Guelph Turfgrass Institute
1991

Ontario Agricultural College
University of Guelph

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TURFGRASS PATHOLOGY

EVALUATION OF SPECIES AND CULTIVARS

INTRODUCTION

Members of the Guelph Turfgrass Institute are pleased to present their Annual Report for 1991. The report is not a complete record of all data collected by the various researchers, but it reflects the highlights of their work. The comprehensive nature of the report is a reflection of the Guelph Turfgrass Institutes's goal to provide information on turfgrass production and management to members of the Ontario Turfgrass Industry.

Highlights of this year's report include, in the area of soils and nutrition, continuing work on **composts as turf fertilizer**, by P. van der Werf and T. E. Bates and by J. E. Eguiza, J. L. Eggens, and K. Carey, and work **on organic lawn amendments, including Ringer products, on turfgrass** by Tom Hsiang, Xuecai Liu, Ken Carey and Jack Eggens. Turfgrass management and renovation research includes studies of **soil temperature and seed germination of tall fescue and perennial ryegrass** by J. L. Eggens, N. McCollum, and K. Carey, ongoing development of **management software for turf areas** by K. Carey and J. L. Eggens, and a series of projects on **non-chemical alternatives for weed control**, by J. C. Hall, J. L. Eggens, K. Sagan, and K. Carey. J. C. Hall and K. Sagan continue to provide extensive data on **weed control and growth regulation in turf**. The area of turfgrass pathology is represented by new and continuing work on the incidence and impact of **necrotic ring spot disease of turfgrass in southern Ontario** by Tom Hsiang, Dan O'Gorman, and Joe Trakalo, chemical trials for **dollar spot disease control** and **resistance of bentgrass cultivars to dollar spot disease**, by T. Hsiang and A. Mueller, and **evaluation and comparison of Agri-diagnostics and Neogen turf disease detection systems**, by Tom Hsiang, Annette Anderson, Art Mueller, and Mike Courneya. The **evaluation of species and cultivars** is a continuing program: this year's report includes data on bentgrass cultivars managed as fairway and putting green turf, perennial ryegrass cultivars, tall fescue cultivars, and sports turf mixtures, presented by J. L. Eggens, N. McCollum and K. Carey.

We want to thank the Ontario Turfgrass Research Foundation for its significant and increasing contribution to the GTI research programs. The support of the OTRF, along with contributions made by companies, agencies, and institutions listed on the following page helped to make 1991 a successful year for turfgrass research.

J. C. Hall
K. Carey
Editors

ACKNOWLEDGEMENTS

We wish to extend our appreciation to the Ontario Ministry of Agriculture and Food for continued support during the year. The Ontario Turf Research Foundation continued to play a major role, not only in providing funding for a variety of projects, but also by indicating directions the research should take to resolve problems which occur in the turf industry. We also extend sincere to the agribusiness community which provided extra operating dollars, chemicals and equipment which made many of the projects reported herein a success.

Ontario Ministry of Agriculture and Food
Natural Sciences and Engineering Research Council
Ontario Turfgrass Research Foundation
Ontario Ministry of the Environment

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The Guelph Turfgrass Institute

The Guelph Turfgrass Institute was established in 1987 to conduct research and extension and provide information on turfgrass production and management to members of the Ontario turfgrass industry. Located at the University of Guelph, the institute is supported by the university, the Ontario Ministry of Agriculture and Food, and the turfgrass industry. The first of its kind in Canada, the institute is already recognized as a world-class centre for research, extension and professional development.

Building on the University of Guelph's long-standing expertise in turfgrass science, the institute will continue to focus its activities in areas such as the environmental aspects of pesticide use (fate and persistence), evaluation of grass species, varieties and seeding methods, sports field construction, fertility and management programs, pesticide use and the biological and cultural control of diseases and weeds.

The Guelph Turfgrass Institute's mandate is

❶ to expand and enhance turfgrass research for Canada's $1-billion turf industry

> Many short- and long-term GTI research projects continue to address problems in both basic and applied turfgrass science. These are amply represented by the descriptions included in this report.
>
> Both the scope and the scale of these research efforts will be significantly increased as we move to the new GTI site.

❷ to expand extension and information services

> Both routine and extraordinary extension services make up a significant proportion of the work of the members of the GTI. The future will see a significant increase, which we hope to handle with increasing effectiveness from the new Information Centre.
>
> Professional development programs such as the Turf Managers Short Course, the Annual GTI Turfgrass Management Symposium, and regular Research Field Days will continue to focus on exchange of information and technology transfer between industry and researchers.

❸ to encourage and prepare young people for careers in the industry and in research through undergraduate and graduate programs

> In addition to extension education, regular undergraduate (degree and diploma) and graduate programs in turfgrass science are available, with courses covering specific areas such as turfgrass production and management, as well as plant nutrition, physiology, genetics and breeding, pathology, herbicides, and soil physics, chemistry, and biology. Correspondence courses in turfgrass subjects are also offered.

❹ to develop a world-class turfgrass facility

Building for the future - The Guelph Turfgrass Institute's Research and Information Centre

The Research and Information Centre, scheduled to be completed in summer 1992, will serve all sectors of the industry and the public. The building is to be strategically located on a 53-acre OMAF site, adjacent to the University of Guelph Arboretum. The Centre will call on the expertise of the University of Guelph's successful research and education programs, OMAF and the turfgrass industry. The Centre will benefit every sector of society, from the turf industry - golf courses, parks and recreation and athletic facilities, sod growers, landscapers, seed, fertilizer and pesticide producers - through to public agencies and the general public. This building will provide a focal point for the continued development of turfgrass science and the turfgrass industry.

