod provided from two different growers), and none occurred on 'A-34' and 'Adelphi'. During 1981 this disease averaged 6 percent, 3 percent, and trace on the 'Merion', 'A-34', and 'Adelphi', respectively. In all cases the herbicide-treated half had less disease than the untreated controls. The reason for this is unclear. On the 'Merion' turf without herbicides, the following levels of disease were recorded: 6 percent on the untreated control, 7 percent on core-cultivated plots, 5 percent on plots given excessive urea, 5 percent on gypsum-treated plots, 10 percent on plots sprayed with hydrated lime, and 4 percent on plots treated with dolomitic lime. Dolomitic lime raised the plot from the native pH of 5.0 to pH 6.3; it was the only plot with less thatch (12 millimeters) than the control (18 millimeters). The disease severity is increasing on this three-year-old plot, and we look forward to more definitive results over the next several years.

Pinelawn Cemetery is the site for another 15,000-square-foot sod nursery established during 1979. A TORO irrigation system allows watering studies to be run in conjunction with other management variables. All of the management studies described in the remainder of this paragraph are installed in duplicate, i.e., in a frequently (daily) watered half of the plot and in an infrequently (usually weekly) watered half. About one inch of water per week is applied in each watering regime. A varietal susceptibility study includes 26 bluegrass monocultures, blends, or mixtures produced on either muck or mineral sod. Half of each variety in the plot is treated heavily with herbicides to induce additional stress. A soil cultivation study includes sod installed on rototilled, rototilled plus peat-amended, or unprepared soil. Core cultivation is performed across these treatments twice each year. A soil amendment study includes gypsum, lime, micronutrient, and wetting-agent variables and their interactions. An herbicide rate study and several etiological studies (described later) are each located in each of the irrigation regimes. Another study involves sod cut in 4-, 6-, or 12-inch-wide strips that were then offset in particular patterns to determine if the cause of Fusarium blight patches is inherent in the marketed sod or occurs after the sod is installed. This nursery has now gone through three summers without being blighted, even though management levels have been amplified greatly to increase chances for disease to occur. The disease occurs at other sites in this cemetery, and each of the sod sources for the study at The Mill River Club are also represented on this study area.

In the various plots described above, repeated applications of lime have reduced the thatchiness of the sod by 50 percent in three years. Gypsum has not altered the depth of thatch. Lime placed in the tilled soil beneath the sod, as well as broadcast over the sod, has led to more rapid decomposition than has surface-applied lime alone. Calcium arsenate applications have retarded the rate of decomposition in limed turf, and core cultivation has accelerated the decomposition rate. In all cases, more thatch exists in the weekly watered plots than in the daily watered plots. Also, applications of micronutrients for three years have not affected thatch decomposition; however, applications of a popular wetting agent have significantly retarded thatch decomposition in plots watered daily and completely prevented any decomposition in the plots watered weekly.

Another study involved the application of growth-regulating chemicals and chemically related systemically translocated fungicides to sod that was later harvested and installed on the two irrigation plots at Pinelawn Cemetery. The chemicals were applied to a blended sod on Long Island in April and in May; the sod was cut, moved, and installed in June. Rates and amounts of early root development were monitored for the 13 treatments, as were the sods' abilities to survive droughty conditions. Several of the chemicals improved early root establishment on sod installed under a limited irrigation regime. They included the growth regulators Cytex (a cytokinin mixture) and Cycocel (chlormequat, CCC) and the fungicides Bloc (fenarimol, EL 222), Vangard (etaconazole, CGA 64251), and Bayleton (triadimefon). Only the Cytex and Vangard were beneficial on sod watered daily after being installed. None of the daily watered sod suffered from drought later in the season, but sod growing under dry conditions became thin and droughty. This stress and the reduced quality of sod was significantly offset by preharvest applications of Bayleton, Cycocel, Cytex, and Gibrel (gibberellin mixture). Three of these compounds are sold as growth regulators and one as a fungicide. The fungicide Bayleton is known for its abilities to reduce the damage from drought in cereal grains and to reduce or eliminate the high-temperature-induced death of *Poa annua* in turf. This study yielded potentially important information about economical methods of improving the establishment of sod on droughty sites--but no Fusarium blight information.

FUSARIUM BLIGHT ETIOLOGY

Considerable attention in my program is devoted to investigations into the cause (etiology) of Fusarium blight. I find it difficult to accept that *Fusarium* species act alone to cause the distinct patches that characterize this disease. This opinion is developed further elsewhere (Smiley 1980). A number of approaches are being used to study the disease.

No one has yet succeeded in producing Fusarium blight at will by inoculating turfgrasses with an array of potential pathogens, including *Fusarium* species. We continue each year with new attempts to develop a successful technique. Inoculated spots are carefully marked and watched for years at various locations in New York. Our understanding of the causal agents of this disease remains incomplete.

One possible explanation for the patch symptom of the disease is that, rather than being governed by the radial spread of a pathogenic fungus, it reflects the clonal growth habit of the host. Although this explanation initially appears illogical, no one has evidence for either of these possible explanations. All patch diseases of turfgrass, other than those that obviously spread by aerial mycelium in the foliage, are similar in appearance and occur only on rhizomatous or stoloniferous species. My question is, "Why do these patches occur only on spreading species?" I am addressing this question at our Pinelawn Cemetery location by producing a normal-appearing turf from over 4,000 spaced (1 x 1-foot grid) plants produced from individual seeds of four bluegrass varieties ('Adelphi', 'A-34', 'Fylking', 'Merion'). The occurrence of Fusarium blight on this stand will tell us much about genotypic variability in these bluegrasses, which span the range from very susceptible to relatively resistant to this blight. Disease observations on this plot will also reveal relationships between the growth habits of individual plants and the circular patch symptom of the disease.

Additionally, I approached the question by taking pairs of four-inch-diameter plugs from advancing margins of disease patches during 1979 and placing them into precisely marked locations on our plots on golf course fairways on Long Island or in Syracuse. One plug from each blight patch is transplanted directly into the sod, and its pair from the original patch is located nearby and encircled by a cylinder made of screen that has uniform openings of about 40 microns. The screens allow unimpeded diffusion and flow of water, nutrients, and soil gases, and they allow emergence of root hairs. But they will not allow primary roots or rhizomes to move out of the screened enclosure. My objective is to determine whether the patch can enlarge through the screen or is restricted by the screened area. The turf inside the four-inch-diameter plugs, screened as well as unscreened, became blighted during 1981, but in no case did the disease extend beyond the original plug's boundary.

Additional etiological studies are conducted on five diseased patches (from two residential lawns and from three golf course fairways) that were relocated as sod to more-controlled sites during the fall of 1980. Half of each patch was taken to our research facility at Pinelawn Cemetery on Long Island, and the other half was established in plots at Cornell University. Twenty-four additional disease patches at four locations in New York also serve as sampling locations. The patches were accurately surveyed, marked, and photographed to enable samplings to be made throughout the season--even when the patch dimensions are not visually apparent. Photographic comparisons from year to year will reveal precisely the shrinking, swelling, or migratory habits of the patches over time. Knowledge of the patch dimensions during the winter and spring enables sampling to be conducted at the patch margins even when they are obscure. Our goal is to determine if some unidentified pathogen weakens the turf in the winter or spring, allowing *Fusarium* species to colonize the unhealthy turf in the summer to complete the disease syndrome. Samples of roots and rhizomes are regularly monitored microscopically for evidence of other pathogenic fungi. Other fungi are being observed, but repeated attempts to isolate them in pure culture in the laboratory have failed. The fungi can be transferred to roots of wheat and oat plants grown over infected bluegrass tissue, but attempts to work with these organisms in pure culture have been fruitless. Debris from edges and centers of Fusarium blight patches have also been shown capable of severely stunting oat plants grown in debris:sand (1:14 v/v) mixtures. We feel that refinements in our techniques may provide some important new insights into this disease.

Another approach for studying Fusarium blight etiology resulted from the observation in Oklahoma (Fermanian et al. 1981) that extracts from patches of spring dead spot yielded toxins that reduced seed germination and seedling growth in bioassays. We have utilized these scientists' extract procedures in three different experiments and have reached different conclusions each time the study was performed. Since the studies were conducted at different times of the season, changes in the chemistry of the blight patches may be responsible for our differences. The most conclusive of our studies was conducted very early in the season. Late-season verification attempts failed to duplicate the exciting results of our first study. Additional emphasis will be given to this procedure during 1982.

Finally, at Pinelawn Cemetery we continue to collect plants that were derived from individual tillers from numerous blighted patches in New York, Pennsylvania, and Nebraska. If the etiological studies yield meaningful results, these plants will be used for studies of their fungal flora and of their resistance to this disease.

ACKNOWLEDGMENTS

This summary of research done during 1981, and of proposed activities for 1982, depicts the investigations on Fusarium blight that resulted directly from the large-value funding that began in 1978 in the name of the Sod Grower's Association of Mid-America. Cornell University provided matching funds to ensure the establishment of the long-term sod plots on Long Island. The Musser International Turfgrass Foundation, the American Sod Producer's Association, and numerous other contributors from the north-central and northeastern United States have also cooperated. Additional unsolicited contributions are welcomed to help alleviate the escalating costs for these studies. All contributions are truly appreciated, for they assist us to develop the well-rounded program that is necessary to develop adequate understanding of and controls for Fusarium blight. I trust that this research will continue to kindle good faith among the principal cooperators who are essential for the continuity of my research program.

The skillful and dedicated assistance of Melissa Craven Fowler, Louis Hsu, Randy Kane, and the entire turfgrass management team led by Dr. Martin Petrovic and Howard Pidduck is also greatly appreciated, for they are the strength of this program.

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SOD PRODUCTION IN THE 1980s

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In order for us to look intelligently to the future, I think we must review the history of the sod industry. In this country, sod was first utilized in the 1920s, but it was then best described as pasture sod. As the name implies, sod was hand cut from pastures that had been improved with fertilizer and perhaps some crude weed controls. The 1930s saw the advent of many bentgrass home lawns in the more affluent areas, which gave impetus to the fledgling sod industry. The war years of the 1940s saw little activity in the sod industry, as all available manpower was focused on the war effort. The late 1950s were really the start of the modern sod industry as we know it today for three important reasons:

1. 'Merion' bluegrass became available; it was a dramatic improvement over the common Kentucky bluegrass, which had been the only bluegrass available.
2. With 'Merion' came more refined cultural practices and a much higher quality turf, which became known as "cultured sod."
3. The automatic cutoff was developed for the mechanical sod cutters which were then available. Many attempts were made to combine the cutting, rolling, and palletizing of sod in the 1970s--some with success, but most without. The successful machines by Princeton, Nunes, and Brouwer revolutionized the sod industry by cutting labor dramatically.

I think our industry is now on a new threshold. We have made great strides in mechanization but need to consolidate and rethink our operations toward conservation--of energy, of water, of labor, and of our soil. The importance of energy conservation is brought home to us with talk of nitrogen fertilizer rising from the present $200 per ton to a possible $600 per ton by 1985. We must strive for varieties with lower nitrogen requirements. We also need further studies on use of sewage effluent as a fertilizer source. In many communities the sludge is readily available free or at a nominal cost and seems to have a dramatic effect on the sod crop.

Water conservation is another area of concern to our industry. There is plenty available on earth--the problem arises with water quality and distribution. Newer grass varieties can be selected for their lower water requirements, and irrigation water can be applied more judiciously (e.g., night watering to minimize evaporation loss).

The necessity of conservation of hydrocarbon materials is brought home to us each time we pull up to a fuel pump. It goes beyond the fuel used in our farm machinery and delivery trucks, though--consider opportunities for savings on such things as irrigation pumping units and shop heating with heaters that burn waste oil. Also consider usage of pesticides, which are

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petroleum derivatives, and how you can cut back to the lowest recommended rate simply by better timing of application and selection of the proper material for the problem involved.

Another technique needing further refinement is the use of plastic netting placed in the seed bed to provide tensile strength to the maturing crop. The possibilities for shortening the time of production and thereby cutting labor and energy inputs are immense.

I have touched on many opportunities for improvements in conservation and efficiency. We all need to rethink our modes of operation periodically to see if any of these improvements can be integrated into our operations to improve our industry as we advance into the 1980s.

ESTABLISHING CART PATHS FOR GOLF COURSES

Robert W. Graunke

Think! Why is there never enough time to do it right but always enough time to do it over? That may have been the case in the past; but, with high cost and the economy in the shape that it is in today, many of us have had to change our thinking. The emphasis today is on taking more responsibility and yet holding the line on cost. When you think of making changes on existing golf courses, you must take into consideration how they are going to improve the condition of the course--and possibly what the payback is for making certain changes. The construction of cart paths would be a major improvement on a course, so to make sure that they are a major improvement we would want to consider the following ideas.

A. The initial design

1. Plan for future maintenance of the path and the course.
2. Consider the following points when planning drainage:
   a. When path crosses natural drain areas, do not interrrupt the natural flow.
   b. Avoid situations where water would flow down the path.
   c. Avoid having the path below turf surfaces, which would create puddles.
3. Make sure that the path will not conflict with the playing of the hole.
4. Consider the cart traffic flow.
5. Place the path so that it will not conflict with the aesthetics of the golf course.

B. Construction

1. Schedule all construction to avoid interrupting play on the course.
2. Select outside contractors who appreciate turf.
3. Watch out for spills of material such as fuels or tar.
4. Use equipment that will avoid compaction problems in surrounding turf areas.

C. Maintenance after construction

1. Have the proper equipment on hand to repair any damage that may occur due to weather (such as freezing and thawing).
2. Always try to patch with material of the same color and consistency.

The question now comes up as to how much of this work can be done by the superintendent and what portion will have to be contracted out. My experience has been in using some of the basic equipment we normally have in

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our maintenance facility. We were able to do the coring and spread and compact the gravel, thereby reducing the cost by about 33 percent. In this way we only needed outside help with the actual paving.

Our experience shows that the additional rounds of golf that we will be able to play because of continuous cart paths will pay for the cart paths in five years.

PRIVATE WEATHER SERVICES (MURRAY AND TRETTEL, INCORPORATED)

Mark Evans

Murray and Trettel, Incorporated, of Northfield, Illinois, was founded in 1946 as an independent meteorological consulting firm. The principals and founders, Dr. John R. Murray and Mr. Dennis W. Trettel, remain actively involved in the firm's operations. Both are Fellows of the American Meteorological Society and are Certified Consulting Meteorologists. In 1970 the firm received the American Meteorological Society's Award for Outstanding Services to Meteorology by a corporation.

Initially Murray and Trettel, Inc., provided operational weather forecasts and storm warnings for the gas and electric power industry. These forecasts were used for planning and allocating power load distributions.

The firm's services now include ambient and emission monitoring, instrument calibration and repair, quality assurance audits, data processing and reporting, atmospheric dispersion modeling, and, of course, aspects of operational weather forecasting.

OPERATIONAL WEATHER FORECASTING SERVICES

Murray and Trettel, Inc., operates one of the largest private meteorological centers in the country.

The center analyzes weather information from around the world received via National Weather Service teletype and facsimile chart circuits. Additionally, substantial amounts of air quality and meteorological data are telemetered to the center from air monitoring stations operated by the firm in the Midwest. The center has direct readouts from weather radar and orbiting satellites.

Professional meteorologists are on duty in the center 24 hours a day, 365 days a year. They provide microscale weather forecasts and storm warnings to power utilities, commercial and industrial firms, and government agencies. Listeners of more than two dozen radio stations receive weather information directly from members of our staff.

DAILY OPERATING SERVICE FOR GOLF COURSES AND GROUNDS MAINTENANCE

The Daily Operating Forecast Service provides forecasts that are detailed for a specific location to facilitate optimum planning and scheduling of work, equipment, and personnel. The service is designed for each individual client to call at his/her convenience for consultation with a

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meteorologist who is familiar with the client's specific operations and problems. Briefings can consist of either a verbal forecast or a duplication of the weather details on the Daily Operating Forecast form.

The Daily Operating Forecast form consists of four parts:

1. *Forecast* - 18-hour forecast period that includes a profile of the temperatures, humidity, and wind direction, speed, and gusts. The profile includes the most current readings and four forecasting hours. In addition, information is provided on clouds, precipitation probability, and evapotranspiration.

2. *General Planning* - two 24-hour planning forecasts that include in-sky condition, precipitation, maximum and minimum temperatures, and wind speeds and directions.

3. *Outlook* - a general two- to three-day outlook.

4. *Log* - a record of the time of briefings and name of client.

SUMMARY

A private weather service can provide detailed, cost-effective service designed to meet individual needs.

DESIGNING A LOW-MAINTENANCE LANDSCAPE

Dennis R. Church

D.R. Church Landscape Company, Incorporated, has been in existence for approximately twenty years in the western suburbs of Chicago. Until two weeks ago, we were in Addison, Illinois. We have just moved to a new and better facility in Lombard, approximately three miles from our old location.

We have a sales volume in excess of one million dollars per year. In season we employ 45 people; off season we employ 15 people.

We are engaged in providing a professional landscape service at a reasonable cost to our clients. Our services consist of landscape design, landscape construction, and landscape maintenance. This combination has worked well for us, although it is cumbersome at times.

Low maintenance landscaping usually presents the following benefits:

- Energy and fuel conservation
- More naturalistic design
- Lower costs

THE DESIGN APPROACH

Trees, shrubs, evergreens, ground covers, hardscape, and structures can add beauty and usefulness to the grounds only if they are designed correctly and chosen, installed, and maintained properly. We can develop a *design concept* by giving due consideration to site analysis and customer preferences.

Land Form

If possible, work with the natural amenities of the site. Altering the site by movement of soil is not only expensive; it also causes many problems. Too steep a slope (in excess of 30 percent) can become a real maintenance problem. Severe slope will cause erosion, requiring the building of retaining walls, steps, and other costly construction projects. These structures in turn require a higher degree of maintenance; for example, they can trap water, necessitating drain installation.

How does this relate to the original concept?

D.R. Church is the president of D.R. Church Company, Inc., in Addison, Illinois.

Structures

Man-made objects (such as lights, benches, and playground equipment) cause other maintenance tasks. Now we must take into account painting, staining, repairing, and other maintenance jobs. Use only the best available materials in order to need the least amount of maintenance.

Is the concept being adhered to?

Pavements

The type of materials used and their durability and placement will greatly enhance the low-maintenance aspect as well as the aesthetics of the project. Walks should accent entrance ways and accommodate the expected pedestrian traffic. Walks should be as direct as possible and should be of sufficient width.

How about the original concept?

Plant Materials

Selecting plants that will be tolerant to the zone of adaptation, the soil type, the exposure, and the moisture available will assure viability and proper maturing. Consider also tolerance to diseases and insects. Now we can consider the composition, color, texture, compatibility with surrounding plants, and size at maturity. A knowledge of plant material or an excellent referral source is necessary at this point. Selecting the wrong plant can destroy the design concept, increase construction or installation costs, and cause a real high maintenance problem.

Other considerations are:

- Give plants room to mature.
- Design beds in continuous flowing lines.
- Group plants in mass plantings for best appearance and ease of maintenance.
- Do not scatter plants, specimens, and ornamentals so as to create an obstacle course.

Consider--has the theme been followed throughout to accomplish the objectives of the original design concept?

HIGH MAINTENANCE DESIGN

High maintenance design can be beneficial when it is in a formal setting, providing that it complements the architecture of the area and accomplishes the desires of the client.

IRON FERTILIZATION OF KENTUCKY BLUEGRASS

Allan Yust and David J. Wehner

Kentucky bluegrass is the major turfgrass species used in Illinois. The quality of a Kentucky bluegrass turf can be judged by its color, density, uniformity, texture, and smoothness. The most noticeable characteristic is color, with dark green being desirable. Nitrogen fertilizers can be used to produce a dark green color, but high rates of nitrogen can also cause certain problems. Frequent mowing, increased disease incidence, and reduced stress tolerance are associated with high nitrogen levels. Foliar application of iron fertilizers can also be used to enhance color. Nitrogen fertilization will still be necessary; however, reduced rates of nitrogen could be utilized, resulting in fewer problems with excessive growth, disease, and other stresses.

Most Illinois soils contain sufficient quantities of available iron for turfgrass growth, but there are certain instances where soil iron is limited and iron-related chlorosis can result. Soil factors that cause iron to be unavailable include high pH, high levels of phosphorus or HCO_3, an imbalance of metallic ions, or a combination of high pH, high lime, high moisture, and cool temperature.

Iron is important in the plant for a number of functions. Iron is directly involved in photosynthesis, respiration, and nitrogen metabolism. Iron is also necessary for chlorophyll synthesis but is not an integral part of the chlorophyll molecule. The relationship of chlorophyll content to green color has been documented in numerous studies.

Iron sulfate and iron chelate are the two main iron fertilizers used to correct plant chlorosis due to iron deficiencies. Iron fertilizers are most commonly applied in solutions directly to the foliage of the plant. Soil applications of iron fertilizers are generally less effective than foliar applications. Iron sulfate is cheaper, but iron chelates are able to maintain iron in a plant-available form longer and can usually be applied at lower rates of actual iron to correct iron chlorosis symptoms.