The Centre will provide:

- 7,620 square feet of space
- public access to publications and computer-reference material
- a computer link with international turfgrass centres
- display area
- conference and seminar facilities
- research laboratory
- pesticide storage and mixing area
- equipment research and support
- office space for the director, the turfgrass extension specialist, the superintendent of turf plots, and graduate student offices
- office space for industry organizations

The site - research facilities

The research plots on site will be developed specifically to service research into turfgrass and related landscape problems, with appropriate state-of-the-art management (equipment, irrigation, evaluation tools). Field plots will include research on turfgrass soils and fertility; sod production and management; evaluation and selection of varieties; control of weeds, insect pests and turfgrass diseases. The field plots and field laboratory facilities on the 53-acre site will provide researchers with the tools to generate new approaches to turfgrass production and management.

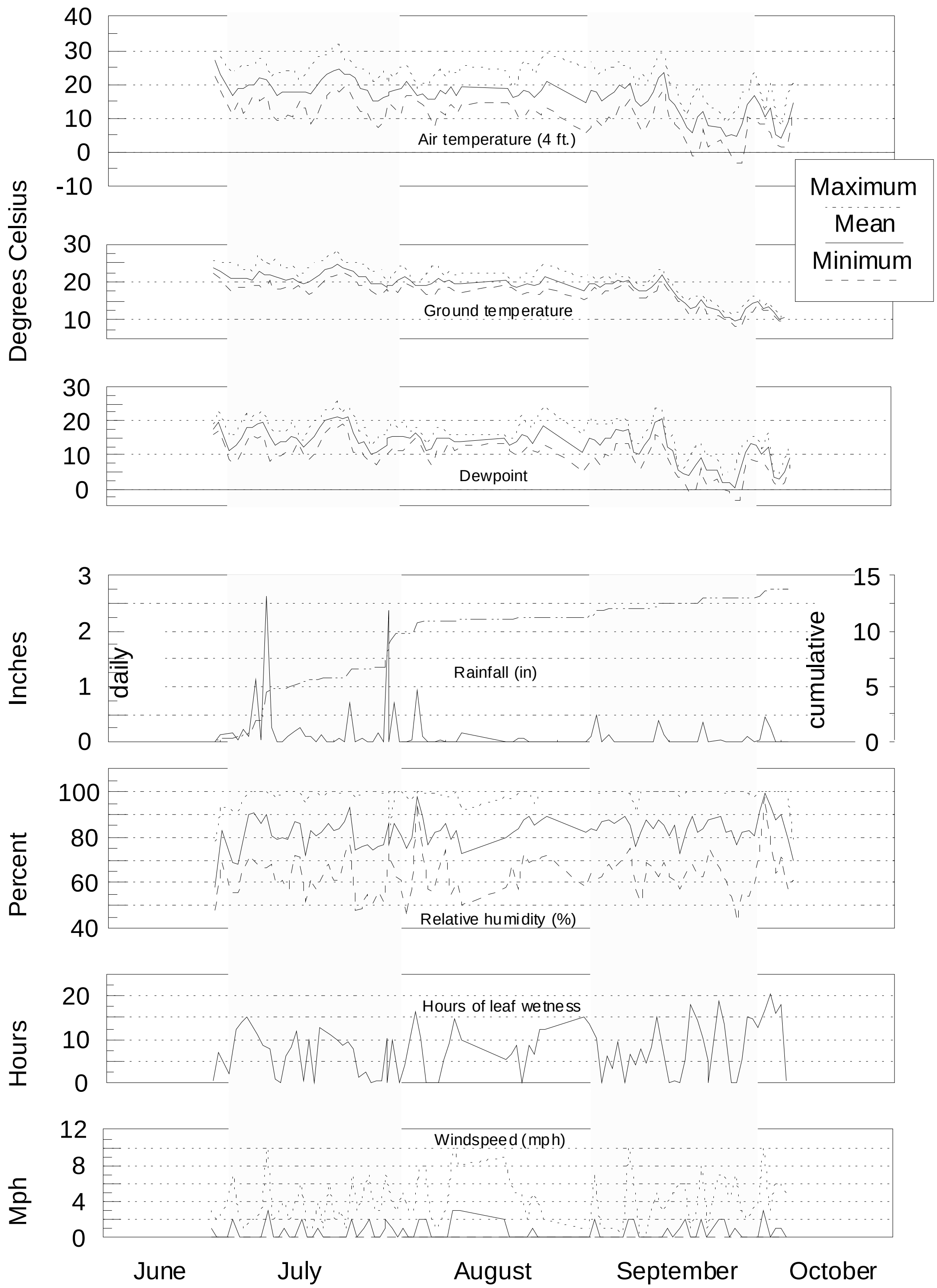
Members of the Guelph Turfgrass Institute

The staff of the Guelph Turfgrass Institute includes the director, other university faculty (twelve at present), research technicians and the Ontario Ministry of Agriculture and Food extension specialist.

Dr. Chris Hall	Environmental Biology Director - GTI
Dr. Jack Alex	Environmental Biology
Ms. Pam Charbonneau	Ontario Ministry of Agriculture and Food, Horticultural Science
Dr. Tom Bates	Land Resource Science
Dr. Greg Boland	Environmental Biology
Dr. Ken Carey	Horticultural Science
Dr. Jack Eggens	Horticultural Science
Dr. Ed Gamble	Crop Science
Dr. Terry Gillespie	Land Resource Science
Dr. J. J. Hubert	Mathematics and Statistics
Dr. Tom Hsiang	Environmental Biology
Mr. Norman McCollum	Guelph Turfgrass Institute
Dr. Ron Pitblado	Ridgetown College of Agricultural Technology
Dr. Mark Sears	Environmental Biology
Dr. Keith Solomon	Environmental Biology
Dr. Gerry Stephenson	Environmental Biology
Dr. Clayton Switzer	Special Advisor to the President
Mr. Pat Tucker	Turf Managers Short Course Coordinator
Dr. Paul Voroney	Land Resource Science

1991 WEATHER DATA, CAMBRIDGE RESEARCH STATION

In order to assist in interpretation of some of the material presented in the research reports, we are presenting weather data for the 1991 growing season. The data were collected by an Envirocaster weather station situated next to the pathology green at the Cambridge Research Station, Cambridge, Ontario.



TURFGRASS CLIPPING WEIGHTS, VISUAL QUALITY, INFESTATION OF ANNUAL BLUEGRASS AND DEPTH OF THATCH AS INFLUENCED BY COMPOST

P. van der Werf and T. E. Bates
Department of Land Resource Science

INTRODUCTION

A considerable portion of municipal waste (household waste, yard waste and sewage sludge) is compostable. Major cities in Ontario are initiating pilot central composting facilities with future plans for full-scale operations. Large quantities of compost will be produced and end uses for compost need to be investigated.

Composting does not always eliminate all pathogenic organisms. This is especially of concern with sewage sludge. Gamma irradiation has been shown to be an effective method to destroy pathogens in sewage sludge prior to composting.

Established turfgrasses, which have a combined area of over 150 000 ha (Sears and Gimpelj 1983) in Ontario, could benefit from compost, as a source of plant nutrients and soil organic matter. Various reports indicate that composts can be used favourably on established turfgrass (Alexander 1990, Logsdon 1990 and McFarlane 1990). Those studies did not examine in detail the specific effects of compost on turf.

The studies reported here investigated clipping weights, visual quality, percent annual bluegrass (*Poa annua*) infestation and thatch thickness as a result of compost addition to established Kentucky bluegrass (*Poa pratensis*), managed as a home lawn and creeping bentgrass (*Agrostis palustris*), managed as a putting green. Compost produced from irradiated sewage sludge was included to determine if irradiation affected the response of turfgrasses to the resulting compost.

METHODS

Two experiments were conducted from mid - April 1990 to September 1991, at the Cambridge Research Station of the Ontario Ministry of Agriculture and Food. One trial was conducted on Kentucky bluegrass, managed as a home lawn cut every five days at 3.2 cm with clippings returned and irrigated when necessary. The other trial was on Creeping bentgrass, managed as a putting green cut 6 days per week at 4 mm with clippings removed and irrigated as necessary.

Irradiated sewage sludge compost (ISSC), City of Guelph leaf compost (LC) and commercially available animal manure compost (AMC) were applied at 10, 20, 30 and 40 t ha^{-1} (dry weight), in three equal applications 3-4 weeks apart, in 1990 and 1991. A control treatment was included of only recommended rates of macronutrients supplied by chemical fertilizers. For the compost treatments, the plant available macronutrients content was estimated and this was supplemented with chemical fertilizers to supply the recommended rates. Plant available N was estimated by adding ammonium and nitrate nitrogen to 10% of the organic nitrogen content. Plant available P was taken as 40% of the phosphorus extracted by sodium bicarbonate and plant available K as the total extracted by ammonium acetate. Table 1 gives the ranges and means of plant available nutrients in compost as a percentage. Chemical fertilizer requirements were split into three equal applications and applied approximately one week after each compost application (except Phosphorus which was all applied 1 week after the first compost application). In effect, each treatment had equal amounts of plant available macronutrients.

Clippings were collected, dried and weighed, three times each year, three weeks after each compost application. Visual quality ratings, encompassing colour, density and uniformity were completed 5 times per season on Kentucky bluegrass and 4 and 5 times, on creeping bentgrass, in 1990 and 1991 respectively. A scale of 1 (poor) to 10 (excellent) was used. Annual bluegrass in creeping bentgrass was visually rated (1=no annual bluegrass 10=only annual bluegrass). A second method of evaluating annual bluegrass involved using a quadrat which allows evaluation of randomly selected

Table 1. Range and mean of plant available N, P and K in all composts over all rates of application, expressed as a percentage of recommended rates.

	Kentucky bluegrass[1]		Creeping bentgrass[2]	
		%		
	Range	Mean	Range	Mean
N	3.4 - 63.4	21.5	2.7 - 50.1	16.8
P	7.3 - 100+	40.1	6.2 - 100+	33.0
K	45.5 - 100+	84.5	17.8 - 100+	61.8

[1] Recommended applications of micronutrients were 200 kg N ha^{-1}, 96 kg P ha^{-1} and 66 kg K ha^{-1}.
[2] Recommended applications of macronutrients were 250 kg N ha^{-1}, 113 kg P ha^{-1} and 166 kg K ha^{-1}.

points on the turfgrass. Each point is identified as being creeping bentgrass or annual bluegrass. Fifty points were evaluated visually per plot and expressed as percentage of annual bluegrass. Depth of thatch was measured, in Kentucky bluegrass, in 1991, by using a slab cutter and measuring each slab (1 per plot) 3 times.

RESULTS

Clipping weights:

On Kentucky bluegrass clipping weights, a function of plant vigour, from the different composts were similar except on the third cut in 1990 when the ISSC treatment produced greater clipping weights (Table 2).

Table 2. Dry weight of Kentucky bluegrass clippings in 1990 and 1991 as affected by compost source.

Source of Compost	1990			1991		
	6/26*	7/17	9/8	6/14	7/12	9/8
	Clipping weight (kg ha^{-1})					
LC	157a[1]	274a	555b	374a	702a	616a
ISSC	158a	267a	609a	313a	691a	554a
AMC	171a	288a	539b	338a	724a	623a
Control	171	276	577	493	551	554
Coefficient of Variation (%)	30.7	22.5	12.6	22.4	17.7	20.8

* Day and month
[1] Means followed by the same letter in a column are not significantly different at P=0.05 according to the protected LSD.