IRON FERTILIZATION

Iron sulfate and iron chelate at rates of 0, 1, 2, and 4 pounds of actual iron per acre were combined with nitrogen at rates of 0, 0.5, and 1.0 pounds per 1,000 square feet and applied to a mature 'Touchdown-Columbia' Kentucky bluegrass stand at the Ornamental Horticulture Research Center in Urbana, Illinois. Foliar applications of the fertilizer treatments were made to the individual 30-square-foot plots with a CO_2 sprayer. Visual color ratings and chlorophyll determinations were made weekly until color differences no longer existed.

A. Yust is a graduate research assistant, and D.J. Wehner is an assistant professor, in the Department of Horticulture at the University of Illinois at Urbana-Champaign.

The first application of treatments was made on 25 July 1980. Color ratings of turf receiving selected treatments are given in Table 1. Turf treated with iron rated higher one day after application than turf that did not receive iron. No color differences due to nitrogen were observed after one day. Turf sprayed with four pounds of iron per acre was rated highest after one day; however, the green color observed was not a healthy green color. It tended to have a blackish cast, indicating a mild toxic effect. This black cast was no longer noticeable seven days after the application.

Table 1. Color Ratings of Kentucky Bluegrass Treated with Iron and Nitrogen Fertilizer Combinations on 25 July 1980

	Days after application*					
Treatment	1	7	14	21	28	35
Check	5.0 E	6.3 E	6.3 F	7.0 B	6.7 D	7.7
1 FeS†	6.7 D	7.0 CDE	7.0 EF	8.3 A	7.3 BCD	8.0
2 FeS	6.7 D	6.7 DE	7.7 CDE	8.7 A	6.7 D	8.0
4 FeS	8.0 B	8.0 ABC	8.0 BCD	8.7 A	7.3 BCD	8.0
1 FeC	7.3 BCD	7.0 CDE	7.7 CDE	8.7 A	7.0 CD	7.7
2 FeC	7.3 BCD	7.7 BCD	8.0 BCD	8.0 AB	7.3 BCD	8.0
4 FeC	9.0 A	8.0 ABC	8.0 BCD	8.0 AB	7.0 CD	7.7
5 N††	5.3 E	7.0 CDE	7.3 DE	8.0 AB	8.0 ABC	8.0
.5 N/1 FeS	6.7 D	8.3 AB	8.7 AB	9.0 A	8.0 ABC	8.0
.5 N/2 FeS	7.0 CD	8.3 AB	8.7 AB	8.3 A	8.0 ABC	8.0
.5 N/4 FeS	7.3 BCD	9.0 A	9.0 A	8.7 A	8.0 ABC	8.0
.5 N/1 FeC	7.3 BCD	8.7 AB	9.0 A	8.3 A	7.7 ABC	8.0
.5 N/2 FeC	9.0 A	8.7 AB	9.0 A	8.3 A	8.0 ABC	8.0
.5 N/4 FeC	9.0 A	8.7 AB	8.7 AB	9.0 A	7.7 ABC	7.7
.1 N	5.3 E	8.0 ABC	8.3 ABC	8.3 A	8.3 AB	7.7
1 N/1 FeS	5.3 E	8.3 AB	9.0 A	8.3 A	8.3 AB	8.0
1 N/2 FeS	7.0 CD	8.7 AB	9.0 A	9.0 A	8.7 A	7.7
1 N/4 FeS	7.7 BC	8.7 AB	9.0 A	8.7 A	8.7 A	8.0
1 N/1 FeC	7.3 BCD	9.0 A	9.0 A	9.0 A	8.0 ABC	8.0
1 N/2 FeC	7.7 BC	9.0 A	9.0 A	9.0 A	8.3 AB	8.0
1 N/4 FeC	9.0 A	9.0 A	9.0 A	9.0 A	8.3 AB	8.0

*Color was rated on a 1 to 9 scale with 9 = dark green and 1 = light yellow. Values in a column followed by the same letter are not significantly different at the 5% level (Duncan's Multiple Range Test).
†FeS = iron sulfate in pounds iron per acre
**FeC = iron chelate in pounds iron per acre
††N = nitrogen rate in pounds per 1,000 square feet

Color ratings taken seven and fourteen days after treatment showed that turf treated with iron and one-half pound of nitrogen per 1,000 square feet was judged higher than turf receiving one-half pound of nitrogen per 1,000 square feet alone and as high as turf sprayed with one pound of nitrogen per 1,000 square feet only.

Between the 14th and 21st days after application, the turf received two inches of rain. Few color differences due to iron were observed 21, 28, and 35 days after the 25 July application. Fresh-weight clipping yields taken after the 25 July 1980 application are listed in Table 2. Clipping yields were a result of nitrogen level and were unaffected by the iron treatments after this treatment date and all subsequent application dates.

Table 2. Clipping Yields of Kentucky Bluegrass Treated with Iron and Nitrogen Fertilizer Combinations on 25 July 1980

	Days after application*			
Treatment	7	14	28	Total
Check	23.4 D	27.1 G	58.7 H	109.2 H
1 FeS†	31.1 CD	35.7 FG	74.3 FGH	141.1 FGH
2 FeS	40.6 BC	34.0 FG	73.8 FGH	148.4 FGH
4 FeS	41.1 BC	40.3 EFG	72.0 FGH	153.4 E-H
1 FeC**	30.4 CD	35.6 FG	67.3 GH	133.3 GH
2 FeC	40.6 BC	40.9 EFG	73.3 FGH	154.8 E-H
4 FeC	40.6 BC	46.8 DEF	87.9 E-H	175.3 D-G
.5 N††	49.3 AB	56.8 BCD	110.4 A-E	216.5 A-D
.5 N/1 FeS	56.5 AB	57.0 BCD	104.6 B-F	218.1 A-D
.5 N/2 FeS	52.2 AB	55.4 BCD	93.9 C-G	201.5 B-E
.5 N/4 FeS	57.3 A	65.6 ABC	111.1 A-E	234.0 ABC
.5 N/1 FeC	56.0 AB	64.3 ABC	110.4 A-E	230.7 ABC
.5 N/2 FeC	53.0 AB	67.8 AB	123.8 A-D	244.6 AB
.5 N/4 FeC	43.4 ABC	51.8 CDE	90.9 D-H	186.1 C-F
1 N	48.9 AB	76.2 A	140.5 A	265.6 A
1 N/1 FeS	51.3 AB	69.8 AB	120.5 A-E	241.6 AB
1 N/2 FeS	49.3 AB	67.6 AB	128.7 AB	245.6 AB
1 N/4 FeS	43.8 ABC	67.5 AB	113.5 A-E	224.8 A-D
1 N/1 FeC	56.0 AB	72.2 A	123.2 A-D	251.8 AB
1 N/2 FeC	54.4 AB	70.0 AB	126.1 ABC	250.5 AB
1 N/4 FeC	42.3 ABC	61.9 ABC	112.9 A-E	217.1 A-D

*Clipping yields are the means of three replications expressed in grams per plot. Values in a column followed by the same letter are not statistically different at the 5% level (Duncan's Multiple Range Test).
†FeS = iron sulfate in pounds iron per acre
**FeC = iron chelate in pounds iron per acre
††N = nitrogen rate in pounds per 1,000 square feet

The second application of treatments was made on 2 October 1980. Color ratings of turf sprayed with selected treatments are listed in Table 3. Color ratings similar to those observed after the 25 July 1980 application were observed 1, 7, and 14 days after application; however, color differences were observed at 65 days after the 2 October application as

Table 3. Color Ratings of Kentucky Bluegrass Treated with Iron and Nitrogen Fertilizer Combinations on 2 October 1980

	Days after application*							
Treatment	1	6	14	20	30	35	43	65
Check	5.7 E	6.0 G	6.0 E	6.0 F	6.0 E	6.3 DE	5.0 F	5.0 F
1 FeS†	7.3 BCD	6.7 EFG	6.3 DE	6.3 EF	6.0 E	6.0 E	5.0 F	5.0 F
2 FeS	7.7 ABC	7.0 DEF	6.0 E	6.3 EF	6.3 DE	5.7 E	5.3 F	5.0 F
4 FeS	7.3 BCD	7.7 B-E	8.0 ABC	7.0 DEF	7.0 CD	7.7 ABC	7.0 CD	7.0 A-D
1 FeC**	7.3 BCD	8.0 BCD	6.0 E	6.3 EF	6.0 E	6.0 E	5.7 EF	5.3 EF
2 FeC	7.7 ABC	7.7 B-E	7.3 BCD	7.3 CDE	7.3 BCD	7.3 BC	7.0 CD	6.7 BCD
4 FeC	8.3 AB	8.7 AB	8.3 AB	8.0 BCD	8.0 ABC	7.7 ABC	7.0 CD	7.0 A-D
.5 N††	6.0 E	6.3 FG	6.3 DE	7.0 DEF	7.0 CD	7.0 CD	6.3 DE	6.0 DE
.5 N/1 FeS	7.7 ABC	7.3 CDE	7.0 CDE	7.3 CDE	7.3 BCD	7.3 BC	6.3 DE	6.3 CD
.5 N/2 FeS	7.7 ABC	7.7 B-E	7.3 BCD	7.7 BCD	7.7 ABC	7.7 ABC	7.3 BCD	6.7 BCD
.5 N/4 FeS	8.0 ABC	8.0 BCD	8.0 ABC	8.0 BCD	8.0 ABC	8.0 ABC	7.0 CD	6.7 BCD
.5 N/1 FeC	7.7 ABC	8.3 ABC	8.0 ABC	7.7 BCD	7.7 ABC	7.3 BC	6.7 CD	7.0 A-D
.5 N/2 FeC	7.7 ABC	8.3 ABC	8.0 ABC	8.0 BCD	8.0 ABC	8.3 AB	7.7 ABC	6.7 BCD
.5 N/4 FeC	8.3 AB	8.7 AB	9.0 A	9.0 A	8.3 AB	8.7 A	8.3 AB	8.0 A
1 N	6.3 DE	7.3 CDE	7.3 BCD	7.7 BCD	7.7 ABC	7.7 ABC	7.7 ABC	7.3 ABC
1 N/1 FeS	7.0 CD	7.7 B-E	7.3 BCD	7.3 CDE	7.7 ABC	8.0 ABC	7.0 CD	7.7 ABC
1 N/2 FeS	7.3 BCD	7.7 B-E	7.3 BCD	7.0 DEF	7.3 BCD	7.7 ABC	7.0 CD	7.3 ABC
1 N/4 FeS	7.7 ABC	8.0 BCD	7.0 CDE	7.3 CDE	7.7 ABC	8.0 ABC	8.3 AB	8.0 A
1 N/1 FeC	8.3 AB	8.3 ABC	8.0 ABC	8.0 BCD	7.7 ABC	8.0 ABC	8.3 AB	8.0 A
1 N/2 FeC	8.3 AB	9.0 A	8.7 A	8.3 ABC	8.7 A	8.3 AB	8.3 AB	8.0 A
1 N/4 FeC	8.7 A	9.0 A	8.7 A	8.7 AB	8.7 A	8.7 A	8.7 A	8.0 A

*Color was rated on a 1 to 9 scale with 9 = dark green and 1 = light yellow. Values in a column followed by the same letter are not significantly different at the 5% level (Duncan's Multiple Range Test).

†FeS = iron sulfate in pounds iron per acre

**FeC = iron chelate in pounds iron per acre

††N = nitrogen rate in pounds per 1,000 square feet

compared to 14 days after the 25 July application. Turf growth was much slower after the 2 October application, so the effect of iron remained longer.

Iron applications made on 2 October 1980 did not enhance 1981 spring green-up of the treated plots. Plots receiving nitrogen in October of 1980 were green before plots receiving no nitrogen in the spring of 1981.

Four applications of the fertilizer treatments were made in 1981. A deeper green color due to iron treatments was noticeable 24 hours after each application; however, these differences lasted different lengths of time. After the 20 April 1981 application, color enhancement due to iron was no longer observed after the one-day rating on turf receiving iron and nitrogen combinations. Plant growth after this application was rapid and was enhanced by several rainfalls. Turf treated on 17 June 1981 showed color enhancement from iron for two weeks, while turf sprayed on 18 August 1981 had green color enhancement from iron that lasted only one week, due in part to the abundant rainfall and rapid growth after this treatment. Turf treated on 3 October 1981 had color ratings similar to plots treated on 2 October 1980.

IRON TOXICITY

Iron sulfate and iron chelate at rates of 0, 1, 2, 4, 8, 10, 16, 32, and 64 pounds of actual iron per acre were applied to a mature 'Touchdown-Columbia' Kentucky bluegrass stand at the Ornamental Horticulture Research Center in Urbana, Illinois, on 6 September 1981. Foliar applications were made to the individual 30-square-foot plots using a CO_2 backpack sprayer. Visual injury ratings were taken on 7, 13, and 20 September.

One day after application, only those plots treated with 16, 32, and 64 pounds of iron per acre showed injury to the turf. Increasing damage in the form of blackening and thinning of the turf occurred as the rate of iron increased from 16 to 64 pounds (Table 4). There was no difference in injury to the plots due to the iron fertilizer source.

Injury ratings taken one week following application of the treatments show that there is no noticeable damage to plots receiving 16 pounds of iron per acre (Table 4). Furthermore, there was a reduction in noticeable damage due to the 32- and 64-pound rates of iron. After two weeks, there was no visual damage on any of the plots treated with iron. Good growing conditions and several rainfalls during the two weeks following the application of these treatments contributed to the plots' quick recovery from injury.

Table 4. Iron Damage on Kentucky Bluegrass

Treatment	Days after application*	
	1	7
16 FeS†	8.3c	0b
16 FeC**	10.0c	0b
32 FeS	25.0b	6.7a
32 FeC	25.0b	6.7a
64 FeS	56.7a	8.3a
64 FeC	61.7a	10.0a

*Percent injury is the mean of three replications. Within a date, means with the same letter are not significantly different.

†FeS = iron sulfate in pounds iron per acre

**FeC = iron chelate in pounds iron per acre

MICROECOSYSTEMS RESEARCH UPDATE

Bruce E. Branham

The turfgrass microecosystem, developed at the University of Illinois to study the fate of pesticides in turf, has been operational for the last year. The system consists of a base with a porous ceramic plate sealed into the bottom of the base. The base holds the soil; but, more important, the ceramic plate is used to apply a tension to the soil. This tension pulls the water from the soil until the remaining soil water is at the same potential as that applied to the porous plate. This setup mimics the situation found in turf. A glass atmospheric chamber rests on top of the base to form a closed system. Air moves through the chamber, and the air stream is scrubbed to remove any volatilized pesticide or $^{14}CO_2$ from the microbial degradation of the radioactive pesticide. Leachate from the base is collected and analyzed for any radioactivity.

Experiments on the rate of breakdown of Dacthal as influenced by soil moisture and soil type have recently been run using the microecosystems. The analysis of the soil residues is all that remains to conclude the experiment. The factor preventing more pesticides from being examined is the analysis time of the samples collected. As soon as the soil analysis of Dacthal is completed, experiments will begin on the fate of the insecticide Diazinon. Variables such as irrigation amount and frequency, soil type, and amount of thatch layer present will be included in the study. We believe that the microecosystems will provide valuable data concerning the factors affecting pesticide dissipation by allowing experimentation with widely differing soil types under controlled conditions.

The versatility of the microecosystem has been demonstrated by the experiments of Torello in 1981 on ammonia volatilization in turf (in press) and the work with Dacthal. As experience is gained with the microecosystem, more and more commonly used pesticides will be examined and the results used to better predict the fate of a pesticide on turf.

LITERATURE CITED

1. Torello, W.A. Ammonia volatilization from fertilized turfgrass stands. Agronomy Journal; In press.

B.E. Branham is a research assistant in the Department of Horticulture at the University of Illinois at Urbana-Champaign.

TOURNAMENT PLAYERS CLUB: STADIUM GOLF

Robert Dickson

I would like to talk about a golf course--one unique in design and concept. It is called the Tournament Players Club. It is located 20 miles southeast of Jacksonville, Florida, at Sawgrass. The club is one and a half miles from the Atlantic Ocean and a half-mile from the Intracoastal Waterway. Starting next March, it will be the permanent home of the Tournament Players Championship; it is called the TPC and will use the same logo. It was built and is owned and operated by the TPA TOUR (TPA stands for Tournament Players Association).

The TPA TOUR is the professional golf tour. This organization is composed of more than three hundred touring professionals--the Watsons, Nicklauses, Trevinos, and others. We had a name change earlier this year from the PGA TOUR to the TPA TOUR because of a conflict with the use of the letters PGA in our name and the PGA Golf Company. For marketing purposes, including promoting the game of golf, products, and services, it became necessary to adopt a different set of initials. We used the initials of our own organization's legal name, the Tournament Players Association, which is a private, nonprofit corporation based in Maryland.

The course was built to be a complete tournament facility, one that would fully take into consideration both player and spectator. We think we have done so. Pete Dye, renowned golf course designer, came up with a unique and most challenging layout. It is not long, but it does require a certain degree of finesse.

We have over 100 acres of parking set aside for TPC week. Parking is usually a problem at most tournaments, as land adjacent to the course is too valuable to be left as an open park. Here we took parking into account from the club's inception. Even more important, we have built what we call the first "stadium golf course"--one with many spectator mounds built to allow spectators to look down on the field of action, as in other sports.

The land was heavily wooded and flat prior to construction. Over the 415 acres comprising the club, there was initially only a three-foot change in elevation--from four to seven feet above sea level.

Among the considerations given in the layout of the course was the protection and utilization of specimen trees such as live oaks. Pete Dye was almost as protective of certain dead trees. As he said on more than one occasion, "Leave them, they look good, they look natural."

R. Dickson is the Director of Marketing for the Tournament Players Club in Sawgrass, Ponte Vedra, Florida.

Hard construction began in March 1979, and the course opened for play in October 1980. It was a difficult site to work with; the land was a dense forest of palms, pines, oaks, gums, maples, and magnolias. It was flat and the soil conditions were less than ideal.

The top 24 inches of soil were muck, a black, acidic soil with poor percolation. Below that were 24-36 inches of marl--sandy clay that impeded percolation even further. Below that was sand down as far as 15 feet, though we seldom dug that deep.

The sand was very fine, almost powdery, with a percolation rate of about 15 inches per hour. We built the tees, greens, and fairways using this native sand. We dug about 22 acres of lakes to get the sand and made our spectator mounds out of the muck and marl. We moved a million yards of dirt in all and changed the elevation of the property from six inches below sea level in our lakes and canals to 35 feet above sea level on our spectator mounds.

Because of the flat terrain and poorly drained soils, we first had to dewater the site. We cleared and dug an 18,000-foot canal around our property; this canal accomplished two important objectives. First, it drains the site. We have a portable 25,000-gallon-a-minute diesel pump that pumps water into a connector canal; the water then goes through another lift station into the Intracoastal Waterway. Second, our perimeter canal, or moat, provides very good security and has saved us dollars in not having to build a security fence around the club.

To further enhance drainage, Pete Dye contoured the fairways to about four-percent slopes every 100 feet, with drain plugs located at each of these swales. The drain plugs are connected to eight miles of drainage tile throughout the course. The drainage tile empties into the lake and canal system around the course.

We planted the course in May, June, and July of 1980 and were opened for play that October. Our fairways are 419 'Tifway' Bermuda, and our tees and greens are 328 'Tifgreen'. We have used 'Argentine' Bahia in our unique pot/links-style bunkers. We do overseed here in northeast Florida with cool-season grasses in October each year; we use ryegrass everywhere except the greens, where this year we have overseeded with 'Penncross' Bent (5 pounds per 1,000 square feet) and 'Marvelgreen' ryegrass (10 pounds per 1,000 square feet). We have about 27 acres of tees, greens, and fairways and a total of only about 40 acres of regularly maintained grass. I believe an average 18-hole golf course has around 80-100 acres of grass to be maintained. We have 330 sprinkler heads on the course, whereas a wall-to-wall grassed course has up to 1,000 to 1,500 heads. We do get some help from our annual rainfall here, which is about 54 inches.

The balance of the 18 holes, which incidentally covers 265 of the 415 acres, is made up of what we call waste areas--flat stretches of sand and grass (to hold the soil in place), trees, and water.

Pete used about 10 linear miles of utility poles and 3 x 8-inch pressure-treated boards to create bulkheading around holes 4, 11, 13, 17, and 18. In addition, we used the boards and poles to build "stadium" seating in amphitheater fashion around our first tee and at our eighteenth green. Seating at these two locations will hold 5,500 people. (Pete has designed some holes that could burn down....)

On the 18th hole alone, over 40,000 people can watch play from spectator mounds behind the tee, on both sides of the fairway, and around the green. The spectator mounds are functional one week a year and offer an aesthetic backdrop the balance of the year for membership play.

The Tournament Players Club is also a national golf club with over 5,000 members from as far away as Japan, England, South America, and Canada. Membership is based on nominal annual dues of $50.00 and a pay-when-used format for greens and cart fees.

We have been pleased with the media coverage the course has received in its first year of operation. The playing of the TPC next spring will bring considerable additional exposure, including feature stories by *Sports Illustrated, Golf, Golf Digest,* and *Country Club Golfer* magazines in addition to CBS's live coverage of the championship.

The Tournament Players Club was designed for the professional, spectator, and club member. It has something to offer everyone.

TURFGRASS DISEASE UPDATE

Malcolm C. Shurtleff

FUSARIUM BLIGHT

Fusarium blight is still our number-one disease problem of Kentucky bluegrass, especially where susceptible cultivars are grown in pure stands and where the turfgrass is under stress--low height of cut, poor or unbalanced fertility, a thick thatch, improper watering, and compacted soil. The majority of our calls from homeowners and lawn care professionals come when muck-grown sod is laid on a poorly prepared, compacted, heavy clay seedbed.