Clipping weights of creeping bentgrass in the third cut of 1990 were higher with ISSC than with other composts (Table 3). This treatment was not applied in 1991 because of lack of materials. Higher rates of application consistently resulted in lower clipping weights, significantly 3 out 6 cuts (Table 4).

Table 3. Dry weight of creeping bentgrass clippings in 1990 and 1991 as affected by compost source.

Source of Compost	1990			1991		
	7/5*	7/26	8/17	6/13	7/11	8/9
	Clipping Weight (kg ha^{-1})					
LC	43a[1]	78a	150c	94b	25a	68a
ISSC	50a	82a	175a	-	-	-
AMC	49a	82a	161b	104a	25a	68a
Control	47	86	172	101	29	72
Coefficient of Variation (%)	23.8	16.5	8.1	11.7	20.4	7.7

* Day and month

[1] Means followed by the same letter in a column are not significantly different at P=0.05 according to the protected LSD.

Clipping weights of compost treatments, in both trials, were generally comparable to the control treatment.

Table 4. Dry weight of creeping bentgrass clippings in 1990 and 1991 as affected by rate of application.

Rate of Application (t solids ha^{-1} yr^{-2})	19901			19912		
	7/5*	7/26	8/17	6/13	7/11	8/9
	Clipping Weight (kg ha^{-1})					
0	47	86	172	101	29	68
10	50a[1]	82a	169a	112a	29a	72a
20	54a	83a	164a	101a	29a	72a
30	40ab	77a	161a	97a	25b	65b
40	45b	80a	155a	97a	26ab	65b
Coefficient of Variation (%)	23.8	16.5	8.1	11.7	20.4	7.7

* Day and month.

[1] Means followed by the same letter in a column are not significantly different at P=0.05 according to the protected LSD.

Visual Quality

In Kentucky bluegrass treatments receiving higher rates of compost had higher visual ratings (Table 5). This was especially noticeable in the overall data from both years. Scores for compost treatments were consistently higher than control treatments. There were no significant differences between the types of compost.

In creeping bentgrass the type of compost exerted a greater effect than rate of application on visual quality scores (Table 6). Overall the AMC and ISSC treatments scored significantly higher than LC. Scores for compost treatments were generally higher than control treatments. Factors that influenced visual quality scores included compost visibility and presence of dollar spot (*Sclerotinia homeocarpa*) both of which affected the colour component of this rating system. A significant source*rate

Table 5. Effect of rate of compost application on visual quality of Kentucky bluegrass

Rate of Application (t solids $ha^{-1}yr^{-2}$)	Turf Visual Quality		
	1990	1991	Overall
		(1-10 scale)	
0*	4.7	5.0	4.9
10	5.8b[1]	5.2b	5.5c
20	5.8b	5.7a	5.8bc
30	6.1b	5.7a	5.9b
40	6.4a	5.8a	6.2a
Coefficient of Variation (%)	11.6	10.1	12.2

* Control treatment

[1] Means followed by the same letter in a column are not significantly different at P=0.05 according to the protected LSD.

interaction indicated that scores for the LC source decreased linearly with increasing rates; AMC increased linearly with rate, but weakly and ISSC had no discernable pattern (Table 6).

Table 6. Effect of rate of compost application and source of compost in 1990 and 1991 on visual quality of Creeping bentgrass .

Source of Compost	Turf Visual Quality Rate of Application - t solids $ha^{-1}yr^{-2}$					
	0	10	20	30	40	Mean
LC		6.4	6.4	6.0	5.8	6.1c*
ISSC		6.5	6.8	6.4	6.6	6.6b
AMC		6.4	6.8	6.9	6.8	6.7a
Mean		6.3	6.4a	6.7a	6.4a	6.4a

Coefficient of Variation 9.9%

Source significant at $p = 4 \times 10^{-9}$ by "F" test.

Source*rate significant at p= 0.007 by "F" test.

* Means followed by the same letter in a column are not significantly different at P=0.05 according to the protected LSD.

Annual bluegrass is common in creeping bentgrass golf greens. Visual ratings in 1990 revealed that the AMC treatments had the lowest incidence of annual bluegrass. In 1991 40 t ha^{-1} compost treatments had significantly less annual bluegrass than treatments amended with 30 and 20 t ha^{-1} but not 10 t ha^{-1} (data not shown). Visual ratings using a quadrat, in 1990 and 1991, did not reveal any treatment differences (data not shown).

Depth of Thatch

The AMC treatments had significantly greater depth of thatch than the ISSC treatments, at the conclusion of experimentation and the 20 t ha^{-1} rate consistently led to less depth of thatch than other rates (Table 7). Generally thatch measurements were higher where compost was applied. Thatch accumulation was increased by compost applications.

Table 7. Depth of thatch measurement on Kentucky bluegrass at the conclusion of experimentation (August 1991).

Source of Compost	Rate of Application - t solids ha^{-1}yr^{-2}					
	0	10	20	30	40	Mean
			Thatch (mm)			
LC		16.1	15.4	15.6	20.7	17.7a*
ISSC		15.8	13.5	16.8	15.1	15.3b
AMC		18.5	13.0	17.7	17.6	17.0ab
Mean		13.11	17.1a	14.0b	17.7a	17.8a
Coefficient of Variation 29.3%						
Source significant at p=0.05 by "F" test.						
Rate significant at p=0.003 by "F" test.						

* Means followed by the same letter in a column or row are not statistically different at P=0.05 according to the protected LSD.
[1] Control treatment.

DISCUSSION AND CONCLUSIONS

1. Irradiation of sewage sludge prior to composting did not lead to positive or negative effects on turfgrass, relative to other composts used.