Dr. Richard Smiley is discussing this disease and its control elsewhere, so I'll conclude by stating that our *Report on Plant Diseases* covering Fusarium blight* and its control was recently revised. An added control measure you might try when establishing a new turfgrass area is to plant one or more of the new perennial ryegrasses in a mixture with several of the newer Kentucky bluegrass cultivars that are resistant to Fusarium blight. California researchers have reported that as little as 10 to 15 percent perennial ryegrass (on a seed-weight basis) is sufficient to mask or control the disease.

YELLOW PATCH

Yellow patch is the new name of a mysterious disease that has been called cool- or cold-weather brown patch. It is fast becoming an important disease of Kentucky bluegrass, bentgrasses, bermudagrass, and zoysiagrass throughout the Midwest. The symptoms closely resemble those produced by Fusarium blight, except that the disease appears during cool-to-cold wet periods from late winter to early summer and again in the autumn or early winter. The symptoms to look for are yellow, tan, or straw-colored rings and patches up to about three feet in diameter, often with fairly healthy grass (or "frogeyes") in the center. The yellow rings or patches usually remain prominent for several weeks or even months.

The causes of yellow patch are one or more species of the fungus *Rhizoctonia* that were formerly considered odd forms of the fungus causing Rhizoctonia brown patch. Yellow patch is favored by lush or succulent grass, excessive available nitrogen fertilization, and various stresses. There are *no* known chemical controls at present for this disease--which, since we know relatively little about this new disease (or diseases), is not unusual.

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*Available from the Cooperative Extension Service at the University of Illinois at Urbana-Champaign.

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The new species of *Rhizoctonia* include *R. cerealis* and *R. zeae*. *R. cerealis* causes yellow patch with attacks occurring during cool, wet weather. *R. zeae* produces a leaf spot and blight of tall fescue and other grasses that is very similar to that caused by *R. solani*, the fungus that incites brown patch of all turfgrasses. *R. zeae*, however, attacks only in *hot* weather (95° to about 100° F.). We will hear and know much more about these new diseases in the future.

DECLINE OF 'TORONTO' BENTGRASS

A new-old disease is the decline and dying-out of 'Toronto' ('C-15') bentgrass. This disease is being studied in a research program headed nationally by Dr. Houston Couch and sponsored jointly by the United States Golf Association, the Golf Course Superintendents Association of America, and the Chicago District Golf Foundation. A research group at Michigan State University, headed by Dr. Joseph Vargas, is also studying the problem. At present, the two research teams feel that a bacterium (rickettsia-like organism) with a rippled cell wall, which occurs in large numbers in the water-conducting cells in the roots and lower crown, is probably the causal agent. The disease appears when the grass is under stress because the roots are few and short.

In trials at several golf courses in the Chicago area during 1981, applications of an antibacterial antibiotic containing oxytetracycline (Terramycin; trade name Mycoshield) gave fair to good remission of symptoms for varying periods of time. More spray trials by Dr. David Wehner are planned for 1982, trying to zero in on the optimum concentration of the antibiotic to use and the exact timing between spray applications needed to keep symptoms at a minimum.

Additional research is needed in a number of areas, including how much water to apply per 1,000 square feet and whether the same organism attacks other bentgrasses as well as 'Toronto'. Many diseased 'Toronto' greens in the Chicago area have been overseeded with 'Penneagle'. Does the bacterium also infect 'Penneagle' and other bentgrasses? Right now we do not know. We also do not know all the factors of when and where infection occurs and the total effects of various stresses (such as low cut, down to 2/16 of an inch) on disease development. Conditions that now appear to be involved in outbreaks of 'Toronto' ('C-15') decline are high soil moisture coupled in many cases with poor internal drainage and/or prolonged periods of rainfall or excessive irrigations, low air temperatures, bright dry days following extended wet periods, a deficiency of iron, and a low cutting height.

Dr. Couch's research team has eliminated species of *Helminthosporium* causing red leaf spot (*H. erythrospilum*) and leaf and crown rot (*H. catenaria*) and cool-temperature species of *Pythium* as the causal agent. Plant-parasitic nematodes are not involved, nor are the type and amounts of fertilizers or fungicides used. While the soil pH, certain management practices, fungi, and nematodes may add to the severity of the disease, they are not by themselves the cause of the problem. Much more needs to be known concerning this disease. Dr. Wehner will be reporting on his spray trials elsewhere.

NIGROSPORA BLIGHT

Dr. Richard Smiley and his research group at Cornell have reported on a disease that occurs in hot, humid, droughty weather and is caused by one or more species of the fungus *Nigrospora*. The disease is easily confused with Sclerotinia dollar spot; it is most severe on perennial ryegrass and creeping red fescue and least severe on most cultivars of Kentucky bluegrass. Diseased patches and the presence of white, cobwebby growth over the grass blades early in the morning are similar to dollar spot. *Nigrospora* is easy to isolate, and diagnosis is simple using standard laboratory procedures. Fungicide trials by Dr. Smiley have demonstrated excellent control using Chipco 26019, Acti-dione RZ, and Daconil. Ineffective fungicides in field trials included Fore, captan, and Koban. Some of the difficulties in controlling what appears to be dollar spot may be associated with misdiagnosis of the disease and the use of fungicides that are ineffective against Nigrospora blight. The importance of Nigrospora blight in Illinois and adjoining states is unknown at present. We plan on making a survey for this disease in 1982.

FAIRY RINGS

We have discussed the biological control of fairy rings, caused by *Marasmius oreades*, in past turfgrass meetings, but perhaps I should repeat it. First, strip the sod from two or more rings, and rototill the soil underneath. Next, collect the dry, white, mycelial spawn of the fairy ring fungi from the rings and blend thoroughly. Then spread the spawn over the soil, rake the blended spawn into the top several inches of soil, rake or roll the soil level, replace the sod, and water thoroughly. The fairy rings should never reappear in the area. The treatment works because all fairy ring fungi are antagonistic to each other, which is why the rings never overlap. In spite of what some people say and write, there are *no* chemicals that will kill or eliminate fairy ring fungi in the soil without also killing the grass when it is left in place during treatment.

NEMATODE DAMAGE

Nematode damage to golf greens high in sand content was not nearly as severe in 1981 as it was in 1980, primarily because soil temperatures averaged five or six degrees F. lower during the 1981 summer than in 1980. Also, we did not have a drought in 1981--it was a much better growing season for turfgrasses. High populations of plant-parasitic nematodes are favored by light, porous (sandy) soils that are low in organic matter, high temperatures, lack of water and fertilizer, and improper maintenance such as allowing a buildup of thatch.

RED THREAD AND PINK PATCH

Red thread and pink patch are now known to be caused by a complex of fungi including *Laetisaria fuciformis*, *Athalia* species, and *Limonomyces* species. Fortunately, this disease complex is not widely found in

Illinois. Attacks occur during prolonged cool-to-warm (55° to 75° F.), very humid weather, mostly near large bodies of water with frequent morning and evening fogs. The same cultural and chemical control practices as for Sclerotinia dollar spot will keep red thread and pink patch well in check.

YELLOW TUFT

A minor disease that we see occasionally is yellow tuft, caused by a downy mildew fungus that attacks a wide range of grasses, cereals, and corn. The symptoms of yellow tuft include the appearance of small yellow spots, 1/4 to 4 inches across, that are made up largely of dense shoots that appear as yellow tufts. The causal fungus is spread by water-borne spores during cool, moist weather in spring and autumn. The disease occurs chiefly in low-lying areas or where the soil is saturated or flooded for 24 to 48 hours or longer and where excessive amounts of nitrogen fertilizer have been applied.

The control for yellow tuft is to provide for good surface and subsurface drainage when establishing a new turfgrass area. The addition of iron sulfate or chelated iron and the implementation of a balanced fertilizer program help to mask the symptoms of yellow tuft. Several applications of Subdue at 10- to 14-day intervals during cool, wet weather should keep yellow tuft well in check when coupled with the cultural practices already mentioned. You may wish to combine Subdue with iron sulfate (Copperas) in the same spray mix.

INTEGRATED DISEASE CONTROL

As we study turfgrass diseases in detail, and go to an ever-higher level of maintenance, we need to think of an overall integrated disease-control program. This program should start with a correct diagnosis. Too often inexperienced turfgrass managers apply fungicides indiscriminately without determining the true cause--fungicides often fail because disease is *not* involved or the disease was misdiagnosed. Turfgrass diseases can usually be managed by a series of recommended cultural practices, by growing blends and mixtures of disease-resistant turfgrass cultivars and species, and by timely applications of recommended fungicides and nematicides. Integrated disease control involves the use of *all* these management tools.

TURF INSECT CONTROL IN 1981

Roscoe Randell

SITUATION

Insects active in Illinois turfgrass in 1981 were primarily grubs found in lawns and on golf course fairways. Annual white grubs were again common in the root zone of Kentucky bluegrass. This activity began in mid-August and continued until mid-November. The most concentrated areas of damage were across the central area of the state from Interstate 80 on the north to Route 50 on the south.

The black turfgrass ataenius beetle was found in damaging numbers feeding on *Poa annua* on many golf courses in Cook and DuPage counties. These infestations varied from lower areas in the fairways to collars of the greens. Some infestations were extremely high--300 to 450 per square foot.

The usual black-cutworm damage was observed on many golf greens. Bronze cutworms were a problem in home lawns in central Illinois.

Sod webworm activity was above normal in 1981. The second-generation worms caused damage in August. Little or no greenbug activity was visible during the past summer in home lawns.

RESEARCH

Several insecticides were evaluated for control of annual white grubs infesting a lawn in Urbana, Illinois, in 1981. A single application of each insecticide was applied to an established Kentucky bluegrass lawn with less than one-half inch of thatch on 27 July, approximately three weeks after peak adult flight. Plots were 10 x 20 feet in size; they were arranged in a randomized complete block design and replicated three times. Sprays were applied with a hose-end sprayer, and granular formulations were applied using a rotary granular spreader. All treatments were irrigated immediately after application with sufficient water to wet the first one-half inch of soil. Post-treatment counts of larvae were made on 8 September by examining ten random 4.25-inch-diameter plugs (one square foot) from each plot. The number of live larvae (grubs) found in a two-inch zone below the soil line was recorded (Table 1).

Oftanol [2 pounds of active ingredient per acre (lb. a.i./A)], Proxol (8 lb. a.i./A), diazinon (5 lb. a.i./A) and the combination of Dursban (2 lb. a.i./A) and Sevin (4 lb. a.i./A) gave excellent control of the annual white grub.

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Table 1. Effectiveness of Insecticides in Grub Control

Treatment	Pounds of active ingredient per acre	Average number of grubs per sq. ft.*
Oftanol 5G	2.0	0.3 a
Proxol 80SP	8.0	3.3 a
Diazinon 14G	5.0	0.7 a
Dursban 4E +	2.0	
Sevin Sprayable (80%)	4.0	1.0 a
Untreated	-	31.3 b

*Means followed by the same letter not significantly different at 5 percent level according to Duncan's Multiple Range Test.

1982 RECOMMENDATION CHANGES

Oftanol 5G performed very well for white grub control in 1981 and will again be recommended in 1982 along with diazinon and trichlorfon (Proxol and Dylox). Turcam, an insecticide from BFC Chemical Company, will be recommended as a turf insecticide for both soil and foliar insects. It was previously called bendiocarb (Ficam).

Dursban and Proxol are still the choices for black-cutworm control. For greenbug infestations, the best insecticide is Orthene.

NEW TURFGRASS FUNGICIDES

Malcolm C. Shurtleff

METALAXYL AND PROPAMOCARB

Two new fungicides specific for the control of Pythium blight have been added to the list of suggested fungicides given in *Illinois Extension Circular* 1076, "1982 Turfgrass Pest Control." These new products are metalaxyl (sold as Subdue 2E by the CIBA-GEIGY Corporation) and propamocarb (sold as Banol by the Tuco Products Division of the Upjohn Company). Both these new fungicides will provide two to three weeks of protection against Pythium blight even during extended periods of hot, wet weather when *Pythium* is most destructive. Both compounds provide long-lasting protective and systemic control, which, of course, is a distinct advantage over older materials such as chloroneb (sold as Tersan SP) and etridiazol (sold as Koban and Terrazole) that have been standard controls for *Pythium* in recent years.

Subdue 2E is an excellent fungicide for controlling Pythium blight. It has been under test in university trials since 1976 and is effective at the rate of 1 fluid ounce per 1,000 square feet applied on a two-week spray schedule.

Banol has been in our University of Illinois tests since 1977. It also does an excellent job of keeping down Pythium blight. It is suggested that it be used at rates of 1-1/3 to 4 fluid ounces per 1,000 square feet. The period for which Banol provides control is dependent upon the rate applied. The residual activity may be longer than two weeks at the 4-ounce rate, especially during periods when rainfall and/or irrigations are not excessive. There have been no reports of fungal isolates tolerant to Banol as there have been with Subdue. However, some researchers have reported that either disease control with Banol was erratic or the product was nonsystemic when applied to seedling turfgrass.

Subdue is fully registered for use on turfgrasses, while Banol in 1981 was available in limited quantities in some areas of the United States. We expect full registration of Banol for control of Pythium blight some time during the 1982 growing season.

A possible problem of Subdue in the future--and I stress future--is the development of *Pythium* isolates that are highly tolerant or resistant to it. Resistance to metalaxyl has occurred on other crops using the same product under a different trade name. We believe that, in any population of *Pythium* isolates, one or more of them are naturally tolerant; apparently resistant and tolerant nuclei occur together in the same fungal hyphae. If you continue to use the same fungicide routinely, every two to three weeks

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throughout the summer, these once-rare tolerant isolates will increase and become dominant in the population. The result is that the product will no longer control *Pythium*. This has happened or is happening to other systemic fungicides such as benomyl (sold as Tersan 1991) and similar turfgrass products (such as Cleary 3336 and Fungo). All three of these systemic products break down within a grass plant to produce the same active ingredient, which is abbreviated as MBC. So, if you have strains of the Sclerotinia dollar spot fungus that are resistant to Tersan 1991, they will also be resistant to Cleary 3336 and Fungo.

How do we get around the growing problem of resistant or tolerant isolates of *Pythium* and fungi causing dollar spot, brown patch, or any other disease? The answer is to either combine two unrelated fungicides in the same tank or to alternate these unrelated compounds. For the control of Pythium blight, alternate Subdue and Banol or use Tersan SP and Koban in an alternating schedule with Subdue or Banol. Or you might try combining in the spray tank two of these fungicides that are active against *Pythium*, unless the fungicide labels say otherwise. Remember, these products have just been registered, and we do not have a complete record of how they react with the wide range of turfgrass pesticides that are available. I have used Banol in combination with Daconil and Dyrene without any adverse side effects. When using any new pesticide combination, you should first test it out in a small way, preferably on a part of your turfgrass nursery, using the two products at more than one concentration until you learn how they react together under your conditions. After all, your job may be on the line if serious injury or lack of control results. When combining other fungicides with ones that control *only* Pythium blight (Subdue, Banol, Tersan SP, or Koban), you naturally want to add another fungicide that will control diseases that may occur together with Pythium blight (Rhizoctonia brown patch, Sclerotinia dollar spot, Fusarium blight, melting-out, and anthracnose).

There is no perfect fungicide, and no one fungicide controls all turfgrass diseases. As a turfgrass manager you can use these two excellent new fungicides, Subdue and Banol, wisely by alternating or combining them. We hope to look forward to their long-lived usefulness--that they will not select resistant populations of *Pythium* and thus lose their usefulness sometime in the future. Even if you use them wisely and another turfgrass manager does not, what can happen? Remember that the *Pythium* fungi can survive in clippings that can be carried on shoes or turfgrass equipment from one area to another, thus introducing resistant isolates where none existed before.

IPRODIONE AND TRIADIMEFON

Two other new or relatively new fungicides are iprodione (sold as Chipco 26019 Turf Fungicide by Rhone-Poulenc, Inc.) and triadimefon (sold as Bayleton by Mobay).

Chipco 26019 and Bayleton both control red thread or pink patch, Fusarium blight, Fusarium patch or pink snow mold, leaf smuts (stripe and flag), Rhizoctonia brown patch, and Sclerotinia dollar spot. In addition, Chipco 26019 controls Helminthosporium diseases and gives some protection against Typhula blight, while Bayleton also controls rust diseases and Typhula blight or gray snow mold.

Bayleton is a protective-contact, eradicant, and systemic fungicide. Chipco 26019 is primarily a protective-contact fungicide with some eradicant and systemic properties; it is truly a broad-spectrum turfgrass fungicide with an excellent record.

DUOSAN AND PCNB

Other changes in our 1982 fungicide recommendations from those in 1981 include Duosan for control of anthracnose and Helminthosporium diseases and PCNB (sold mostly as Terraclor) for control of leaf smuts and Helminthosporium diseases. PCNB is a long-lasting product that does not kill fungi but does prevent their growth and the germination of fungal spores. In other words, it is a fungistat and not a fungicide. Injury to turf has resulted where repeated PCNB applications have been made to turf in hot weather and where the emulsifiable formulation has been used. As with any pesticide, be sure to follow the manufacturer's directions on the container label.

PESTICIDE INCOMPATIBILITY

Another point that should be noted is pesticide incompatibility. There are three kinds--physical, chemical, and placement. Physical incompatibility is easy to observe; a precipitate may form in the bottom of the spray tank or a gummy-to-oily deposit may be seen around the edge.

Chemical incompatibility is much more difficult to determine since the spray mix may go on normally with no plugging of nozzles or other evidence as with physical incompatibility. In the case of chemical incompatibility, one pesticide in the spray mix destroys the effectiveness of another, resulting in a lack of control. I feel that some of the cases reported of a product no longer being effective, or reports of so-called resistance, may actually be cases of chemical incompatibility. This is why it is important to test all turfgrass pesticides separately and in various combinations in a nursery or other out-of-the-way place before spraying golf greens, athletic fields, or other turfgrass areas that are highly visible to the public. Cases of what you feel are chemical incompatibility, and instances of a product no longer performing as it once did, should be reported to the chemical company representative. We would also like to know about it at the university. Dr. Fermanian, Dr. Randell, and I are constantly evaluating cases of resistance or chemical incompatibility.

The third type of incompatibility is that of placement. For example, to control powdery mildew, red thread, and rusts you need to apply only enough spray to wet the grass blades, perhaps 1 to 3 gallons per 1,000 square feet. To control Pythium blight and Rhizoctonia brown patch, we suggest 10 gallons of spray per 1,000 square feet to ensure wetting the thatch and the upper quarter-inch of soil where the *Pythium* and *Rhizoctonia* fungi are lurking. To control Fusarium blight, leaf smuts, and nematodes you need to drench the fungicide into the root zone to get effective control. Correct placement of a pesticide is therefore important. You will not get good control of Helminthosporium diseases or Sclerotinia dollar spot or Fusarium blight with one spray application. If you drench in the spray, the grass blades will be left largely unprotected. If you apply 1 to 3 gallons of spray per 1,000 square feet, you will control leaf diseases but not Fusarium blight or nematodes.

APPLICATION

In the future we expect even more new turfgrass pesticides and new clearances for some older products. We need to use these materials wisely to maintain an effective arsenal of pesticides. This means following the manufacturer's directions.

It is important to diagnose the problem correctly at first and then to apply the *right* pesticide in the *right* amount at the *right* time, to use the *right* interval between applications, and to use the *right* equipment in the *right* way. The suggested times, intervals, and amounts are in the spray schedules in *Extension Circular* 1076. The right way involves proper pressure, nozzle selection, placement, and pattern. A pressure of 25 or 30 pounds per square inch will provide good coverage in the right spray mix.

Do not guess at the areas of turf to spray; measure them carefully every year or so and then record the figures on a card posted near the pesticide shelf.

It is also important to use only clean water. When preparing a spray solution, avoid lake, pond, or river water that may contain organic matter, clay, herbicides that injure turfgrasses, or other materials that could decrease the effectiveness of the fungicide or other pesticide. Every year we get calls on "what went wrong"; in many cases we can go back to the water supply as being the culprit.

DEVELOPMENTS IN TURFGRASS APPLICATION EQUIPMENT

Stephen L. Pearson

Effective and efficient pesticide application to ornamental and turfgrass areas requires maximum deposit of pesticide on the intended target with minimum amount of carrier needed to keep off-target drift within acceptable limits. Spray drift, target deposit, and coverage depend largely on the range of droplet sizes produced by the nozzle. Small droplets provide excellent coverage on the intended target, but they do not deposit effectively on many surfaces and are highly susceptible to drift. Conversely, large droplets contain most of the total volume of spray solution and provide poor coverage on the target area.

EQUIPMENT AVAILABLE

Conventional spray nozzles, such as the flat-fan and the hollow-cone agricultural nozzles, produce sprays with a wide range of droplet sizes. Application rates of 20 gallons per acre or more are frequently required with conventional spray nozzles to obtain adequate coverage for consistent pest control.