2. In this study composts did not reduce incidence of annual bluegrass in creeping bentgrass in a consistent manner.

3. Depth of thatch, in Kentucky bluegrass, was increased by compost addition.

   Compost addition with supplemental fertilizers supplied a high level of macronutrients to the turfgrass. Compost treatments may have supplied greater amounts of macronutrients than the control treatment leading to greater growth and depth of thatch. Reduced amounts of supplemental chemical fertilizers in compost treatments may reduce this problem.

4. Composts can be added to established turfgrass such as Kentucky bluegrass and creeping bentgrass contributing to macronutrient requirements. Clipping weights, an indication of plant vigour, were similar and visual qualities enhanced, relative to the control treatment. No compost or rate of application was consistently superior.

   Composts, at the rates applied, in these studies, generally do not meet plant nutrient requirements (Table 1). In selecting a compost and rate of application, the compost with the greatest amount of plant available nutrients, without exceeding plant requirements and/or leading to pollution, would lead to the greatest reduction of chemical fertilizers.

5. In this study composts were more effective on less intensively managed turfgrass such as a home lawn as opposed to a putting green.

Mowing removed compost from creeping bentgrass, managed as a putting green, even with precautions such as raking, irrigation and mowing with the baskets off for the first day after application. Incorporation of composts into Kentucky bluegrass was facilitated by denser and higher growth of the turfgrass sward compared to creeping bentgrass.

ACKNOWLEDGEMENTS

The authors wish to express appreciation for the support provided by Nordion International Inc.

REFERENCES

Alexander, R. 1990. Expanding Compost Markets. Biocycle 31(August):54-59

Logsdon, G. 1990. Selling Sludge Compost. Biocycle 30(May):75-76

McFarlane, P. 1990. Ontario Implements Composting Programs. Biocycle 31(January):32-33.

Sears, M.K. and E.J. Gimpelj. 1983. A Survey of the Turfgrass Industry in Ontario. University of Guelph Publication.

COMPOSTED SEWAGE SLUDGE AS A NITROGEN SOURCE FOR THE MAINTENANCE OF PUTTING GREEN AND FAIRWAY TYPE TURF.

J. E. Eguiza, J. L. Eggens and K. Carey.

ABSTRACT

The potential use of composted sewage sludge as a nitrogen source for turfgrass maintenance was studied on putting green and fairway turf. Composted sludge was compared against two other nitrogen sources. Turfgrass growth was evaluated during the two years of the experiment. Plant N uptake was measured as well as N availability in the thatch layer and soil rootzone. The effect of N sources on thatch and soil pH, thatch accumulation and botanical composition was also investigated.

Sulfur-coated urea and Milorganite produced higher turfgrass yields and a darker green color than the composted sewage sludge on either type of turf. Nitrogen availability for plant uptake in both the thatch layer and in the soil rootzone was highest in sulfur-coated urea treated plots and lowest in the composted sludge treated plots. The highest total N values in leaf tissue were produced by sulfur-coated urea, with Milorganite being intermediate. Thatch and soil pH were affected by type of N source. The thatch layer was more susceptible to changes in pH than the soil rootzone.

INTRODUCTION

The concern of people towards the environment has increased in recent years. The release of untreated municipal effluent into bodies of water such as rivers and lakes, represents a problem of increasing magnitude around the world. In general, waste water treatments are designed to remove contaminants and pollutants. When effluent waters are treated, a residual material composed of a dilute suspension of solids referred as "sewage sludge" is obtained as an end product, which needs to be disposed of. Most municipal sludge is now disposed of by land filling, incineration and ocean disposal (Elliot, 1986).

According to Tester et al. (1982) sewage sludge is a valuable source of organic matter for most soils and also contains macronutrients and micronutrients essential for plant growth. Tester (1989) regards composting of sewage sludge as one of the most attractive methods for treatment. The content of heavy metals in sewage sludge depends on its source and origin. In order to minimize possible contamination of the chain food, a maximum tolerance concentration of heavy metals in sewage sludge acceptable for use in agricultural land has been adopted in Canada (Environment Canada, 1984).

Composted sewage sludge may be used as an organic nitrogen source or as a soil amendment for the maintenance of turfgrass areas. Sabey et al. (1990) observed that after a number of applications with composted sewage sludge, the biological and physical properties of the soil were modified and the supply of nitrogen, phosphorus and potassium were increased.

The objective of the study was to determine the feasibility of using composted sewage sludge as a nitrogen source for the maintenance of putting green and fairway type turf. Thatch pH and accumulation, turfgrass color, plant N response and annual bluegrass/creeping bentgrass competitiveness under different nitrogen sources and rates were evaluated in this study.

MATERIALS AND METHODS

For this experiment, a composted sewage sludge material was provided by the Windsor Water Pollution Control Plant located in Windsor, Ontario. The experiment was conducted on a 10 year-old creeping bentgrass/annual bluegrass putting green and on a fairway-type turf established on a Fox sandy loam soil at the Cambridge Research Station, Cambridge, Ontario. The experiment was conducted from May 1989 to October 1990. Irrigation for both the putting green and fairway plots was provided as needed to prevent drought stress. The mowing heights were set at 5 mm for the putting green and 9 mm for the fairway plots. Putting green plots were mowed on a daily basis during the growing season, whereas fairway plots were mowed every other day. Neither herbicides nor fungicides were applied during the course of the experiment.

Turfgrass plots (1 m x 4 m) received 1 of 3 nitrogen treatments; Sulfur-coated urea (32-0-0), Milorganite (6-2-2) or Windsor composted sewage sludge (1.8-2-1) applied at two different rates, 180 kg N ha^{-1} yr^{-1} and 360 kg N ha^{-1} yr^{-1} (referred to here as low and high N rate respectively). Treatments were laid out in a complete randomized block design with a 3x2x2 factorial arrangement for both putting green and fairway experiment site. The three factors used in this experiment were; 3 N sources, 2 N rates and 2 artificial wear stress levels. Each of the 12 treatments was replicated four times. Nitrogen treatments were applied with a drop-type fertilizer spreader and split into 3 or 4 applications during the growing season. Nitrogen treatments for putting green turf were applied on June 1, 1989; July 6, 1989; August 8, 1989; September 15, 1989; May 23, 1990; June 25, 1990; July 27, 1990 and on August 27, 1990. For the fairway experiment site, treatments were applied on June 13, 1989; August 15, 1989; September 26, 1989; June 20, 1990; July 25, 1990 and August 26, 1990.