A hand-held spinning-cup atomizer (Herbi), which is being marketed in the United States, has a potential of limiting or controlling the droplet size spectrum. The premise is that eliminating droplets smaller than 150 microns will reduce off-target drift and that eliminating droplets larger than 300 microns will allow good coverage with low application rates. The advantages of Herbi over conventional hydraulic nozzles include the use of less carrier with equal coverage and probably less downwind drift deposit. Since the Herbi sprays a concentrated chemical mix, a large area can be covered with a fraction of the volume needed for conventional nozzles. The Herbi unit is lightweight and easily maneuverable for hard-to-reach areas. It sprays a hollow-cone pattern about four feet in diameter when held about eight inches above the target weeds. If there is a slight wind, the Herbi can be lowered closer to the ground and still not affect the four-foot swath significantly.

The Herbi, as with conventional nozzles, should be calibrated carefully. Since low volume applications with the Herbi do not wet the surface as do appli-cations with conventional nozzles, it is difficult to obtain the correct overlap when spraying turf areas. Changing the title angle on the sprayer head will change the spray pattern uniformity. It would be advisable to spray some water on a concrete or asphalt surface to check the spray pattern from the Herbi. It is critical for the operator to become familiar with the unique characteristics of the Herbi sprayer to avoid misapplication.

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When spraying turfgrass areas it is critical that the pesticide remain in the treated area and not be allowed to move to surrounding sensitive plants. Selective, "wipe-on" pesticide equipment has become available and is a practical solution for weed control in sensitive areas. One of the most adaptable wipe-on applicators is the rope wick.

A rope-wick applicator works as the name suggests. The chemical is moved from the reservoir into the ropes by the action of a wick. The chemical is then wiped onto the target by placing the ropes in contact with the weeds. Interest in such applicators has grown tremendously with the development of nonselective, translocatable herbicides such as glyphosate (Roundup).

Advantages of the rope-wick applicator are the comparatively low cost of construction and the availability of components. For more information about the construction of rope-wick applicators, see Pearson (2/81).

Use of the rope-wick applicators appears, at first, to be rather simple. Research has shown, however, that ropes vary greatly in their ability to transport glyphosate solutions. The use of different grommets and adhesives to secure ropes to the pipe causes considerable variation in the flow of herbicide solution, and the length of exposed sections of rope also has a dramatic effect on herbicide flow.

The rope-wick applicator is ideal for pulling close to the ground just above the turf canopy to control large weeds growing in the fairway. Hand-held rope-wicks can be used around the fringes, trees, or buildings for economical weed control.

DRIFT CONTROL

When using conventional hydraulic nozzles for pesticide application, there are several things that can be done to decrease the potential for drift to occur. One change is to decrease the operating pressure and increase nozzle size. For example, if you are operating an 8003 flat-fan nozzle at 50 pounds per square inch (psi) and you change to an 8005 flat-fan nozzle at 20 psi, the gallon-per-acre output remains the same, but the drift potential is decreased significantly.

Another way to decrease drift is to use a nozzle called the LP or low-pressure flat-fan nozzle. It is available from the Spraying Systems Company. This nozzle develops a normal fan angle and distribution pattern at spray pressures from 10 to 25 psi. Operating at a lower pressure results in large drops and less drift than with a regular flat-fan nozzle designed to operate at pressures of 15 to 30 psi.

Yet another possibility is the Raindrop nozzle, designed by the Delavan Corporation to produce large drops in a hollow-cone pattern at pressures of 20 to 60 psi. The RD Raindrop nozzle consists of a conventional disc-core, hollow-cone nozzle to which a Raindrop cap has been added. The RA Raindrop

Nozzle is a whirl-chamber nozzle with a Raindrop cap. These nozzles provide excellent drift control, but the coverage provided by small droplets is impaired when large droplets are used. It is a give-and-take situation.

Drift-control additives allow for the decrease of drift without changing equipment. In recent years these additives have been improved tremendously. Their chemical makeup may differ (although most of them are polyvinyl polymers), but they all are specifically designed for drift control. By using just a small amount of Nalco-Trol, Drifgon, Winfall, Mist-Control, or one of the many other products, the amount of drift can be drastically reduced. If you have to spray on a windy day or if there are susceptible ornamentals near your turf area, the addition of a drift-control additive can help prevent damage.

CONCLUSION

All the products previously mentioned can help the turfgrass manager do a more effective and efficient job of weed control. As with all other types of pesticide application equipment, they must be used with care to allow the products to perform to their potential.

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ORNAMENTAL DAMAGE

Robert E. Partyka

The lawn-care service industry has grown in the past few years to become a sizeable industry in the United States. Materials used in lawn-care areas are primarily compounds used in other agricultural endeavors, with modifications for rates and sensitivity readings on other plants. There is certainly a vast difference in using a material for only one crop compared to the selectivity that must be used in the urban landscape where many plants are grown. In fact, we try to control only a few obvious plants and save the rest--the complete opposite of many other agricultural operations.

Since the herbicides are primarily used to reduce certain plant populations and our mass media have conditioned the population to regard pesticides as being detrimental to plant and animal life, we become involved in situations where any abnormality on plant material after the lawn area has been treated is seen as a reflection of herbicide action.

Granted, some problems do exist, as is often evident in new products, formulation factors, and application equipment; there are also mistakes in fill procedures and application. However, these problems are a part of development, and if one waited for everything to work perfectly every time, progress would be slowed.

The adaptation of herbicides to the lawn-care industry has seen some problems, but diligent research and careful field observations have put us in a period where desired results have been achievable. When certain problems develop, one can often relate them to weather conditions that have not been considered in field-crop usage. Specific problems are often related to human mistakes or carelessness; but, in general, the weed-control materials have performed well in the turf area.

However, due to environmental and human concerns, materials are being curtailed or taken off the market for lawn industry use. This means that standard approved materials will have to be used at higher rates or greater frequency to get the job done or that newer compounds that have the proper labeling will be used, resulting in renewed investigation of tolerable levels for the mass of urban plants.

HERBICIDE-RELATED DAMAGE

Our familiarity with 2,4-D, MCPP, and dicamba symptoms on broadleaf turf plants and resultant overdose symptoms on woody ornamentals has made us aware of what to expect. The parallel veins, leaf cupping, and strap-leaf effect have been observed by most people in the industry.

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The damage resulting from chlorophyll inhibitors such as simazine and atrazine has been seen on broadleaf plants.

Soil sterilants have been used too often with a misunderstanding of how some of them can move in the soil or on the surface or of exactly the length of their residual life in the soil.

Some of our newer materials that appear to decline readily in the soil may be more persistent under some conditions than was formerly suspected, especially if woody ornamental roots are in the vicinity of the turf roots or if methods are employed in the turf to enhance direct root uptake.

An area that needs much emphasis is related to the numerous problems that are encountered by ornamentals. Too often symptoms that mimic herbicide-related problems develop on landscape plants. Because the area was treated with a particular herbicide, the lawn-care industry often replaces the plant. The decision to do this has to be determined for each situation. However, knowing how materials work in the turf and their impact on woody plants is important in determining a replacement. Too often poor plants, improper handling practices, poor planting techniques, and poor location, timing, watering, and genetics of the plant are all related to the decline of the plant. Plants of this nature that fail should not be replaced by the turf industry. There are situations where a combination of problems is involved and a sharing of the responsibility is necessary as a goodwill gesture to the consumers. Why not? Without them we cannot sell services or products.

We know much about the materials that are in use and will have to keep abreast of newer compounds as they develop. But what about next season when we will have to use older materials at higher rates to obtain weed control? How can the higher rates affect woody ornamentals?

Preemergence herbicides in general have not caused any major visible problems on woody ornamentals. There is, however, evidence that some of these materials can inhibit root development of turf plants. Can there be some influence on woody ornamentals? If not for compounds currently in use, can this be a factor to consider for new materials that are developed? Can they predispose the plant to other problems?

Most preemergence herbicides can act as a food source for microorganisms. In fact, organisms contribute to the breakdown rate of most pesticides. However, one has to be concerned with materials that are broken down by soil microbes, especially if the microbes are disease-enhancing organisms. The continued use of one material may contribute to a buildup of certain organisms that may become troublesome if proper environmental conditions persist for the prerequisite time in the turf.

REDUCING HERBICIDE-RELATED DAMAGE

The growth-regulator materials often cause symptoms to appear on many woody ornamentals. A decision has to be made as to whether the symptoms are severe enough to cause death or to weaken the plant so that other factors may kill it. If not, the damage may be cosmetic, and the plant will grow out of the problem. Since these materials are volatile, are soluble in soil water, and move with soil moisture, a number of factors should be considered.

Plant Susceptibility and Root Depth

Be mindful of plants that will react readily to dicamba, 2,4-D, and MCPP. In most cases the problem is related to dicamba. Pin oak, linden, willow, redbud, and magnolia appear to react more than others to this material. In some cases the problem appears to relate to the extent and depth of the root system. But in other cases such as grape, tomato, and vine crops, volatile fumes are important; they can contribute to considerable foliar distortion and affect the set and eating quality of the fruit.

Soil types can affect movement of water and can carry materials readily into the root zone. Therefore, one can expect more problems in coarse soils such as sand than in clay (or possibly where a thick organic layer developed as thatch). The ability to detain the material and allow microbial activity to degrade it will result in less movement to the root zone. However, a fine soil on a graded terrain could allow the materials to concentrate in low spots and create a problem on plants in that area.

Irrigation systems found in many lawns may provide the water to move materials to the ornamental root zone more rapidly. Since irrigation systems are often designed to wet the soil to the depth of the turf roots, a problem may be created if the herbicide is carried rapidly to the ornamental roots before it has become fixed or degraded in the soil. On the other hand, excess water from natural rain may carry the material beyond the ornamental roots, resulting in minimal or no symptoms.

Reapplications

Because materials may not be efficient in controlling weeds, there may be a greater need for reapplications. This may create problems with excess materials building up if too much is applied. Too often, one will soak the turf well to control the weeds. In other cases, if a weed is missed and a service-call application is run, a buildup of materials in a short time span will result. Heavy rains at the proper time may carry materials down into the root zone and affect woody plants. Where reapplications are necessary, it is important to make sure that the material has sufficient time to perform, and spot treatment is preferable to overall application to reduce potential buildup in the soil.

Persistence in the Soil

Because these materials are subject to water movement and biological breakdown, local environmental conditions can often determine where the material will go and how long it will remain in the soil. Warm, moist soils with sufficient oxygen favor microbial activity and rapid breakdown of the pesticide. Conditions that inhibit microbial activity, such as low soil temperatures, dry soils, or low oxygen tension, will result in materials remaining in the area for a long enough period of time to allow for absorption by woody plants.

The half-life of 2,4-D under favorable soil temperatures is a week to ten days. Natural movement through the soil profile is slow, so the chance of deep penetration of 2,4-D is limited unless it is used in specific situations of very coarse soils and large volumes of water. The half-life of dicamba is longer (25 days). Because of its water solubility, dicamba may move to a greater depth in the soil. Lower soil areas often have low oxygen tension and thus less microbial activity. Therefore, the chances of dicamba remaining in the soil longer are greater. In some cases, there is a question as to whether the material moves with capillary soil moisture during periods of water stress in the soil. Foliage symptoms on late-season growth have been observed on many plants long after dicamba was used in the area. In some cases, symptoms appear on susceptible plants one or two years after dicamba application, suggesting a soil reservoir that moves upward and is absorbed by the plant when moisture stresses occur due to limited rainfall late in the season. Although symptoms may be present on the foliage, the degree of leaf distortion is often an indicator as to whether any serious plant damage is occurring.

Fumigation or Volatilization

Higher rates result in greater volatilization and concentrations to cause a foliage distortion on susceptible plants. Periods of slow drying and evaporation may result in greater concentrations of the materials in and around susceptible plants. Therefore, windless conditions may result in more symptom expression than when some air movement is present. However, a slow, steady wind can move volatile materials in one direction and produce a reaction on susceptible plants on the downwind side. Again, the need to be cautious on reapplications within a short time span is emphasized.

Droplet size control is important to prevent movement of the herbicide to susceptible plants. Therefore, a close check on pressures is necessary. Higher pressures allow the turf specialist to spray faster, but more fine droplets will be produced; there is also a greater chance of droplet bounce from the turf to low ornamental branches. Droplets with greater concentrations of active materials will produce more noticeable symptoms on susceptible plants.

SUMMARY

The chances of more herbicide damage to woody ornamentals can be minimized by being aware of these factors. If and when a problem occurs, it will be necessary to review application dates, fill charts, and customers treated that particular day to see if other problems exist. Also, consider the history of the affected plant and its location. Determine if the problem is truly herbicide related, herbicide enhanced due to other predisposing factors, or totally unrelated to the lawn spray but coincidental in timing.

USING COMPUTER TECHNOLOGY FOR EFFICIENT RECORD KEEPING

Robert F. Parmley

WHAT IS A COMPUTER?

A computer is an electronic digital device used to store and process data or text. I like to think of it as an office tool that performs the functions of a file cabinet, calculator, editor, sorter, collater, copier, and typewriter.

The term "hardware" refers to all the machinery involved with a computer. You can touch, see, and hear hardware. The term "software" refers to programs or sets of instructions that operate the hardware. Software is transparent to the user; it is not tangible.

The first electronic computer was put into use in 1946. It used 18,000 vacuum tubes to operate and required a huge room and rigid environmental controls. With the integrated circuit technology of today, we have desk-top units that have no environmental constraints--at a fraction of the cost. IBM estimates that a calculation on a computer cost $1.26 in 1952. Today that same calculation costs $0.007. Technological advancement even in the last two years has made a computer for a business with fewer than ten employees not only possible but probably justifiable.

WHY DO YOU WANT A COMPUTER SYSTEM?

The following five statements have often been heard as the justification to employ a computer.

1. "My competitor has one." WRONG! Your competitor may be doing you a big favor. You have no way to know if he has properly prepared his company for a computer.

2. "My business is all screwed up and I need a computer to fix it." WRONG! Postpone a computer installation until you develop procedures, establish standards, and install controls. If a good manual system is lacking as a foundation, the computer will simply help you make a bigger mess faster.

3. "A computer will allow me to cut down on staff." WRONG! Studies of computer installations in companies of all sizes show that staff can rarely be cut back. What is more likely is that the computer will permit more growth without additional hiring.

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4. "We can try and see if it works." WRONG! Computer installations tend to be a one-way street. To abandon a computer may result not only in a dollar loss but also in frustrated staff, poor morale, and a loss of respect for management.

5. "We'll ease into a computer and learn it while we use it." WRONG! This attitude leads to unrealistic expectations and almost certain disappointments. You need to know what you expect *before* you decide to computerize.

A more sound approach includes analyzing all four of the following statements:

1. "I know what processes in my company will benefit from a computer." You have analyzed and you *understand* the procedures of your company. You have a controlled manual framework in existence and can see where improvements can be made with the speed and accuracy of a computer. This is a great opportunity to really look at your operation. It is beneficial even if the decision is no.

2. "I have a business plan for growth that includes specific objectives for the role of the computer." You need to know how and at what rate you plan to grow and what role the computer will play. Set priorities for your improvement needs: accounts receivable management, truck routing, cancellation follow-up, timely financial statements, and so forth. You cannot implement 100 percent of your plan on the day of installation, so be certain that you know where your business can benefit the most.

3. "I have studied the costs of a computer and believe that the benefits justify the cost." There are obvious out-of-pocket costs. But realize that there are many hidden costs, too. You will be taking a financial risk.

4. "I am willing to get involved." A successful installation *must* involve the commitment of someone at top management. It is not necessary that the person know how to program, but he/she must know what data are being accumulated and the capabilities of the system. He/she must be able to design applications, to set objectives, and to be creative.

POTENTIAL BENEFITS OF A COMPUTER

Improved Customer Service

By using the computer screen to provide immediate, up-to-the-minute status of a customer, you can satisfy most customer questions on the spot.

You might use the computer to record lawn history data (e.g., problems seen on the lawn, materials used, dates of applications). This history can be quickly available to service personnel before new service to a lawn is performed.

Improved routing and response times are possible by allowing the computer to do the bulk of the work. Let it tell you what lawn is done or overdue for service. Print work orders only when you are ready for service so that new accounts or cancellations are handled by machine, not staff.

Improved Cash Flow

A computer should help you turn over your accounts receivable more quickly. Determine how long accounts are overdue in minutes; print overdue notices for mailing; hold service until the last invoice is paid; list problem accounts for personal follow-up.

Accounts payable can be paid more strategically if you can easily see who is offering cash discounts; let the computer monitor big vendor accounts.

Timely financial statements and variance to budget reports can help you spot excessive expenses quickly.

Improved Vehicle and Inventory Control

Collect data on each vehicle. Let the computer help you determine when preventive maintenance is due or when it is time to trade.

Quickly know the material consumption of each truck to help you control this big cost.

Forestallment of Hiring

Generally, you can expect manpower costs to increase in the short run at the time of installation. Once installed, however, office productivity should rise, and substantial growth might be possible before staff must be added.

Streamlined Systems and Procedures

Remember the old adage that "confusion costs money." Computers can become the only place to look for information. Eliminate numerous paper files.

Improved Quality of Staff Time

The computer should reduce time now spent on petty, mundane problems like searching for a customer's file. It permits more time to be spent in true customer service.

Better Management Data

This area is where your creativity comes into play. With a computer you can run analyses in minutes that might take your manual staff days to assemble. And you can perform these analyses frequently for management control.

EVALUATION OF COSTS FOR AN IN-HOUSE SYSTEM

Because of the uniqueness of our business, you will probably be unable to find an acceptable system from outside service bureaus. That fact, coupled with the affordability of the new desk-top computers, points you to an in-house system.

Out-of-Pocket Costs

The following are the obvious costs to be considered:

1. Hardware--purchase, lease, financing, charges
2. Maintenance--manufacturer or third party, contractor time and materials
3. Depreciation
4. Monthly supplies--ribbons, paper, forms, diskettes
5. Software--monthly rent, one-time purchase
6. Software maintenance--upgrading purchased software
7. One-time setup cost--electrical, furniture

Hidden Costs

The following hidden costs must be considered:

1. Diversion of management time during installations
2. Training of staff in use of computer
3. Conversion of manual records to computer. Consider converting as much data as possible *before* the computer comes in the door. This way you will get better value for your computer from day one.

4. Technological obsolescence. Consider the rate of growth of your company and the possibility of adding to your system.

5. Excessive programming. Do not expect an outsider to tell you what you want. If you do, you will pay the programmer extra to learn what you really want.

Possible Hidden Costs

The following hidden costs may be incurred:

1. Reprogramming. If the system is poorly designed, it is generally more expensive to reprogram.

2. Loss of data or inaccurate data. This results in extra staff time to recreate or verify. Frustration and low morale may result.

3. Loss of customer goodwill. Do not let the customer think he is now just a number. Be certain that the computer does not make a mistake.

4. Delays in business operations. You become vulnerable if you are unable to access data because the computer is down. Evaluate your equipment reliability and maintenance response time before purchase.

SYSTEM CONSIDERATIONS

Consider the following points when choosing your system:

1. Operator ease. A system should be designed for ease of the user. Let the machine do the work. Edit for errors on the screen whenever possible.

2. Daily back-up. Never totally trust your computer. The system should be copied to diskettes for storage every day.

3. Security. The system should have the ability to allow users to access only what *you* want them to access. For example, payroll records should be protected.

4. Documentation. Some day a stranger will try to understand your program. Be sure your flow of data is well documented.

5. Planning for growth. Be aware of the expandability of your hardware. Are your programs convertible to other hardware?

Several features that are useful to have are:

1. Report generator. Nonprogrammers can create their own reports by filling in blanks.

2. Text editor. Compose letters; they are easy to change.

3. Word processor. Merge data and text to create personalized letters.

CONCLUSION

In conclusion, a successful computer installation is dependent on a key manager's planning, organization, and direction of the project. The computer will take on a personality; it will become a part of the company. Be certain that it is a lovable personality.

DEVELOPING COMPUTER SOFTWARE SYSTEMS

Thomas W. Hofer

I began developing a computer system for our franchisees a little over two years ago. We initially used IBM 5110 equipment, but now we are converting to an IBM System 23. Both of these machines are small business computers. They are larger and more sophisticated than personal computers, but they are not large centralized computers with terminals and telephone lines to remote sites. Our system is designed so that each of our franchisees can purchase his own computer. We then lease the software to the franchisee.

Prior to developing our computer system, I had no computer training or experience. What I have learned has come from doing some things right and some things wrong. My goal in this paper is to pass on pointers, warnings, and advice about bringing a computer on line.

Introducing a computer into your business is definitely like going down a one-way street--there is no turning back. The investment of both time and money in putting a computer in your business makes it highly unlikely that you would ever go back to a manual system. If problems with your computer system arise, it is probably going to be cheaper and easier to fix the problem than to revert to a manual system. Therefore, when you add a computer to your business, do it with the idea that it is a serious decision that is irreversible.

Let us assume that you have made the decision to add the computer. Let us also assume that you have chosen the hardware (the computer itself). You know, generally, what you want the computer to do and what reports and types of analyses you want it to generate. Now it is time to think about developing the software you need.

WHAT IS SOFTWARE?

Software consists of two kinds of recorded information--programs and data files. Programs are simply sets of instructions to the computer that enable it to interact with data to produce what we want. It might produce a screen display, a printed report, statements to overdue accounts, or many other possibilities.

Data files are structures for storing information electronically. Programs interact with the information stored in the data files.