Artificial wear was applied to half of the turfgrass plots on each experiment site. A modified lawn tractor with a set of five rollers fitted in the front was used to apply artificial wear and soil compaction. A minimum of 20 passes per week were applied to those plots assigned to wear treatments.

Turfgrass on both experiment sites was evaluated for color, clipping yields, broadleaf weed content, botanical composition (percent of annual bluegrass *Poa annua* L. and creeping bentgrass *Agrostis palustris* Huds.), dollar spot (*Sclerotinia homoeocarpa* L.), plant nitrogen uptake and availability in both the thatch layer and soil rootzone.

Turfgrass color was evaluated visually with a 0-9 scale, where 9 = darkest green color and 6 = minimum acceptable color rating. The botanical composition was measured 3 times during the course of the experiment by using a point quadrat (0.5 m x 0.5 m) with 25 observation points within the square. Three measurements per plot from random locations were taken, providing 75 identifications per plot. Clipping yields were collected with a walk-behind greensmower. The turf was allowed to grow for 3 to 4 days before mowing. Plant tissue was collected from an area of 2.08 m^2 which represented a single pass with the mower across the length of the plot. After collection, clippings were placed in a forced-air drying oven at 70°C for 72 hours and weights were recorded on a dry weight basis. Total N, ammonium-N and nitrate-N were determined for the plant tissue.

Laboratory analyses were conducted at the Analytical Services Laboratory at the Department of Land Resource Science, University of Guelph. Plant total nitrogen was determined by the wet digestion (Kjeldahl) method described by Thomas et al. (1967). Plant ammonium-N and nitrate-N were determined according to procedures described by Bremner and Mulvaney (1982). The two forms of inorganic nitrogen in plant tissue were extracted by using deionized water. The filtrate concentration of NH_4^+-N and NO_3^--N in plant tissue was measured colorimetrically by using a Braun and Lube trAAcs 800 autoanalyzer.

Nitrogen availability for plant uptake was analyzed in both the thatch layer and in the soil rootzone. For these analyses, one sample per plot was taken at random with a slab cutter (1cm x 8cm x 10cm). The soil and thatch layer were analyzed separately for exchangeable ammonium and nitrate contents. The upper 5 cm of soil was used for the analyses of the two inorganic forms of nitrogen. Exchangeable ammonium-N and nitrate-N were extracted by using 2M KCl as described by Keeney and Nelson (1982). The filtrate concentration of NH_4^+-N and NO_3^--N were measured with a Braun and Lube trAAcs 800 autoanalyzer.

Soil and thatch pH were determined for both experiment sites at the end of the experiment. One sample per plot was collected at random using a slab cutter. The thatch and soil layer were analyzed separately. The pH of both soil and thatch layer were determined by the electrometric method described by McLean (1982).

Thatch accumulation was determined by measuring its thickness with a ruler. The thickness is expressed in millimetres (mm) and represents the mean of 3 measurements per sample collected at random.

Seven series of thatch measurements were made during the course of the experiment.

Broadleaf weed infestation of turfgrass plots was evaluated visually with a 0-5 scale, where 0 = no broadleaf weeds and 5 = heavily infested ($40% of plot). Dollar spot incidence was evaluated visually with a 0-5 scale, where 0 = no disease and 5 = high disease incidence ($40% of plot).

Statistical analyses of all response variables were carried out with the Statistical Analysis System for linear models (SAS, 1986). Treatment means were separated and compared by the protected LSD method at the 0.05% level of significance. When non parametric variables were correlated, the Spearman correlation procedure was used and the Pearson procedure was used when correlating parametric variables (Snedcor and Cochran, 1989).

RESULTS AND DISCUSSION

Clipping Yields

During the first year of the experiment, no significant differences in clipping yields were found among nitrogen sources on either experiment site. However, on the second and final year of the experiment significant (p = 0.05%) differences among N sources were found. Sulfur-coated urea produced the highest clipping yields and composted sewage sludge the lowest. In general, significantly higher clipping yields were obtained from turfgrass plots treated with the high N rate than with the low N rate (Table 1). Clipping yields collected from wear plots on both experiment sites were in general significantly higher than those collected from non-wear plots.

Table 1. Nitrogen uptake and total yield from putting green turf†.

N SOURCE	TOTAL NITROGEN (%)‡	LEAF NITRATE-N‡ (mg kg^{-1})	LEAF AMMONIUM-N‡ (mg kg^{-1})	TOTAL YIELD§ (g)
SCU	4.96	20.68	54.25	16.91
Milorganite	4.68	11.58	44.98	7.93
Windsor	3.88	1.57	46.35	1.61
LSD 5%	0.36	10.70	NS	1.97
N LEVEL				
Low	4.19	4.42	47.86	4.53
High	4.82	18.14	49.19	13.10
LSD 5%	0.29	8.73	NS	1.60
WEAR				
Yes	4.63	14.88	49.22	10.71
No	4.38	7.67	47.83	6.92
LSD 5%	NS	NS	NS	1.60

† Clipping yields are expressed on a dry matter basis and collected from an area of 2.08 m^2.
‡ Samples collected on 90-09-17 (20 days after most recent fertilization)
§ Collected on 90-09-07 (10 days after most recent fertilization)