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SOURCES OF SOFTWARE

Software is available from three general sources:

1. Computer manufacturers (such as IBM, Burroughs, etc.)
2. Software vendors (companies or individuals who create software)
3. Other companies in a business similar to yours (such as other lawn-care companies)

TYPES OF SOFTWARE AVAILABLE

Software is available in three basic forms: canned packages, modified packages, and customized packages. Canned software packages are typically for standard applications; they normally work well without modification. You just load the program into your machine and enter the start-up data, and it is ready to use. General ledger is an example of an application that is available in many different canned packages.

Modified packages are usually canned packages that do not quite meet your needs, so they are modified slightly. Modification sometimes requires an additional programming fee.

Custom packages are normally the most expensive alternative. In this case your needs are unusual. There are no other packages available that can be modified to meet your needs, so the programmer starts essentially from scratch in developing your software.

INVESTIGATING SOFTWARE NEEDS

First, you must generally know what you want the computer to do. But how do you know what you want it to do? You have several alternatives to help you zero in on how the computer should function in your operation. Your best alternative is to talk to people in a similar business who have a computer and to determine what they are doing. Other good sources of information are software vendors and computer manufacturers. These people have worked with many different types of businesses, and they might have some good ideas for you.

After investigating, you should be idealistic. You should make a list of all the things you would like the computer to do. Then you should apply realism to your list. The list should be ranked according to the particular application and what you can afford.

INVESTIGATING SOFTWARE SUPPLIERS

During your investigation of software suppliers, you will be able to clarify the software choices. It will gradually become clear whether a canned package, a modified package, a customized package, or a combination of these types of packages will be necessary to satisfy your needs.

No matter what combination of software you need, you must be confident that it will handle anticipated business growth efficiently with little or no reprogramming. You simply do not want to make a substantial investment of both time and money and then find it impractical in a year or two. This is true of hardware as well as software.

You want to investigate the permanency of the language your software uses. A language is not the same for all computers, even though it has the same name. For instance, BASIC language on an IBM 5110 is not the same as BASIC language on an IBM System 23. Reprogramming to switch from one of these machines to another can be expensive. You want a language with which you can upgrade your computer hardware to a more sophisticated machine (if that is likely) without reprogramming.

Another area of concern in a software supplier is ongoing support. Will the bugs (or mistakes in the program), which are certain to be found over a period of time after the system is in operation, be fixed? At what point does the software supplier's responsibility end? What will be the charges of maintaining the programs after the supplier's responsibility ends?

You should be concerned about training in the use of the software and the documentation that the software supplier provides. You need to be aware of the idiosyncrasies of the software before it is too late.

Software suppliers should be reliable and knowledgeable. They should be technically superior. Your supplier should be someone you can work with and get along with because you will probably work together closely on the project. Software suppliers should also be accessible. If you have a problem with the software, you want an answer quickly. An inaccessible programmer can be a real problem.

In investigating software suppliers, your best source of information is other people who have used the particular supplier. You will want to get answers to certain questions:

1. In general, how did you like the work they did?
2. Did they conform to your timetable?
3. Were they accessible; were you able to get problems solved quickly?
4. In general, what is it like to work with this supplier?
5. Did one programmer handle your account, or were there several?

Because we all have different likes and dislikes in people, you should talk to more than one of the supplier's clients. One person can give a pretty distorted view, but it is unlikely that several people will all give you the same distorted feedback.

DETERMINING A TIMETABLE FOR IMPLEMENTATION

To successfully implement any project, timetables, schedules, and deadlines must be established. Bringing a computer system on line is no exception. A timetable is necessary for the software supplier to schedule their work. It is also necessary for you to schedule your preparation for the computer. You must get your records ready so that you can enter the data in the computer at the proper time. The preparation of your records should be discussed with the software supplier so that you will know when various phases of preparation must be done.

Timetables are easy to set but hard to maintain. There are several reasons. One reason is the general characteristics of programmers and software suppliers. They have a relatively new and exciting technology that is very flexible. They can do almost anything you want, if you have enough time and money. As a group, programmers tend to be optimistic about what they can accomplish in a certain period of time. They tend to overcommit and find themselves having to scramble to deliver on time.

Another reason for difficulty in keeping on a timetable is that new ideas and new possibilities arise as you get into the project. You start to see additional features that you would like to add to the software. Adding additional features tends to put you behind schedule and costs money.

Your timetable should have plenty of extra time in it; you will probably need it. These projects almost always take longer than initially seems necessary. The timetable should be put in your contract with the software supplier, with penalties for getting behind schedule.

HOW DO YOU KNOW IT WORKS?

Test it! Test it yourself or have someone in your organization, who is very familiar with the computer system, test it. Do not take the programmer's word that it has been tested. The programmer might be thinking it is supposed to do things in a certain way, while you want it to work another way. Make the computer handle every possible situation. Then check to see if it handled all situations properly.

When you have proved to yourselves that the system works, you will be confident in it. Unless you have confidence in the system, you will always worry that it is messing up the business. Getting very familiar with the software in the testing phase will help you in solving operational problems that tend to crop up later.

Testing is of utmost importance. An unknown bug in a computer program can really mess up a business.

SUMMARY

Important points to remember are:

1. Talk to people--both in the process of determining what you want the computer to do and in choosing a software supplier.

2. Put plenty of extra time in the timetable of implementation.

3. Test thoroughly.

AN EVALUATION OF LIQUID NITROGEN FERTILIZERS FOR HOME LAWNS

Bruce G. Spangenberg and Thomas W. Fermanian

Nitrogen is generally considered the controlling nutrient of turfgrass growth. Actively growing turfgrass responds quickly to available nitrogen with improved color and increased shoot growth. There are many fertilizers available that supply nitrogen to turf; the majority are applied as dry materials. However, liquid-nitrogen-bearing materials, some of which are relatively new, may also be used on turf. Liquid application can offer the advantages of reduced labor, uniform distribution, and reduced mixing and loading time. With the rapid growth of the home lawn-care industry in recent years, an evaluation of these types of materials is needed. Liquid fertilizers could prove to be a vital part of a total lawn-care program. As research on fertilizers conducted by private industries is not generally available for others to use, the purpose of this study is to evaluate the performances of liquid sources of nitrogen relative to each other and to granular sources in a home lawn-use situation.

DESCRIPTION OF STUDY

This study was initiated on 1 May 1981 on an established stand of 'Columbia-Touchdown' Kentucky bluegrass (*Poa pratensis* L.) at the Ornamental Horticulture Research Center in Urbana, Illinois. Each treatment was replicated three times as 3 x 10-foot plots in a randomized complete block design. Liquid materials were applied using a CO_2 backpack sprayer with an 8010 LP nozzle, with a final spray volume of four gallons per 1,000 square feet. Granular fertilizers were applied by hand. A schedule similar to that of a home lawn company was set up, with four applications in 1981 on 1 May, 18 June, 6 August, and 9 October. A similar schedule is planned for 1982.

Nitrogen sources applied as liquids include FLUF, Formolene, UAN, Folian (12-4-4 and 12-4-6), Nitroform, and urea. Granular sources used in this study include SCU, urea, ammonium sulfate, ammonium nitrate, urea with inhibitor, and ammonium sulfate with inhibitor. FLUF, or flowable liquid ureaform, is a nonburning, nonleaching material with slow-release nitrogen characteristics. Formolene is a solution of short-chain urea formaldehyde compounds with moderate initial response and a nitrogen release period of eight to twelve weeks. UAN is a urea/ammonium nitrate solution with a high initial response and a nitrogen release period of four to eight weeks. Folian is basically a free urea solution; however, its performance was surprisingly poor in this first year of the study. This reduced response was later found to be the result of a calibration error. Nitroform has a very low initial response but a long residual response, lasting two to three years in the soil.

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Urea is added to some of the liquid sources to provide a soluble source of nitrogen for the turf until the controlled-release source becomes available to the plant. In addition, chelated iron was added to some mixtures rather than urea to provide quick green-up without the possible detrimental effects, such as disease, that excess nitrogen may cause. There was a total of twenty-five different treatments in addition to the check. Nitrogen rates were generally one pound of actual nitrogen per 1,000 square feet per application, except for SCU, for which the rate was two pounds of nitrogen per 1,000 square feet in May and August. Less nitrogen was used when mixed with chelated iron.

Color, quality, growth rate, and fertilizer efficiency are the main factors being monitored in this study. Visual ratings of color and quality were recorded regularly using a scale of one through nine, with nine being excellent. Growth rate is measured approximately every two weeks from fresh clipping weights. Fertilizer efficiency will be determined from the total nitrogen content of oven-dried clippings using the Kjeldahl method. Data also include phytotoxicity, disease occurrence, and thatch buildup. Weather data are recorded daily throughout the study. All data collected were analyzed statistically.

RESULTS

As expected, the addition of urea as a soluble nitrogen source to controlled-release materials such as FLUF and Nitroform did give a faster response than the controlled-release material by itself. Color ratings were significantly higher within seven to ten days in the period following the second application (18 June). However, after the third application (6 August), the addition of urea to FLUF and Nitroform did not make any significant difference in color.

Chelated iron gave similar results when used in the same manner, although the response came within 24 hours. The plots with urea mixed with iron compared to those with urea alone showed similar timing. The iron gave significantly greater color response within 24 hours, and the urea by itself gave greater color response seven to ten days later. There was no significant difference in growth rate between the two.

Sulfur-coated urea showed a very good response throughout the growing season, especially in late summer. Both FLUF and Nitroform showed a gradual increase in response as the season went on. Of the liquid sources, urea showed the quickest response, followed by UAN and Formolene.

Phytotoxicity occurred on UAN plots following appplication on all dates. Additionally, liquid urea treatments showed tip burn following the 9 October application. Some granular materials showed spot burn in the early applications; this damage was due to inadequate hand application and was not a problem in later applications.

There were few disease problems in 1981. Dollar spot was present in early August, but it was restricted to the check plots.

CONCLUSIONS

It would not be justifiable to make conclusions regarding final evaluation of these materials with only one season of data. The 1981 season did show some trends that will be helpful in making conclusive evaluations after an additional season of data. Finally, with two seasons of data, a schedule of practical use to home lawn-care companies may be drawn.

ALTERNATIVE SOURCES OF INCOME FOR THE PROFESSIONAL LAWN CARE INDUSTRY

J. Martin Erbaugh

My topic today addresses the subject of alternative income sources for our industry. What we are talking about here is diversification into other spheres of activity by businesses that are principally oriented toward minimum-maintenance chemical lawn care.

CUSTOMER TURNOVER

In order for us to get serious about this subject, I believe that we should take more than just a few minutes to come to grips with the industry-wide phenomenon of increasing rates of customer turnover. If you believe as I do that increasing rates of customer turnover are inevitable, then the search for alternative income sources becomes crucial for profitable growth through the 1980s.

The lead article in the July 1981 issue of *Lawn Care Industry* magazine carried the following headline: "Customer Retention Down, New Sales Up, Lawn Businessmen Say." It went on to provide a brief demand analysis for lawn-care services and to cite many businessmen around the country with respect to their experience in the spring of 1981 in the area of customer retention and new sales.

I know of no lawn-care businessmen who are not concerned about their annual retention of customers. Notice I did not say "paranoid," or "suicidal," or "immobilized." I said "concerned." This concern is based on an awareness of the accelerating cost of acquiring a new customer.

Costs of Acquiring New Customers

Let us take a very simple hypothetical situation. Let us assume that your company serviced 1,000 customers this fall and, further, that from fall of 1980 through spring of 1981 you experienced a 20 percent attrition (cancellation) rate on your 1980 customer base. Using this 20 percent factor as your experience base, you could project that by spring of 1982 you would be retaining 800 of those customers serviced this past fall.

Without taking your probable interest in growth into account, this set of facts would indicate the need to acquire 200 new accounts next spring to finish that period with the same number (1,000) that were serviced this fall. To develop my thesis, let us assume that the cost of acquiring a new customer is $30.00 (total cost of advertising, estimating, and closing divided by the number of accounts acquired). This figure is debatable, and there is no data bank on which to draw for verification. Based on my experience, however, if you are acquiring new customers at a cost less than

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this, you might consider diversifying your business into marketing consulting. I can assure you that you would have plenty of clients.

Using this figure of $30.00 would indicate the need to spend $6,000.00 to acquire the 200 customers needed to get back to the 1,000 number. That is a considerable investment just to replace lost customers. This cost is also accelerating as an increasing number of companies compete for a decreasing number of nonusers.

The thoughts that can go through your mind as the manager of this hypothetical business are many, such as, on the positive side:

- Well, I did a better job this year than last so my retention next spring should be better.

- I am not going to increase my prices as much as I did last spring, so my retention should be better.

Or perhaps you are really thinking that your cancellation rate will in fact increase because:

- The quality of my product is good but not much better than that of my competition.

- Inflationary pressures are such that I must increase my prices as much as last year.

- My existing competitors are not asleep, and they are as aware of the dimensions of this retention issue as I am.

We are in the business to make a profit, and we hope to see this profit increase. It is extremely important to analyze your future profit potential with an eye toward the total cost impact of acquiring new customers to replace lost customers. The 1970s were rather a halcyon period of growth for our industry. Market demand saw us growing at a much faster rate than I believe we will see, in general, in the 1980s. Advertising dollars were those that we spent to grow, to add to our relatively stable customer base. Now there is increased competition and all that it implies. Let it be sufficient to state that the replacement cost of lost customers is a critical variable in our profit structures today--one that can only increase in importance in the future.

Inevitability of Customer Turnover

My own inclination is to believe that increasing rates of customer turnover are inevitable. I say this because--whether we are dry or liquid, whether we offer four or five applications, whether we charge $1.00 per application higher or lower than a competitor, whether we have tank trucks or vans--a nonuser of lawn-care service sees that we offer a rather undifferentiated product.

My belief is further strengthened by the old supply-and-demand analysis. For the sake of simplicity, let us assume that in your city there are 1,000 properties that are potential lawn-service customers. Let us further assume that, in this city, Company A presently services 500 customers and Company B services 300 customers. Company C will enter the market next spring. On the supply side there will be three companies; on the demand side there are 200 unserviced properties. Let us assume that Company C, the new company, will enter aggressively with slight price advantages in the interest of developing a market share.

We know that, of the unserviced properties, a certain percentage are do-it-yourselfers and that another percentage are the province of the full-service maintenance firm. We also know that there has been some new building, which will increase market size. On the other hand, we are aware that there has been less new construction than in the past, due to today's real estate environment.

Last year Companies A and B experienced a 20 percent cancellation rate. The question is: in this environment, what will their turnover rate be next year? Supply in this hypothetical situation is approaching demand even without the prospect of a new entrant into the market. The new entrant will undoubtedly attract some customers from the established firms. As the established firms had a 20 percent turnover last year without the new entrant, is it realistic for Companies A and B to project on the same basis of 20 percent, knowing that the new company is coming in, that the market is nearing saturation, and that the market (due to economic conditions) is not growing rapidly? I think not.

This supply-and-demand analysis is only relevant to the individual firm when it is done with a view to cities in which the firm is actually working. We know that the nationwide demand for lawn services is still greater than the supply and that our industry--nationwide--will grow next year and into the future. That is small solace to the firm doing business in one city that is highly competitive.

There can be a tendency to point to the economy as the real villain. I do not recommend this. Rather, if the position I have outlined makes sense to you, I would use whatever conclusions you draw as the basis for a reanalysis of your short- and long-term goals and the planning of your strategy.

DIVERSIFICATION

Clearly, one strategy that can be employed in this context is diversification--a search for alternative sources of income. It is a strategy that, while attractive, should be employed carefully. As we tackle the business problems that are to a certain extent peculiar to our industry (for example, seasonal cash-flow requirements), it is easy to look in other directions--sometimes any other direction--sigh, and say, "If I were only in *that* business, my life would be complete." Most of us have this psychological bias in favor of diversifying.

We provide our consumers an economic value, and in this sense our industry is stable. The textbooks are full of cases of premature diversification. If you are servicing markets that are still somewhat virginal, where increasing rates of customer turnover have not yet really been experienced, diversification is probably not the way to go. Why diversify and "take your eye off the doughnut" when market factors indicate that you can profitably increase your market share in your basic service line? Further, even if you *are* working in competitive markets and are experiencing increasing rates of customer turnover, you must look at your profit structure. There are no guarantees that diversification will be more profitable. There is the possibility that you could diversify into an activity that is less profitable, spend a lot of time and money on it, and experience a net move backward. Perhaps your time, money, and attention are better directed at shoring up service systems in your basic service.

Case History

Diversification is not a panacea. I will cite an example from my own firm. A fellow approached us and wanted to come to work for us. He was a friend of one of our managers. He had been in his own chimney sweeping business, wanted to continue in it, wanted a stable income, and thought there was a fit. He was a likeable fellow. I began to think. We have all those customers, and 95 percent have fireplaces. The peak season is late fall and early winter, so in this sense it could extend our season. We have vans that could be utilized. The capital investment is low. We have an experienced man. It makes sense; let's do it.

We hired the guy. He worked with our advertising people to put together some pieces. This was in early September. Our lawn-care people began passing out the material. Our chimney sweep had told us that there would be no problem doing five a day. A group of us went out with him, watched him do the work, and agreed. So we set up our scheduling system for five a day. What we did not know (and probably should have known) was that our chimney sweep had never done five a day himself!

The sales poured in. Our customers loved it. We developed about a three-week backlog overnight. We were thrilled. We decided to set up operations in all our branches and bought the equipment. We were so revved up that we developed a newspaper advertising campaign to launch in mid-October.

The sales kept pouring in. I went on vacation. Our good chimney sweep worked hard the first several weeks. However, he rather quickly concluded that he needed more money if he were to continue doing five a day, let alone train the people in the branches. Then, while I was still on vacation, I got a call telling me that our chimney sweep had quit. This was in early October. We had five weeks of work to do; we were committed to the newspaper campaigns; we had bought the equipment for the branches; and we had no one to do the work in our initial branch. It was a mess.

We had a considerable amount of lawn care still to do. We had no choice, however, but to pull lawn-care people out of production to get the chimney work done. This created havoc with our lawn-care production. Can you imagine what it is like trying to get a good lawn-care person to sweep chimneys? Do you know what soot can do to bear rugs or 14th-century orientals? What is worse, we had a large quantity of caps. We knew that flue sizes vary, so we ordered a good selection. Nearly every time we went out to put on a cap, however, it was an odd size; so we had to special order. We made trips and more trips back to the home for a lousy $50 cap. We literally had to put the full thrust of our management into straightening out this mess. We started to have lawn-care cancellations because we were late with our treatments. We also had chimney-sweeping cancellations because we missed our chimney appointments. Service-call systems went up in smoke. The problems were compounded when customers, poorly spent advertising dollars, and employee disgruntlement resulted in a lot of sales, but a lot *more* cost than sales income. It was a classic case of a good idea that was poorly researched and poorly managed. We took our eye off the doughnut. We diversified improperly. It cost us a lot of money and a lot of good will. We would have been much further along if we had not considered the idea.

There is a happy ending to this tale of woe. We are still doing chimney cleanings and putting on caps. We sweep chimneys only after the first of November and for our lawn-care customers *only*. Our sales are lower, but we are not conflicting with our basic service line. We finally know what we are doing--sort of.

Options

My major point today is that diversification opportunities are abundant. There are literally hundreds of directions you can go. The problem is not the idea, it is the integration. Can you make the idea work profitably for yourself? Do you have the management time to devote to it? How will it fit in with your basic lawn-care schedules (personnel, etc.)? These questions must be answered affirmatively before embarking successfully.

There are five major directions that diversification can take for the lawn-service business: (1) other lawn-care services; (2) other green industry services; (3) services and products unrelated to the green industry that are sold using the customer base we have; (4) vertical integration into the supply chain of our business; and (5) ventures totally unrelated to lawn care.

Other Lawn-Care Services. These services are quite common, and most of us are engaged in some of them. The include aerifying, dethatching, renovation, seeding, mowing, and fungicide programs.

Other Green Industry Services. These services (chemical programs for tree and shrub care in particular) are receiving much attention at this time. I see growing market receptivity to this type of service as companies develop programs and systems to make this service affordable to the upper-middle-income consumer. Also in this category are the other arboricultural services and landscaping services.

Customer-Base-Oriented Services. Our customers are our biggest asset. In our lawn-care business we tend to develop rather large customer bases. Our residential customers, generally speaking, have similar buying habits; they all tend to be up-market homeowners. We already have them on board, so what else can we sell them? Chimney sweeping, mower repair, garden tool sales, window washing, carpet cleaning, snow plowing, driveway sealing, house painting, interior house cleaning, basement sealing, and thermostat installation are examples of activities that lawn-care businesses are doing or have tried.

Vertical Integration into the Supply Chain. Diversification efforts in this area are aimed primarily at reducing costs of lawn service and hence are becoming both more profitable and more competitive. I know of two lawn businesses that have purchased small printing companies. Their strategy is simple: we use a lot of paper in the lawn-care business; if I can get my printing done at cost, I have a cost advantage over my competition. In both instances the printing businesses are separately managed entities owned by lawn-care firms doing business with the public.

Other examples in this area are ownership of a fertilizer-blending operation, a distributorship of agricultural chemicals, and multitenant real estate. I am not aware of any lawn-service companies that own a bank or truck dealership, but if there were such companies, they would be examples of businesses that have diversified in this way, with a view toward reducing costs of doing business in the basic business as well as toward having other profitable enterprises.

Ventures Totally Unrelated to Lawn Care. I know of one lawn-care business that developed a condominium community. I know of another that is engaged in hardcover book publishing. In both cases there were special circumstances involved, but still the business owners took cash from their lawn-care businesses and employed it in activities unrelated to the basic business. The imagination can run rampant here.

CONCLUSION

It is impossible for me to make objective evaluations of any of the ideas or areas for you. What you might do successfully, I might fail at miserably. The decision as to what direction to take is subjective on the part of the individual firm; it takes each firm into an analysis of its own strengths and weaknesses, financial condition, confidence, and opportunities.

What I tried to do at the outset of my presentation was to argue that the economic and competitive environment for *active* consideration of diversification opportunities exists today but that diversification is not a panacea. I then suggested that before you diversify you should: (1) make sure that your basic service would not be affected, (2) test, retest, and plan, and (3) be aware that diversifications usually cost more up front than you planned. Finally, I set forth five categories or directions that one can take once the decision to diversify has been made and gave some examples within each category that are presently being undertaken by lawn-service firms.

Through PLCAA and being here at the Illinois Turfgrass conference before, I have had the opportunity to get to know some of you quite well. If the firms of Rick White, Bob Parmley, Charlie McGinty, and John Latting are representative, I see that firms here in Illinois have successfully diversified their businesses. It appears to me that the movement toward diversification has more momentum here than in Ohio or other states that I have studied.

COST-EFFICIENT WEED CONTROL

Steve Derrick

Cost-efficient weed control is important to all of us in the lawn-care industry. We are constantly striving to offer the best possible product at the lowest possible cost to our customers. In order to accomplish this, we are involved in a never-ending battle to keep expenses as low as possible. We must therefore consider many factors when deciding which product or products best suit our needs.

EFFECTIVE WEED CONTROL

First of all, we need to be able to control a wide range of weeds. Customers are not satisfied with dandelion control alone. We need to make our application, control all of the broad-leaved weeds, and avoid as many retreatments as possible. Most of us guarantee broad-leaved weed control, but I think I can safely say that during most seasons ineffective weed control generates more service calls than any other problem. Our primary objective should be to keep these recalls to a minimum, while at the same time keeping costs down. Throughout the industry, various costs for retreatments (or recalls) are mentioned. Generally, you hear a figure between $20 and $25. It is difficult to put a definite dollar figure on the cost of retreating, but some costs to be considered are:

1. additional material costs
2. additional fuel costs
3. additional labor costs
4. opportunity cost
5. unsatisfied customer costs

Additional material costs are generally minimal. When comparing products on a cost-per-acre basis, however, a material that requires dual applications would rarely come out ahead.

The opportunity cost is the most important and is the hardest one to assign a figure to. Could you be using that same employee and truck to spray a lawn for a fee, rather than retreating a lawn at no charge?

Consider also the customers who do not call in. They decide that the treatment did not work, may or may not pay their bills, and are very likely to cancel the service. We have all said too many times, "But all you had to do is call us." Unsatisfied customers may be the biggest expense of all.

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PRODUCT SAFETY

Our second consideration when deciding which product is most cost efficient is product safety. Is it safe to use around ornamentals? How likely are we to cause any turf injury? Replacing plants, lawns, or both is very expensive.

CHOOSING THE PRODUCT

Third, we must find a product that fits the first two criteria and is the most economical on a cost-per-acre basis. We need to take a look at the products that are available and to decide which ones will do the best job at the best price.

Common Herbicides

Dicamba, 2,4-D, and MCPP are the most common herbicides used in the lawn-care industry. None of these products by itself will control the broad range of weeds that we encounter, so we are forced to combine products or buy a combination. The only product that contains all three herbicides is Trimec, which is manufactured by PBI Gordon; it is sold as Trexsan by Mallinckrodt. However, tank mixing 2,4-D, MCPP, and dicamba does not make Trimec; I will explain that later.

The United States Department of Agriculture lists 383 broad-leaved weeds found in the continental United States. Of these 383 weeds, 2,4-D alone controls 43. These weeds are usually the easiest to kill, but control of them generally allows the invasion of weeds that are more difficult to control. Adding MCPP to our mix will give us control of 20 more weeds. Adding dicamba gives us 20 more weeds for a total of 83 weeds.

Trimec, however, controls all 383 reported broad-leaved weeds. Obviously, Trimec is more than just a combination of 2,4-D, MCPP, and dicamba. Each of these three herbicides uses a different solvent in its manufacturing process; each solvent has different chemical properties. Trimec is manufactured by reacting three base acids into a common dimethylamine salt to form a new product. This new product causes a synergistic effect between the three herbicides--an effect that is greater than the total effects of the individual contents. This synergism gives Trimec the ability to control the 300 additional broad-leaved weeds.

Tank Mixing

When looking at our product possibilities, we also need to consider the problems that are associated with tank mixing. These problems include accuracy of mixing, compatibility of products, and disposal of containers.

Accuracy of Mixing. Mixing two to three different products--one in quarts, one in pints, and one in ounces--leaves a lot of room for error. We also need to be assured that we have a homogeneous solution in the spray tank. Regardless of how good the agitation in your sprayer may be, it is difficult to be sure that a few ounces of dicamba in 200 gallons of solution are mixed uniformly.

Compatibility of Products. As I mentioned earlier, 2,4-D, MCPP, and dicamba are all manufactured with different solvents; each has a different pH. When they are mixed into a spray solution, they are forced to standardize into one pH. Obviously, the spray solution does not have multiple pH readings. If you will remember your high school chemistry, when two substances of unlike pH are mixed together, the weak robs from the strong. The pH of 2,4-D is 7.14; that of MCPP is 7.43. When they are mixed together into a concentrated solution, the pH is not high enough to hold all of the active ingredient of the MCPP in solution, and some salting out will occur. We have all seen granules on the bottom of a spray tank and have probably assumed that it was fertilizer that did not go into solution. In actuality, we were probably seeing some of the effect of incompatible products. The end result of this tank mix is a solution of whose composition we are unsure. We may spray some crystallized active ingredient on the first lawns of the day, and our mix may change as the day progresses. At best, we end up with variable results. At worst, we can cause turf injury by overapplication of various products. While this possibility may be unlikely, it should still be considered.

Container Disposal. Tank mixing creates more empty containers than does using a homogeneous product such as Trimec. We all want to comply with regulations of the Environmental Protection Agency, but we are all aware that it is costly to do so. The less time we spend in compliance, the less it will cost us.

PRODUCT COST

The final factor that we need to consider is the cost of the products (see Table 1). The cost of 2,4-D at one pound to the acre is $1.98. MCPP at one-half pound to the acre costs $1.72. Three ounces of dicamba to the acre costs $0.97; the total cost is $4.67 per acre. Trimec at the rate of 2.3 pints per acre, which is the label rate on Trimec 891, costs $5.07 per acre. Thus it will cost only an additional seven cents per lawn to use Trimec. If you treat 1,000 customers with weed control on your spring and fall applications, it translates to an additional $140.00. Do you know of a cheaper insurance policy?

Table 1. Herbicide Cost Per Acre

	Rate Per Acre	Cost Per Acre
2,4-D	1 pound	$1.98
MCPP	1/2 pound	1.72
Dicamba	3 ounces	.97
Total Cost Per Acre		$4.67
Trimec	2.3 pints	$5.07

SUMMARY

In summary, cost efficiency of weed control goes beyond the cost of the product. You need to decide which product will consistently do the best job so that your customers are satisfied. You need a product that will minimize retreatments. You need a product that is safe, and you need a product that is economical.

NONTARGET EFFECTS OF PESTICIDES ON TURFGRASSES*

Richard W. Smiley

The efficiency of pesticides for controlling specific pests is well known throughout the turfgrass industry. But turfgrass managers and scientists alike have very little information regarding the beneficial and deleterious effects of pesticides on turfgrass processes other than that of controlling pests. These side effects, or nontarget effects, continue to be one of the least-understood aspects of pesticide use. We can be sure that some side effects do result from our use of pesticides and that the beneficial effects are likely to help offset the negative effects. It is also clear that, if the beneficial effects can be identified and exploited and the deleterious effects minimized, the art of turfgrass management will become more soundly based and maintenance costs will be reduced to the minimum.

Our knowledge of nontarget effects of pesticides in the specialized turfgrass ecosystem is limited, but even the existing body of information has not been adequately extended to turfgrass managers. This paper highlights some effects of pesticides on turfgrass diseases and the results of my studies on the turfgrass characteristics influenced by fungicides.

HERBICIDE-INDUCED INCREASES AND DECREASES IN DISEASES

Knowledge about the influences of herbicides on turfgrass diseases is meager. Recent reviews of these effects on other crops (Altman and Campbell 1977; Anderson 1978; Bollen 1979; and Papavizas and Lewis 1979) indicate that herbicides have the ability to suppress certain diseases and to increase the incidence of others. Some investigators feel that weed-control chemicals can affect diseases by altering (1) the virulence of certain pathogenic fungi, (2) the relationships between the pathogenic fungi and their parasites and/or competitors, or (3) the level of disease resistance in the grass. Papavizas and Lewis (1979) concluded that the latter mechanism is the only one with unequivocal supportive evidence at this time.

Engel and Callahan (1966) demonstrated that growth of Kentucky bluegrass was affected by applications of several herbicides. They concluded that, after an herbicide has been used, normal-appearing turfgrass foliage is not sufficient assurance of the chemical's safety. In their study, Betasan (bensulide) generally reduced root growth, but ChipCal (calcium arsenate), Xytron (DMPA), Dacthal (DCPA), and some polychlorodicyclopentadiene (PDCP) herbicides did not. In contrast, all these herbicides reduced shoot

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production, some by very little and others by up to 33 percent. The growth suppressions were not visible but were nevertheless important.

Karr et al. (1979) recently demonstrated that Betasan and Balan (benefin) slightly enhanced the severity of brown patch (*Rhizoctonia solani*) and dollar spot (*Sclerotinia homoeocarpa*) on bermudagrass and Pythium blight (*Pythium aphanidermatum*) on perennial ryegrass but had no effect on Pythium blight on bermudagrass. Pythium blight was also unaffected by repeated applications of Zytron to turfgrass (Anderson 1978). Stripe smut (*Ustilago striiformis*) and Fusarium blight (*Fusarium* spp.) of Kentucky bluegrass have been increased by applications of Bandane (PCDP), ChipCal, and linuron (Altman and Campbell 1977; Smiley 1980). Urea-derivative herbicides, such as linuron, have also enhanced powdery mildew (*Erysiphe graminis*) and reduced eyespot (*Pseudocercosporella herpotrichoides*) of wheat (Simon-Sylvestre and Fournier 1979).

Hodges (1980) recently reported the effects of five herbicides on Helminthosporium leaf spot (*Drechslera sorokiniana*) of Kentucky bluegrass. Disease was increased by applications of 2,4-D, 2,4,5-T, MCPP (mecoprop), and Banvel (dicamba) and decreased by 2,4,5-TP (silvex). These hormone-like herbicides were considered to increase the leaf senescence rate and, subsequently, the pathogenesis of *D. sorokiniana* on the dying leaves. In addition, 2,4-D can increase the severity of wheat and corn foliar diseases caused by *Drechslera* and *Bipolaris* species and reduce these diseases on barley (Simon-Sylvestre and Fournier 1979). Take-all disease (*Gaeumannomyces graminis*) of wheat and barley has also been increased by applications of MCPP but not of 2,4-D plus MCPP (Papavizas and Lewis 1979). MCPP increased the production of perithecia, mycelia, and microconidia of *G. graminis*. This pathogen also causes Ophiobolus patch of bentgrass.

Other examples of herbicide-induced increases or decreases in diseases of Gramineae are numerous, but many involve herbicides that are not generally used on ornamental turfgrasses. A reasonable conclusion from the few examples discussed here is that generalities regarding the effects of specific herbicide groups on individual diseases are not appropriate at present. Perhaps most important is that managers recognize the potential for nontarget effects and modify their maintenance programs based on their experience.

THE EFFECTS OF INSECTICIDES AND NEMATICIDES ON DISEASES

If our knowledge about the effects of herbicides on turfgrass diseases is meager, then that about the influences of insecticides and nematicides is rare. It is unlikely that this gap in our knowledge exists simply because there are few important examples of such interactions. Since a scientist tends to record only the observations of most interest to his or her discipline, the trend for turfgrass scientists to work independently is perhaps a more likely reason for this void. Science will advance when more of the shields between these specialties are lowered.

The work of Gould et al. (1966) at Puyallup, Washington, probably represents the best-known insecticide-disease interaction. Chlordane was much more efficient than any of the fungicides tested for suppressing Ophiobolus patch (*G. graminis*) of bentgrass. A more recent study at that location failed to confirm the earlier results, but it was conducted with longer intervals between applications and over a shorter period of time. Engel and Callahan (1966) determined that chlordane increased the rooting capacity of Kentucky bluegrass but, like the herbicides studied, also suppressed leaf production.

Fairways on one New York golf course have suffered for several years from what appears to be Curvularia blight (*Curvularia lunata*) of *Poa annua*. The disease control program before the first recognized occurrence of this disease was dominated by benzimidazole fungicides. Curative attempts with Tersan 1991 (benomyl) and several heavy metal fungicides were unsuccessful. By accident, the turf superintendent observed that fairway areas recovered quickly and totally after applications of Dursban (chlorpyrifos). The superintendent has repeatedly demonstrated the phenomenon and now uses the insecticide as needed. The insecticide and its solvent were not, however, toxic to *C. lunata* in our laboratory tests.

Although the reason for Dursban's success in this instance is not understood, the ability of insecticides and nematicides to enhance or to reduce diseases of other plants is fairly common (Anderson 1978; Papavizas and Lewis 1979; Powell 1971; and Simon-Sylvestre and Fournier 1979). Pesticides may act directly by influencing the capacity of the pathogens for growth or indirectly by altering host resistance or the balance between pathogenic fungi and other microorganisms. Beute and Benson (1979) and Powell (1971) have also emphasized that interactions between small soil fauna (insects and animals) and pathogenic fungi may be of considerable importance. Vargas (1972) demonstrated the importance of nematodes feeding on predisposition of Kentucky bluegrass to Fusarium blight in Michigan. Possibly, predisposition to Curvularia blight on the golf course in New York is caused by the feeding activity of an unsuspected arthropod or nematode, although tests seemingly have ruled out the latter.

The examples here and in review papers (Anderson 1978; Beute and Benson 1979; Papavizas and Lewis 1979; Powell 1971; and Simon-Sylvestre and Fournier 1979) underscore the necessity for amplified research interest in the nontarget effects of insecticides on turfgrass diseases.

INFLUENCE OF FUNGICIDES ON DISEASE PREVALENCE

A voluminous data bank is available to anyone wishing to determine the efficacy of specific fungicides for controlling diseases. The positive results from such research are thoroughly extended to turfgrass managers. Moreover, the fungicide package labels pertaining to ornamental turf list nearly all known efficient registered uses, because residue and related problems are few compared to those for food crops. Negative aspects of disease control studies, however, are communicated less frequently. Turfgrass workers can deduce which diseases a fungicide is unable to control efficiently by simply failing to find mention of the diseases on the product's label. But there remains a dearth of available information regarding instances where fungicides have increased the prevalence of diseases. This discussion will concentrate on that void.

Turfgrass managers periodically experience occasions when a fungicide allows a particular disease to become more severe or when a second disease occurs soon after a fungicide has been applied to control the initial, or target, disease. These occurrences are not always recognizable on uniformly treated turfgrass areas. If recognized by a turf manager, they are not always brought to the attention of industry or public-sector scientists and extension personnel who could allocate resources to study the phenomena. Replicated and randomized research trials plus demonstration trials frequently reveal such examples. The fact that these results have not been summarized is a basis for concern.

During the past decade, over 90 examples of fungicide-induced increases in turfgrass diseases have been listed in *Fungicide and Nematicide Tests,* a series of reports published by The American Phytopathological Society.* These reports greatly underestimate actual occurrences because (1) most tests are based on single-season studies, (2) most tests are conducted on experiment station research plots where atypical use patterns exist, and (3) the publication presents the results of only a small proportion of the scientists and practitioners who conduct such studies. Detailed papers on this topic have also been published in *Phytopathology, Plant Disease Reporter, Journal of the Sports Turf Research Institute*, and other periodicals. Additional examples have been reviewed in turfgrass textbooks, and unpublished results of studies conducted in various states and countries are available to turfgrass scientists and pesticide manufacturers. Data from many of these sources have been summarized in Table 1.

Benzimidazole-derivative fungicides, such as benomyl (Tersan 1991) and the thiophanates (Fungo, CL 3336), have been given considerable attention during the past decade. Quite early, these fungicides were recognized as not being toxic to oomycetes. The potential thus existed for Pythium blight to become amplified where the benzimidazoles were overly emphasized in a disease-control program. This possibility was confirmed in studies by Warren et al. (1976).

These fungicides were also known to be nontoxic to most basidiomycetes and certain hyphomycetes. Scientists were little surprised, therefore, when benzimidazoles were established as also capable of amplifying diseases caused by fungi in these taxonomic groups. Such documentation is now available for Typhula blight (*Typhula incarnata*), rusts (*Puccinia graminis*), red thread (*Corticium fusiforme*), some Rhizoctonia diseases (*Pellicularia filamentosa* and *Ceratobasidium* spp.), and some Helminthosporium diseases (*Drechslera* and *Bipolaris* spp.). The ineffectual control of dollar spot (*Sclerotinia homoeocarpa*) by benzimidazoles in certain areas represents a special circumstance in which

*These publications may be obtained from the American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121.

Table 1. Increases in Turfgrass Disease Severity Associated with Treatment of Plots with Fungicides*

	Helminthosporium leaf spot	Dollar spot, copper spot	Red thread	Rust	Stripe smut	Yellow tuft	Rhizoctonia diseases	Fusarium blight	Fusarium patch	Typhula blight
Acti-dione	...	...	...	...	...	...	S	...	...	N
Bayleton	N	...	...	...	...	N	...	...	...	...
CGA 64251	...	...	S	...	...	...	S	S	...	...
Chipco 26019	...	...	...	...	N	S	...	...	...	...
Daconil	S	S	...	...	I	...	...	S	N	N
Dyrene	...	I	...	...	N	...	...	S	N	...
Heavy metals (cadmium, mercury)	I	N	...	...	...	...	N	...	...	...
Koban	N	I	...	...	...	...	I	...	N	...
Terraclor (PCNB)	...	S	....	...	S	...	S	N	...	...
Tersan 1991, Fungo, CL 3336	S	S	S	S	...	...	N	...	...	N
Tersan LSR, Fore, Dithane M-45	...	S	...	...	...	...	...	...	S	...
Tersan SP	...	...	...	...	...	...	S	...	...	...
Thiram and combination products	S	S	...	...	N	...	S	...	N	...

*S = significant increases in at least one study; I = increases that appeared important but for which statistical analyses were not performed; N = increases that were not statistically significant.

strains of the pathogen have undergone adaptive mutation and thereby become tolerant of these fungicides.

Turfgrass variety trials at Cornell University have revealed nontarget effects from fungicides on several occasions. Half of each cultivar plot is treated with fungicides to provide comparative quality observations with the untreated half. Although the common observation is that the fungicide-treated half is superior in quality to the untreated half, the opposite has been noted on several occasions. In 1980, red thread occurred on the perennial ryegrass and red fescue plots about one week after Tersan 1991 had been applied (M.B. Harrison and A.M. Petrovic, unpublished). The disease was significantly more severe on the treated half of the plot, and many of the ryegrass cultivars that were free from red thread on the untreated area were quite susceptible on the treated half. Burpee and colleagues (*Fungicide and Nematicide Tests,* 1978) also found that a benomyl-treated turf became more susceptible to red thread. Another basidiomycete-caused disease was observed in Cornell's Kentucky bluegrass cultivar trials. Again, the disease was greatest in the areas treated with fungicides and less active or absent in the untreated halves. The disease appears identical to that which Smith et al. (1970) found occurring only on benomyl-treated bentgrasses in Australia. Circular patches of fluffy to mealy, white- to cream-colored mycelium caused considerable unsightliness and some premature leaf senescence but did not appear to infect the turf.

Tersan SP (chloroneb) and Acti-dione TGF (cycloheximide) predisposed creeping bentgrass on a New York golf course to a disease caused by *Rhizoctonia cerealis*. The winter brown patch disease was present where these fungicides had been applied to prevent the anticipated occurrence of a snow-mold complex consisting of *Fusarium nivale* and *Typhula incarnata* and absent where the fungicides had not been used. Experimental confirmation was collected on one of the untreated putting greens (*Fungicide and Nematicide Tests,* 1974). The July 1980 issue of *Golf Course Management* contains an intriguing popular article by A.D. Brede describing a number of similar nontarget effects of fungicides observed on the turfgrass plots at Pennsylvania State University and elsewhere.

RESULTS OF ONE STUDY ON KENTUCKY BLUEGRASS

Influences of pesticides on the microflora of soil have been extensively studied and reviewed (Anderson 1978; Bollen 1979; Brown 1978; Papavizas and Lewis 1979; and Simon-Sylvestre and Fournier 1979). Additional references for effects of fungicides on turfgrass ecosystems may be found among the literature cited in my publications (Smiley 1980; Smiley and Craven 1978, 1979*a*, and 1979*b*; and Smiley et al. 1980). One of my studies at Cornell University is briefly described here.

A Kentucky bluegrass sod that had never been sprayed with any pesticide was purchased in 1975 and installed at our field research site. The underlying soil was a moderately well-drained silty clay loam. The new turf stand was marked into 66 (1 x 5 meter) plots for the long-term investigation of 22 different pesticide treatments.