Significantly higher clipping yields were produced by sulfur-coated urea and Milorganite, indicating that the release properties of the three nitrogen sources used in this experiment are different. The higher yields produced by sulfur-coated urea are probably the result of a higher and faster availability of nitrogen for plant uptake. Differences between sulfur-coated urea and Milorganite became smaller with increased time after application. This seems to be the result of both a higher N availability from Milorganite and a reduced N availability from SCU over time. Sharma et al. (1976) estimated that between 18 to 38% of the total nitrogen content in SCU could be released during the first 7 days after application. The higher yields obtained from wear plots is probably due to the effect of the wear treatment on the N release properties of both sulfur-coated urea and Milorganite. The effect of wear on the N release properties was highly dependent on type of N source and secondly on the N rate. Kohlmeier and Eggens (1983) suggested that clipping yields could be used as an indication of the extent of the wear injury. In this study, wear injury was minimal and in either putting green or fairway turf no negative effects of wear on clipping yields were found. It appears that the difference between the two experiments may be attributed in part to the different type of artificial wear simulators used.

Nitrogen Uptake

Results from both experiment sites indicate that sulfur-coated urea produced higher levels of total N and nitrate-N in leaf tissue than either Milorganite or the composted sludge (Table 1 presents data from one sample date on the putting green turf. The pattern of nitrogen and yield data was similar on other dates and on the fairway turf). Total N and nitrate-N levels in leaf tissue obtained from Milorganite treated plots were significantly higher than those treated with the composted sewage sludge. The high N rate produced significantly higher levels of both total N and nitrate-N in leaf tissue than those produced by the low N rate. The effect of wear treatments on total N and nitrate-N levels in leaf tissue was highly dependent on the type of N source and secondly on the N rate. Total N was highly correlated with clipping yields (Fig. 1). Plants with higher levels of total N in leaf tissue produced higher yields.

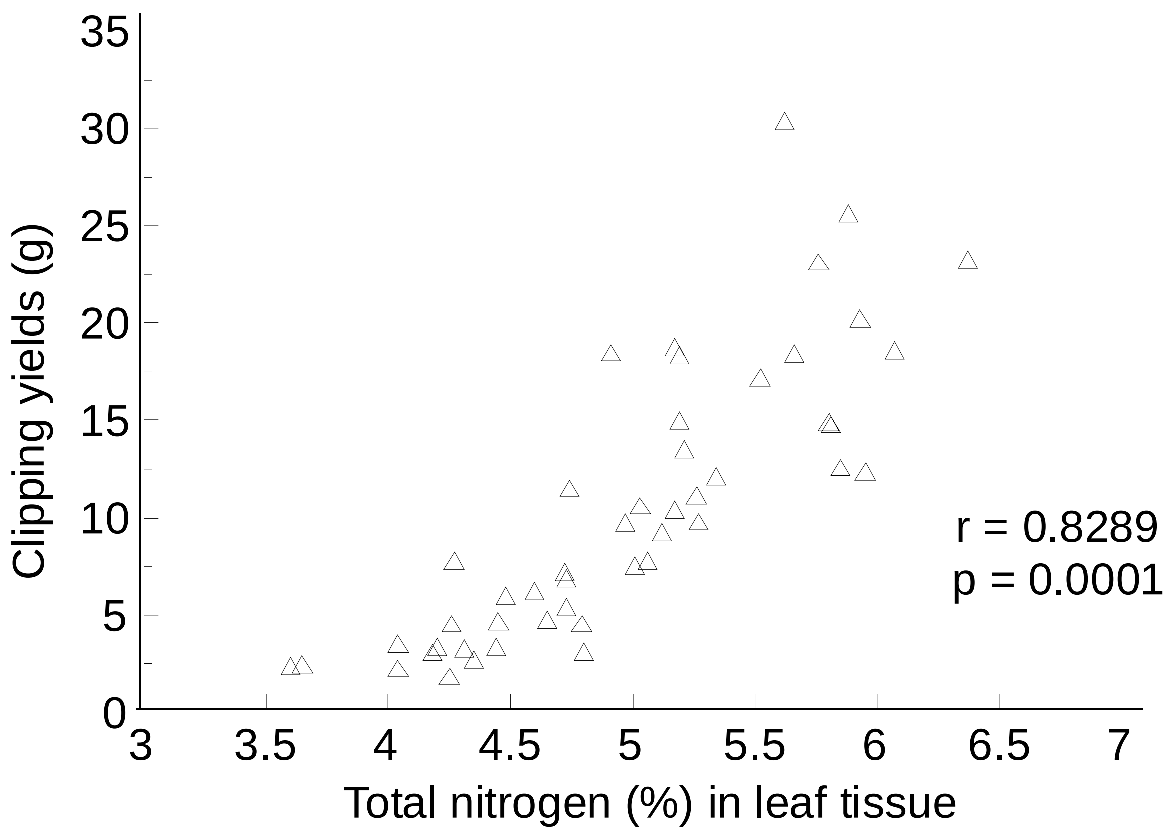


Figure 1. Correlation between total N in leaf tissue and clipping yields from putting green turf.

Levels of free ammonium-N in leaf tissue were significantly different among N sources. However, there was not a significant pattern that would allow us to determine the N source that produced the highest ammonium-N levels in leaf tissue. Neither N rate nor wear treatments had a significant effect on the level of free ammonium-N in leaf tissue.

The higher nitrate-N levels in leaf tissue from sulfur-coated urea and Milorganite treated plots clearly indicates that these two N sources provided higher amounts of NO_3^--N for plant uptake. Granstedt and Huffaker (1982) concluded that nitrate accumulation rate in plant tissue is a function of both the rate of NO_3^- uptake from the external solution and its rate of reduction within the plant. The low ammonium-N levels found in leaf tissue are the result of its continuous assimilation and metabolization by the plant. High ammonium levels within the plant may cause severe toxicity, and one of the mechanisms used by the plant to avoid such toxicity is the reduction of NH_4^+ into other N compounds such as glutamine and asparagine (Givan, 1979).