Fourteen fungicides were selected as representative of those likely to be used commercially on highly maintained turfgrasses. These pesticides and no others (except single applications of 2,4-D during 1979 and 1980) have been applied to designated plots nine times annually from 1975 to the present. The fungicides were applied at 21-day intervals from April to September, except for nine applications of Terraclor 75 (quintozene, PCNB) and Koban (ethazole) made at weekly intervals during July and August. In addition, two drenches of Tersan 1991 and one of the nematicide Nemacur (fenamiphos) were applied annually to designated plots. Five other treatments were more typical of commercial programs than the repetitive applications of only one fungicide: two or three fungicides alternated so that any one material was applied at 42- or 93-day intervals or alternated as described and combined with midsummer treatments of Koban and Terraclor 75.

The first two years of study were devoted to establishing a well-documented, long-term fungicide history on the plots. Some of the data collected since 1977 are summarized in Table 2. The fungicides are grouped according to inhibition of thatch decomposition and acidifying characteristics from 1975 to 1977. Nonacidifying and nonthatching fungicides included Dyrene (anilazine), Captan (captan), Daconil 2787 (chlorothalonil), Acti-dione TGF (cycloheximide), Koban (ethazole), Terraclor 75 (quintozene, PCNB), and Acti-dione RZ (a combination of cycloheximide and quintozene). Nonacidifying but thatch-inducing chemicals included Cadminate (cadmium succinate), Nemacur (fenamiphos), and Chipco 26019 (iprodione). The following fungicides induced both thatch and acidity when used alone and when used as part of the rotation: Tersan 1991 (benomyl), Dithane M-45 (mancozeb), Tersan 75 (thiram), Bromosan (ethyl thiophanate plus thiram), and Duosan (methyl thiophanate plus maneb).

Some fungicides caused the soil immediately below the thatch-soil interface to become quite acidic, in spite of undissolved lime granules in the thatch (Smiley and Craven 1978). This effect was reflected in reduced pH values of the surface three centimeters of soil plus thatch in the corresponding treatment areas (Table 2) and in the constant pH of the thatch alone. The lowest pH values occurred in plots treated with benzimidazole-containing fungicides, such as Tersan 1991, or with fungicides containing large amounts of sulfur, such as Dithane M-45 and Tersan 75. The largest amount of acidity occurred in plots treated with combinations of these fungicides (Bromosan and Duosan). Acidification was measured to a depth of 20 centimeters in some plots (see Figure 1). Although the reasons for this acidification are unclear, it may relate to the fact that the active ingredients of some fungicides contributed up to 49 kilograms per hectare (1 pound per 1,000 square feet) of sulfur annually and up to half that amount of nitrogen. Unknown amounts of potentially acidifying "inert" ingredients were also added. Fay and Melton (1973) described typical wettable powder formulations to contain 50 to 85 percent active pesticide ingredient, 10 to 45 percent clay carrier, 1 to 3 percent wetting agent, and 1 to 3 percent dispersing agent. Clays are predominantly aluminum silicates; wetting agents are generally anionic taurates, sulfates, or sulfosuccinates; and dispersing agents are generally lignosulfonates.

Table 2. Characteristics of Kentucky Bluegrass Plots Treated Repeatedly with Fungicides since July 1975

Characteristic	Evaluation date	Untreated control	Fungicide groups: Nonacidifying, nonthatching	Fungicide groups: Nonacidifying, thatching	Fungicide groups: Acidifying, thatching	LSD (0.05)
Thatch depth (mm)	12/77	6	3-11	14-17	12-22	6
	7/80	3	1-6	6-9	5-13	8
Thatch and soil pH (0-3mm)	12/77	6.3	6.1-6.5	6.0-6.2	5.6-6.0	0.4
	7/80	6.3	6.3-6.5	6.3-6.5	6.2-6.6	0.4
Leaf clippings (g/m^2)	5/78	13	12-19	21-46	20-43	25
	8/78	16	13-26	18-26	19-30	12
	7/80	2	2-5	3-5	2-6	2
Root density						
(mg/cm^3) 0-4 cm	7/78	1.6	1.1-1.9	2.0-4.0	1.3-2.2	0.5
4-10 cm	7/78	0.5	0.3-0.8	0.6-2.1	0.6-1.0	1.0
Sod strength (kg)	10/79	14	11-20	24-35	18-37	8
Turf quality (9=best)						
Overall	8/78	5.7	6.0-7.3	6.3-8.0	6.7-9.3	1.7
Density	8/78	5.7	7.0-9.0	8.3-9.0	7.0-9.0	1.4
Color	8/78	6.7	3.3-6.7	3.3-8.7	5.3-7.7	2.9
Overall	6/80	4.7	4.3-6.0	4.3-7.0	3.7-7.0	1.9
Microbial numbers (proportion of control)						
Bacteria	7/77	1.0	0.6-5.2	0.7-1.3	0.6-5.5	0.8
Pseudomonas	7/77	1.0	0.3-16.8	0.1-2.8	0.9-43.4	2.5
Bacillus	7/77	1.0	0.7-1.2	1.0-1.4	0.7-1.6	0.5
Actinomycetes	7/77	1.0	0.7-1.2	0.7-1.2	0.8-2.0	1.2
Fungi	7/77	1.0	0.7-1.4	1.0-1.2	0.6-1.6	0.7
Fusarium	7/77	1.0	0.8-1.8	0.7-1.4	0.1-1.0	0.3
Pests (% affected area)						
Helminthosporium leaf spot	6/77	77	20-80	3-87	17-18	19
Fusarium blight	7/77	33	12-37	0-3	2-30	16
Typhula blight	3/78	55	43-65	48-67	43-63	17
Weeds	6/79	63	43-61	25-50	54-79	25
Sod webworm	8/80	7	3-53	0-37	3-40	24

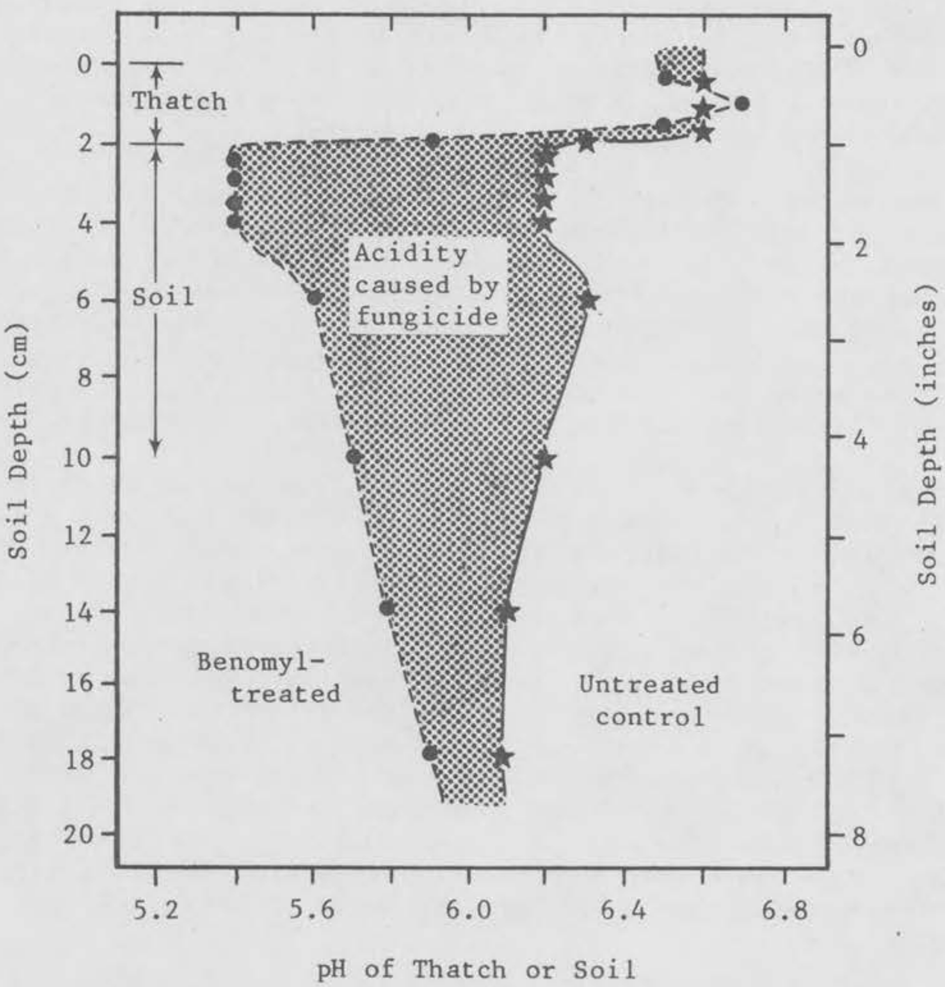

Figure 1. Soil pH profiles in benomyl-treated and untreated turfgrass.

When the sod was installed in 1975, the depth of its thatch was two centimeters. Decomposition processes reduced the depth to six millimeters in the untreated control by late 1977. Half of the fungicides slowed the decomposition rate, and some inhibited it almost entirely (Smiley and Craven 1978). More recent studies indicate that decomposition is now occurring in all plots. Decomposition of cellulose (cotton) and natural thatch enclosed in 10 x 10-centimeter nylon-mesh bags and buried two centimeters in turf plots for five months was likewise inhibited up to 50 percent by some fungicides. Sod shear strengths, a measure of the integrity and amount of dead and intact rhizomes, correlated with thatch depths.

Root masses were altered by only a few fungicides, the most notable being a threefold amplification of rooting by Chipco 26019. This fungicide also increased the mass of leaf clippings in the spring but not in the summer. The overall quality of bluegrass was improved by all fungicides and was attributable mostly to increases in shoot density. The nematicide Nemacur greatly improved turfgrass quality without increasing root mass. Populations of pathogenic nematodes were about 2,500 and 10 per 100 cubic centimeters of soil in control and Nemacur-treated plots, respectively.

The treatments generally did not greatly alter estimated total numbers in each microbial class (Smiley and Craven 1979*a*) but did cause considerable shifts in compositions of species within the classes. Special emphasis was given to *Fusarium* species (Smiley and Craven 1979*b*). The fungicides also caused considerable variation in the severity of several nontarget diseases. Some interesting comparisons could be made among sets of data. For example, Fusarium blight was controlled by several chemicals that have no suppressive effect on *Fusarium* species in thatch, in soil, or in vitro--or on the disease when these chemicals are used in single-season preventative studies. Cadminate, Daconil, Dithane M-45, Nemacur, and Chipco 26019 meet the first criterion and all but Chipco 26019 meet the second. The thatch decomposition rate and plant growth parameters were more associated with the occurrence of Fusarium blight than were *Fusarium* numbers and known attributes of these fungicides (Smiley et al. 1980).

The results summarized here cannot be extrapolated to other turfgrasses because they were obtained from only one nonirrigated turfgrass sod grown on a single soil type in a humid climate zone. Much additional research is necessary to determine the undoubtedly different nontarget effects that may or may not occur on various turfgrass genera grown in other areas, on various soil types, and under limitless variations in management programs.

FUTURE NEEDS

That pesticides can exert many effects on nontarget organisms and processes in turfgrasses is readily apparent. In addition to direct effects, each chemical and biological change may cause secondary, tertiary, and other changes until the entire management program becomes improved or hindered by the use of certain pesticides. The effects may be so slight as to be unnoticeable but large enough to increase expenses for certain management procedures. It can be theorized that frequent use of certain pesticides does alter the long-term costs of such management procedures as controlling pests, thatch, and soil acidity. These nontarget effects need greater attention in the original decision-making process. If, for instance, four fungicides were known to be almost equally effective against a target pathogen but three were much more likely to increase thatchiness or weediness, the means of selection could be improved.

The long-term costs of thatch and weed control are certainly greater than the immediate cost differences among competitively priced fungicides. Although product costs, application costs, technical services provided, immediate availability of a product, and personal preferences are very important considerations, it is also important for scientists to provide additional facts on which to base pesticide-use decisions.

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SAND TOPDRESSING: IS IT FOR YOU?

Ronald E. Miller

As golf course superintendents, we are always trying to upgrade the quality of our putting surfaces and our total turf program. We must ask ourselves what our customers or members want, and with this question in mind we must try to produce the desired results.

Most members of private clubs and public golfers do not want to be inconvenienced by aerification, topdressing, or any of the cultural practices required to maintain quality turf. What we have found to be beneficial is the sand topdressing.

We use a program of topdressing with an FA 10 blending sand. (The FA 10 is a state-specified number for size of sand.) We try to top-dress once every two weeks. This schedule works out the best for our customers and for ourselves. We use a Lely spreader with a mass-feed ring to spread the sand and a TORO Sand Pro with three street brooms mounted on the bottom of the rake to work the sand in.

In the summer months (June-September) we put about one yard of sand per green. In October we go considerably higher, with about three to four yards of sand per green.

We have built three greens so far, using FA 10 blending sand and horse manure. The sand stays moist, so we are using less water; and the greens seem to hold a ball better than our old soil, sand, and peat greens. The mixture of seed we are using is 50 percent 'Penneagle' and 50 percent 'Emerald' creeping bentgrass.

On a 3,000-square-foot green, we use 240 tons of sand (12 inches deep) and 12 yards of horse manure.

In conclusion, we must consider the members and golf customers who are paying the bill and give them what they want with the least inconvenience to them. If your members are happy with your program, why change?

R.E. Miller is the superintendent of the Springfield Park District in Springfield, Illinois.

SELECTION OF FLOWERS AND THEIR CARE

Marvin C. Carbonneau

A successful flower display does not simply develop by itself. Several choices must be made to produce the effect desired. The flowering season in the Midwest begins in late April and ends with a killing frost in late September or early October.

SELECTION OF PLANT MATERIAL

A few principles must be kept in mind in planning the garden or bed area.

For public areas masses of the same plant material should be considered.

Continuous flowering should be the prime objective. Flowering annuals for flowering in late spring and through the summer should be the basic choice. For the same area, bulbs such as tulips or hyacinths can be used for a spring display. As soon as flowering is finished, the bulbs should be lifted and the area planted with annuals.

You may enjoy perennials in a home garden, but the use of them in a public area should be limited to background or bed borders. Peonies, iris, day lilies, and hosta are useful for borders, but the flowering is limited to three to six weeks.

Petunias, ageratums, marigolds, zinnias, and snapdragons are just a few of the genera that are now offered as new hybrid annuals. The vigor of these hybrids is impressive, because they flower shortly after planting and continue flowering throughout the growing season. Table 1 lists the flowering annuals that are commonly grown in Illinois.

BUYING STARTED PLANTS

The gardener will find many advantages to buying started plants. At time of purchase, started plants are generally in the flowering stage of their development, but it is more important to get healthy, well-branched plants than ones with blooms on them. They are easy to transplant and will bloom quickly, so you will have flowers from the frost-free time in the spring until at least the first killing frost in the fall. If you plant seed in your garden, you will have no flowers for several weeks. Of course, you eliminate the germination problem by setting out started plants. Using started plants also helps you control the number and spacing of the plants in your garden.

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Table 1. Common Annuals Grown in Illinois Gardens

Low Growing 4 to 12 inches	Medium Growing 12 to 20 inches	Tall Growing 20 to 60 inches	Annuals That Grow Best in Shade
Ageratum	Balsam	Amaranthus	Ageratum
Bachelor's Button (dwarf)	Basil	Aster	Balsam
Balsam	Bells of Ireland	Bachelor's Button	Begonia (fibrous or tuberous rooted)
Begonia (fibrous rooted)	Carnation	Celosia	Browallia
Browallia	Celosia	Cleome	Caladium
Calendula	Coleus	Cosmos	Coleus
Celosia (dwarf) plumosa and cristata types)	Dahlia (dwarf)	Dahlia	Impatiens
Dianthus	Dusty Miller	Hollyhock	Lobelia
Dusty Miller	Geranium	Marigold	Pansy
Gomphrena	Gomphrena	Scabiosa	Sweet Alyssum
Impatiens (dwarf)	Helichrysum	Snapdragon	Torenia
Marigold (dwarf)	Impatiens	Tithonia	
Nasturtium	Kochia	Zinnia	
Pansy	Petunia		
Phlox	Rudbeckia		
Salvia (dwarf)	Salvia		
Snapdragon (dwarf)	Snapdragon (half dwarfs)		
Sweet Alyssum	Vinca		
Torenia	Zinnia		
Verbena			
Vinca			
Zinnia (dwarf)			

SOIL PREPARATION

You must improve the drainage and aeration of most Illinois soils to do a top job of growing annual flowers. Many gardeners plant extensive flower beds and then have disappointing results because they did not prepare the soil before planting.

Apply materials such as sphagnum peat moss, leaf mold, compost, and rotted manure in early spring and spade or fork it into the soil before planting. Application rates will vary with the type of soil you have and its previous use, but in general you can work two to four inches of organic matter into the top six to eight inches of the planting area and get satisfactory results. Apply this material several weeks before planting annuals in areas that have been used for flower gardening in previous years. If you are planting in an area that has not previously been used for flower gardening, work organic matter into the soil during the fall preceding your plantings.

If you grow annuals in partial shade (area on which the sun shines for as little as an hour each day) they will need very well-drained soil. Plan to have at least 25 to 35 percent organic matter in the soil in such areas. Remove the top six to eight inches of soil from the area, mix it with sphagnum peat moss or other organic matter, and return it to the bed. If the area is poorly drained, you may have to dig 18 to 24 inches deep when removing the soil so that you can put three to four inches of gravel or cinders in the bottom. Remember that all annuals require good drainage and that you may have to raise the soil beds to improve drainage.

Change the soil in tubs, window boxes, urns, and other small plant holders each year. Use a mixture containing one-third garden loam, one-third sphagnum peat moss, and one-third vermiculite or perlite to form a potting mixture. This mixture will perform best only if there is drainage in the bottom of the container. Place materials such as crushed rock, crushed flower pots, or gravel in the bottom two inches of the container, especially if there are no drainage holes to permit the rapid runoff of excess water.

WEED CONTROL

Another important consideration in soil preparation is the control of weeds, especially perennial weeds. Perennial weeds grow from root stocks already in the soil and usually cannot be controlled effectively by hoeing or spading. You can easily control common perennial weeds such as quackgrass, Canada thistles, and dandelions when you use herbicides. Do not use fertilizer-herbicide mixtures. Herbicides remain active in the soil for several weeks, and the residues can injure growing flowers; so all herbicide activity must stop before flowers are planted. Shallow hoeing and mulching will help you control most ordinary annual weeds.

FERTILIZING THE AREA

Be certain to work some fertilizer into the soil when you are spading in the organic matter. Use a complete fertilizer, such as 5-10-4, 10-6-4, or 10-10-10, and apply at the rate of one to two pounds per 100 square feet of flower bed area. If you use a fertilizer with a high analysis (such as 10-10-10), then apply it at the one-pound rate. Apply lower analysis fertilizers at higher rates. Follow application recommendations listed on the fertilizer container.

You will have to apply lime or agricultural limestone if your soil has an acid reaction. There are many areas in Illinois where lime is not needed, so check with your county extension adviser to see if you need to have your soil tested. Soil tests take time, so have them done well in advance of the planting season.

If the fertility level of your soil is low, you may need to make applications of dry or liquid fertilizers at regular intervals through the growing season. A good program is to apply one-half to one pound of 5-10-4, 10-6-4, or 10-10-10 per 100 square feet every month to six weeks, as indicated by plant development.

You may use either liquid or dry fertilizers. If you use liquid fertilizers, be certain not to make concentrated applications. Check to make certain your equipment is working correctly. Excessive use of nitrogen can cause lush growth of stems and foliage with little development in the flowers.

When you fertilize, be sure the soil is moist before you apply any material. Water the beds, apply the fertilizer, then water again. Do not let dry or concentrated liquid fertilizer fall on the foliage or flowers of the plants. If any does fall on the foliage or flowers, wash it off immediately because plant tissue burns may be caused. Plants growing in partial shade may require less fertilizer than those in full sunlight. On shaded flowers, use inorganic fertilizers that are low in nitrogen or use organic fertilizers. These plants are succulent and have very shallow, fibrous root systems that can be burned by an overdose of fertilizers.

Observe your plants as they grow, because varying environmental conditions will change their fertilizer needs. Fertilize and water plants that become yellow or stunted. If plants have lush foliage and few flowers, they may be getting too much fertilizer.

PLANTING DATES

When the danger of frost is past and the planting area is thoroughly prepared, you may begin planting. In general, it is fairly safe to set out plants in the southern part of the state on 1 May, in the central part on 15 May, and in the northern part from 20-30 May. This schedule does not mean that you should plant everything on these dates, but it indicates that there are generally no severe frosts after these dates.

You may sow the seeds of some annuals outside in early spring, but check the seed package for specific recommendations. Remember that seeds germinate best when the soil temperatures are above 60° F. Warm soils also aid root growth. You will not necessarily get early flowers from early planting, because soil temperatures may be too low.

TIPS ON PLANTING

If you are planting started plants, be certain not to set them too deeply into the outside bed. Planting too deeply often causes poor root growth and stunted, poorly developed plants. Set the plants only slightly deeper than they were set in the container in which you bought them. If the plants are in pots or wood bands, remove the container at planting time and set them so that the top of the soil ball is about one-half inch below the surface of the bed. You do not need to take plants out of fiber or peat pots, but remove the portion of the pot above the surface of the soil ball. This is a safeguard against overwatering, because the top section of these pots can trap excess water. You may also remove the bottoms of fiber or peat pots to improve water drainage and rooting.

Few gardeners leave enough space between plants. Plan to leave 10 to 12 inches between most low-growing annuals. Leave 19 to 24 inches between tall annuals. If you leave space in which your plants can grow, you will get much better results. A good rule of thumb is to leave a space between plants that will be approximately one-half of their anticipated height.

PINCHING

Most of the common annuals respond well to a horticultural practice known as pinching. To pinch a plant, you remove the top inch or two from its growing tip to encourage branching. If you pinch your plants they will produce many more flowers during the growing season. Started plants may already have been pinched by the greenhouse grower. Look for cut areas on the uppermost portion of the stems to see if a plant has been pinched. When you pinch flowers, you sacrifice the first bloom so that you will have more flowering branches through the growing season. Do not pinch celosia, balsam, or poppy.

MULCHING AND CULTIVATING

Mulching flower beds, rather than cultivating them, is not a new practice, but it has recently gained popularity. You may mulch your flower beds, but care must be taken to do a good job. Mulching will help to conserve moisture, reduce the annual weed population, reduce cultivation time, preserve the soil aeration and drainage, and improve the looks of the finished planting bed.

You can use several materials for mulching. Some of the more popular ones are sphagnum peat moss, ground or crushed corncobs, cocoa bean hulls, pine needles, compost, wood chips, partially decomposed sawdust, granite chips, black plastic covered with gravel, peanut hulls, shredded bark, and pecan shells.

Be certain that the soil is moist and that its temperature is 60° F. before you put the mulch down. Make the mulch two to three inches deep and keep it at that depth through the growing season. Do not mulch until one week after planting, in order to allow time to replace plants that are not doing well. If you use an organic material for mulching, incorporate it into the soil at the end of the growing season to improve drainage and aeration of the soil. Some of the organic mulches decompose rapidly during the growing season and deplete the soil's nitrogen supply if additional fertilizer is not added. Be sure to fertilize the flower beds so that a supply of nitrogen will be available during the growing season. Use sphagnum peat moss to mulch plants that grow in partial shade; these plants have shallow root systems and need a regular water supply.

WATERING

If you want to raise good annual flowers, you must do a good job of watering so that the flowers will develop properly.

When you water, water thoroughly. Generally, a gardener using a hand-held hose and nozzle will not water a garden thoroughly because this method takes too much time and patience. Use a sprinkler to water your garden beds and make certain the water penetrates down to the root zone, which extends 7 to 10 inches below the surface. Do not water again until the soil begins to dry out.

Many kinds of sprinklers will help you do a good job. Let the sprinkler run long enough for the soil to be well soaked, but do not let large puddles of water collect. If the soil is poorly drained, run the sprinkler for short periods through the day, giving the water a chance to soak into the soil. Put a mulch on sloping flower beds so that watering will not cause erosion. Plants, flowers, foliage, and stems must be dry during the night if they are to resist diseases, so avoid watering in the late afternoon or early evening hours.

You can also use soaker hoses effectively. If you purchase enough of them to water several flower beds at once, you will save yourself much time. When you use a soaker hose, you lose little water to runoff and evaporation and have less soil compaction. Move the hoses periodically so that there will be no dry spots left in the bed.

REMOVING FADED FLOWERS

Many annuals flower throughout the growing season. Most of them will look and rebloom better if you remove the old flower heads every five to seven days. Marigold, zinnia, pansy, snapdragon, and cosmos respond especially well to this practice. Pruning long stems of petunia, ageratum, fibrous-rooted begonia, lantana, annual phlox, verbena, bells of Ireland, coleus, and pansy will keep these plants compact.

A NEW APPROACH TO THE CONTROL OF ANNUAL BLUEGRASS

Ray P. Freeborg

We have only begun in our efforts to evaluate the potential of growth regulators as inhibitors of a single plant type in a mixed stand to reduce that plant's competitive ability. It appears that it is possible to restrict the growth of one species in a mixed stand over one or more of the other plant species in that stand. Existing as well as experimental growth regulators are able to do this. The reduced growth rate and subsequently the reduced ability of the plant to compete can assist a turf manager in the gradual alteration of a population. It has potential as a management tool that, when used with patience and skill, could manipulate desirable plant growth and thus accelerate the population change.

To some extent this has been successfully attempted in the past, although we do not think of it as growth regulation or inhibition of a plant species. One of the early herbicides used in an attempt to reduce the competitive ability of a weed species involved lower rates of inorganic arsenic (lead or calcium arsenate). The objective was to restrict the growth of *Poa annua* (annual bluegrass) more than that of *Poa pratensis* (Kentucky bluegrass), *Agrostis* species (bentgrass), and others. Unfortunately, results were not easily controlled and were occasionally so rapid as to cause total kill of the existing *Poa annua*. Sometimes a reduction in existing perennial grass species was also observed.

Another more recent example, and a truer concept of growth regulation, was the use of maleic hydrazide in conjunction with chloroflueronals to restrict *Poa annua* growth and seedhead production. With a reduction in new seed production of the annual grass species, there was less seed available for new crop development in subsequent years. The potential is there, and it is a viable alternative to the total destruction of a weed.

Several examples of newer experimental growth regulators that have shown selectivity of species response include EL500 (Cutless^{R}), a new growth regulator from Elanco, and EL222, a turf fungicide for disease control, also from Elanco. *Poa annua* appears susceptible to both products. ICI Americas has a new growth regulator, PP333, to which grass species also respond differently. Another herbicide with growth regulator potential is Eptam^{R} (EPTC). It has been used for some time as a preemergence control of various annual grasses and broadleaf weeds. Examples of other experimental growth regulators with the ability to inhibit one species over the other include experimental growth regulators from CIBA GEIGY and ethephon (Ethrel) from Union Carbide.

One of our current efforts is to explore the potential for growth regulators, including EL500 (Cutless^{R}), EL222, PP333, and Eptam, to selectively reduce the ability of *Poa annua* to grow as well as to produce a

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viable seed. A new flowable formulation of tricalcium arsenate is also now under investigation. As it is more active than the older granular ChipCal, lower rates are practical; possibly, through moderate inhibition of *Poa annua*, it can help to introduce a more acceptable, gradual transition of the population from stands of *Poa annua-Poa pratensis* or *Poa annua-Agrostis* species to pure stands of either the *Poa pratensis* or *Agrostis* species.

SOIL TEMPERATURE AND RELATED FAIRWAY MANAGEMENT PRACTICES--NORTHERN TURFGRASSES*

Oscar L. Miles

Over the next 10 years it will be tremendously important to the golf course superintendent and the clubs for us to make a sincere effort to conserve our resources--to resolve to be better managers of people, equipment, and supplies that the industry has made available to us. Collectively, we must share ideas and experiences so that we may learn together. I want to share with you an experience in fairway turf management using the daily soil temperature as a forecaster of the do's and don't's in the culture of turfgrasses.

Could soil temperature be as important a factor as air, sunlight, water, and soil? Dr. Donald V. Waddington, Professor of Soil Science, Pennsylvania State University (1), must feel it is very important because in *Turfgrass Science* he states, "Soil temperature influences plant growth and microbial activity, and Troughton (1957) compiled a list of optimum temperatures for root growth for various species as follows: bermudagrass 80° to 100° F., ryegrass 44° to 63° F., Kentucky bluegrass 55° to 73° F., and bentgrass 59° to 72° F."

Dr. C.Y. Ward, Agronomist, Auburn University, on the subject of "Soil Temperature and Turfgrass Growth" (2) states: "Temperature at the soil surface may be more important than air temperature in determining turfgrass adaptability. This is because the growing points of turfgrasses, especially those of rhizomes and stolons, are at or near the soil surface. The knowledge of turfgrass response to variation in soil temperature is limited. Beard and Daniel (1966) found root growth of creeping bentgrass correlated with the soil temperature at a depth of six inches. In their investigation, new root growth always followed a sharp drop in soil temperatures." Well, everyone knows you must have roots to have grass. Many years ago, a wise greenkeeper somewhere gave me a phrase that has always stuck with me: "Understand and manage what's below the turf and you will have turf to manage."

DESCRIPTION OF COURSE

Before we get into the substance of soil temperature, I believe it is important to understand the environment of the Broadmoor Country Club. It will then be easier to understand why we use soil temperatures to assist us in fairway management. Broadmoor Country Club is an 18-hole course designed by Donald Ross. The club is 60 years old with a membership of 330. It is located in the northwest section of Indianapolis. Of the 17,000 rounds

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played there each year, one-third are played in electric carts. The membership desires maximum turf conditions on the greens and tees, above-average results from the fairways and the adjacent rough and bunkers, and average conditions in the rough and other playing areas. These objectives serve as a plan to understand our overall priorities and budget limitations.

Climate

Because of our location, it is very difficult to grow consistently high-quality golf turf. The growing season is only 192 days. We are in the southern edge of the transition zone. We average 40 inches of rain per year, but from March through August we average 3.58 inches per month. The average July air temperature is 76° F.; humidity average at 8 A.M. is 80 percent and at noon 50 percent. Mean average temperature during December through February is 30° F.

Soil Conditions

Generally speaking, our soil is a moderately fine-textured, brown silty loam, low in organic matter, having high moisture capacity, with slopes of 0 to 2 percent for slow surface runoff.

Turfgrass and Cultural Considerations

The fairway turf consists of 30 percent to 50 percent annual bluegrass, 10 percent to 30 percent elite bluegrasses, 10 percent to 20 percent creeping bentgrass, and 0 percent to 10 percent improved turf-type ryegrasses. Each fairway has a different percentage of these grasses. With the high population of annual bluegrass we are forced into two separate turf management regimes. One program favors the bluegrasses, bents, and ryegrasses during the spring and fall, while the second is geared to keep the annual bluegrass from dying out during the hot and humid summers. The surface mass consists of 1/4 to 1/2 inch of live mat and below this a 1/2-inch layer of thatch intermixed with soil from frequent aerifications the past five years. Root penetration is vigorous in late fall, early winter, and spring. Roots begin to turn gray in late May.

We are very fortunate to have a cooperative membership and board of directors that understands the problems of maintaining good fairway turf.

When Ross designed and constructed Broadmoor, he built a marvelous drainage system for the fairways. Every fairway has three to four 4-inch lines running the length of the fairway, on 30- to 40-foot spacings. This drainage system removes excess water very quickly, and so our heavy soil dries and firms up rapidly in the spring. Also, we now enjoy rapid surface drainage after heavy rains since we installed surface drains in the low areas in recent years. The biggest single factor that keeps us from having above-average fairways by holding annual bluegrass through the summer is an inadequate manual watering system. Because of this inferior system, we overwater some areas and underwater others. Either way the turf is weakened. Our board is aware of this problem and plans to correct it when funds become available.

Fusarium blight was so severe on the fairways during the early and mid-1970s that much of the 'Merion' bluegrass has been replaced by annual bluegrass.

DATA COLLECTION

In 1966 I began looking for a technique that would help me forecast when Fusarium blight might be active so that we could time the fungicide application to control this disease better. By keeping soil temperature data we learned that we could expect blight symptoms at 65° F. when the soil was dry. When I attempted to understand the relationship between soil temperature and Fusarium blight, I became interested in soil temperatures as they might relate to other turf problems.

In 1977, I selected the 10th fairway as the typical problem fairway. Fortunately it is only 50 yards from the maintenance headquarters, and it gave us excellent access to perform and observe tests. It is ideal for investigating fairway turf stress because it has: (1) slight southern slope and, therefore, adequate direct sunshine; (2) 50 percent annual bluegrass population; (3) 20 percent improved turf-type ryegrass population; (4) high water table and poor internal drainage; (5) soil compaction and mower injury from mowers and tractor; (6) electric cart crossover in front of the green; (7) under- and overwatering from sprinklers; and (8) annually gets all the pest problems.

In this project, we used the Taylor soil thermometer. It is a very simple instrument. The probing stem is six inches long and a quarter-inch in diameter. It has a sealed weather-resistant glass face with degree Fahrenheit reading from 20 to 220. It was inserted into the ground to a depth of two inches. It remained in the soil in this area for 24 hours every day. A cart directional arrow is placed in front of it to keep it protected from golf carts, golfers, grounds equipment, and golf balls. It is noticeable but not objectionable to the golfers. It has sparked an interest in the labor force to observe conditions and to attempt to correlate turf problems with the temperature. This instrument has also stimulated questions and conversations from members.

On 16 May 1977, we began recording the daily low soil temperature. Within eight weeks we had gone through three thermometers. One was wrecked by the gang mowers, another was vandalized, and the third was stolen. So our study was terminated at the end of June 1977. During the winter of 1977-78, I purchased more thermometers and renewed my determination to read, record, and study soil temperatures during 1978. The 1978 season proved more successful and provided us with the data and turf condition problem observations that were needed in formulating a program for the next year. During the winter of 1978-79, I searched for scientific supporting information. The publications that were most helpful were *Turfgrass Science and Culture* (4) by Beard, *Turfgrass Science* by Hanson and Juska, *Proceedings* from the First and Second International Conferences, various magazine articles, and the "Michigan State University Research Report No. 352 on Annual Bluegrass," by Beard, Rieke, Turgeon, and Vargas, sponsored by the USGA Green Section.

At last I was able to put together the information that would serve as my guide for a chart (Table 1).

Table 1. Optimum Soil Temperature (° F.) Growth Characteristics Chart

1. Roots -- Max. 50°-65°; Med. 40°-50°; Min. 40°-30° and 70° and above.

2. Shoots and Tillering (stems, buds, and leaves) -- Max 50°-65°; Min. 70° and above and 50° and below.

3. Carbohydrate Reserve -- More documentation needed. My estimate: Max. 40°-60° (when roots and shoots are most active).

*4. **Seed Germination**	**Weed Science**	**Northrup King Seed Co. (3)**
Cultivar:	**Optimum**	**Minimum**
a. Annual Bluegrass	68°-86°	37°-40°
b. Bentgrass	50°-86°	50°
c. Kentucky Bluegrass	59°-77°	50°
d. Perennial Ryegrass	59°-77°	50°
e. Hairy Crabgrass	68°-95°	50°
f. Goosegrass	68°-95°	59°

*Temperature separated by a dash indicates an alternating temperature--the first numeral for approximately 16 hours and the second for approximately 8 hours.

This chart is set up for turf highly populated with annual bluegrass, with its inherent difficulties of survival. If we were maintaining turf favoring the elite bluegrass or improved bents, I would raise the high Optimum Soil Temperature about five degrees. These parameters, as general as they may appear, provided organization and meaning which then allowed me to prepare a basic line graph.

This line graph shows the temperatures on the sides, the month and day at the top, and is overlaid with a piece of blue paper in the 45° to 65° F. range to illustrate the zone for optimum growth and cultural considerations. The area above or below the blue reminds me to BEWARE. If I am contemplating any cultural practice that might disturb the soil or cause mechanical or chemical stress on the plant, I proceed with extreme caution. From this experience we have put together our soil temperature turf management guide (Table 2).

I realize that the parameters established for this guide are not so exact that they can be used by all turf managers. My intention is to get you to think about it and possibly develop a soil temperature forecasting planning system of your own.

Table 2. Soil Temperature Turf Management Guide

Cultural Practices	Parameters	
	anticipate at degree F.	to do at degree F.
Mowing		
As needed at 3/4 inch	45	45-60
Every other day at 7/8 inch	55	61-65
Every other or third day at 1 inch	62	66-70
Infrequently, in evening, after soil temperature drops below 74° F. at 1-1/8 inch	67	71-74
No mowing	72	75 & higher
Irrigation		
.50 inch on Monday and Friday	45	54-60
.30 inch every other day	60	61-65
.25 inch every day	65	66-70
.10 to .20 inch before 10 A.M. and again before 2 P.M. -- daily	70	71-75
.05 to .10 inch before 9 A.M. and again at noon and at 3 P.M.	70	75 & higher
Wilt Control -- Non-infectious Disease		
Physiological Condition Syndrome -- excessive evapotranspiration rate, high temperature -- low humidity phenomenon (see 5th procedure under irrigation)	70	75 & higher
People Pressures -- carts and equipment traffic -- restrict them to roughs only	70	74 & higher
Fertilizer or chemical applications -- don't take any chances with applications that burn turf or encourage rapid lush growth	65	65 & higher
Weeds		
Soft -- Hairy Crabgrass	45	45-55
Silver Crabgrass	45	50-60
(2nd half rate preemergent)	60	65-75
White Clover	50	55-60
Knotweed	45	45-55
Plantain	50	55-65
Dandelion	45	50-60

--continued on next page

Table 2. Soil Temperature Turf Management Guide (continued)

Cultural Practice		Parameters: anticipate at degree F.	Parameters: to do at degree F.
Cultivation and Thatch Control			
Aeration	spring		45-55
	fall		65-50
Slicing or Spiking	early summer only		50-65
Verticut or Thinning	spring		50-70
	fall		65-50
Thatching	spring		50-65
	fall		65-50
Establishing or Reseeding			
Creeping Bentgrass	only fall		65-50
Kentucky Bluegrass	only fall		70-55
Perennial Ryegrass -- turf-types	spring		50-60
			65-50
Infectious Diseases			
Pythium Blight		72	74 & higher
Pythium Blight of Ryegrass		70	72 & higher
Brown Patch		68	70 & higher
Dollar Spot	late spring	60	60-75
Dollar Spot	late summer and fall	70	70-50
Helminthosporium -- Melting Out		40	45-75
Helminthosporium -- Leaf Spot		65	70-85
Fusarium Blight		60	65-75
Snow Mold -- Typhula	early winter	55	55-35
Surface Insects			
Cutworms		60-85	65-85
Frit-fly and Leafhoppers		60-85	65-85
Soil Insects			
Annual White Grub (*Cyclocephala*)		65	70-80
Black Turfgrass Beetle (*Ataenius*)			
first adults flying		58	55-60
first generation larvae		60	65-75
second adults flying		70	70-75
second generation larvae		75	75-55
Common White Grubs -- damage noticed in late summer and fall		75	75-55

Could this soil temperature record also be used to determine which grasses should be encouraged? The record over the past two years indicates that we have had 15 consecutive weeks with the minimum soil temperature above 65° F. I feel this is above the annual bluegrass range of adaptability. The soil temperature was above the 70° F. line for only nine weeks during this same period. The bluegrasses and bentgrasses have an optimum range up to 72° F. This poses an agonizing question. Are we encouraging the right grasses? Maybe we should consider a herbicide renovation and reseeding program to more desirable grasses, which in the long range may conserve our resources and be less expensive to maintain.

Immediately outside my office is my "1980 Soil Temperature and Weather Record Information Board." On this board I keep the following data:

1. The daily soil temperature, air temperature, precipitation record

2. The three-month permanent record soil temperature graph

3. Chart of Optimum Growth Considerations

4. The 1977 to 1982 Monthly Average Soil Temperature Record

5. Original Soil Temperature Record Chart

6. Cultural Practice Soil Temperature Turf Management Guide

7. Monthly, Day-by-Day Weather Record and Condition of Grass Canopy, Thatch, Soil, and Management Variables

Number 7 is a new record to be maintained in 1980 which includes two sections. The first section records weather data as follows:

a. Air temperature at 6 and 10 A.M. and 2 P.M. and daily lows

b. Atmospheric pressure at 6 A.M. and 2 P.M.

c. Relative humidity at 6 and 10 A.M., 2 and 6 P.M.

d. Wind direction and speed at 6 and 10 A.M., 2 and 6 P.M.

e. Rate of evaporation -- transpiration, using key symbols of H = high, AA = above average, A = average, and L = low

f. Day precipitation in inches

g. Night precipitation in inches

The second section records observations of the conditions of the grass canopy, thatch, and soil.

a. Day irrigation in inches

b. Night irrigation in inches

c. Thatch moisture: S = saturated, M = moist, D = dry

d. Soil moisture: S = saturated, FC = field capacity, M = moist, D = dry or permanent wilting point

e. Soil temperature at 6 A.M. and maximum

f. Dew and guttated water: H = heavy, M = moderate, L = light, N = none

g. Condition of roots: W = white active, G = gray inactive, B = brown deteriorating

h. Vigor of grass: H = high, M = moderate, L = low, SD = semidormant

CONCLUSION

My intention for this expanded record system is to better document the day-to-day and hour-to-hour environmental conditions. This should help us do the right thing at the right time. Hopefully, it will help us keep from making a cultural management mistake. The additional data, I believe, will help us set up a program that a data processor or computer can maintain for us. I feel it is inevitable that minicomputers will make their way into golf course management systems. This is not as far-fetched as you might think. Recently, I received a letter from Elliot Lapinsky, a manager in Or Akiva, Israel. He requested this soil temperature information for a program he is formulating for the computer he is presently using in his management.

I am looking forward to the challenge of the 1980s with confidence and enthusiasm, knowing that soil temperatures play an important part in turf management for golf.

LITERATURE CITED

1. Waddington, *Turfgrass Science* -- American Society of Agronomy, Soil Temperature, page 97.

2. Ward, *Turfgrass Science* -- American Society of Agronomy, Soil Temperature & Turfgrass Growth, page 46.

3. Information provided by Mr. Keith Ahti, Northrup King Seed Co., Minneapolis, Minnesota.

4. Beard, *Turfgrass Science and Culture,* Temperature, Table 7-3, page 225.