The composted sewage sludge produced the lowest levels of total N in leaf tissue. However, plants treated with the compost do not seem to be under N deficiency. Reuter and Robinson (1986) reported deficiency levels for perennial ryegrass (*Lolium perenne* L.) below 2% total organic nitrogen by dry weight. Unfortunately, no N deficiency levels for creeping bentgrass have been reported.

Turf Functional Features

On both experiment sites sulfur-coated urea and Milorganite produced a darker green color than the composted sludge (Table 2 presents representative data). The pattern for the other dates and experiment site was similar. Sulfur-coated urea generally produced a darker green color than Milorganite.

Table 2. Nitrogen uptake and turfgrass color from putting green turf.

N SOURCE	TOTAL NITROGEN† (%)	LEAF NITRATE-N† (mg kg^{-1})	TURFGRASS COLOR†‡
SCU	4.96	20.68	8.68
Milorganite	4.68	11.58	8.31
Windsor	3.88	1.57	6.81
LSD 5%	0.36	10.70	0.39
N LEVEL			
Low	4.19	4.42	7.58
High	4.82	18.14	8.29
LSD 5%	0.29	8.73	0.32
WEAR			
Yes	4.63	14.88	8.16
No	4.38	7.67	7.70
LSD 5%	NS	NS	0.32

† Samples collected on 90-09-17 (20 days after most recent fertilization).

‡ Evaluated visually with a 0-9 scale, where 9=darkest green color and 6= minimum acceptable color rating.

A significantly darker color was produced by the high N rate as compared to that produced by the low N rate. Although significant differences between wear treatments were found there was a lack of a consistent pattern. Turfgrass color was highly correlated with levels of total N in leaf tissue, where plants with high N level were to produce a darker green color (Fig. 2). This was possibly due to higher amounts of nitrogen available for chlorophyll synthesis. Johnson (1974) reported a positive correlation between concentrations of chlorophyll and nitrogen content in grass clippings. Color differences in turfgrass were attributed to differences in chlorophyll contents within the plant.

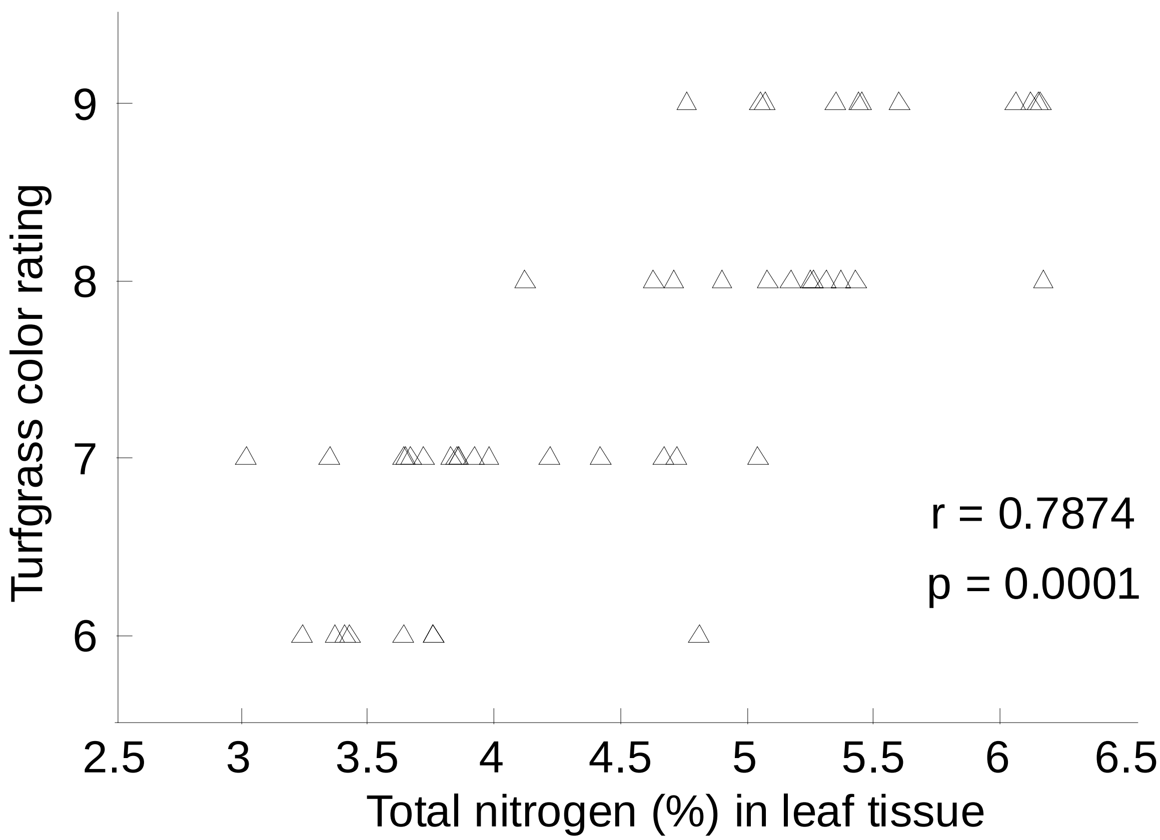


Figure 2. Correlation between total N in leaf tissue and turfgrass color rating from putting green turf.

Broadleaf weed infestation was significantly higher in the composted sludge than in the sulfur-coated urea or Milorganite treated plots on either putting green or fairway turf (Table 3 presents representative data). Differences between sulfur-coated urea and Milorganite were not significant. Neither N rates nor wear treatments had a significant effect on broadleaf weed content of the plots on the putting green site. On fairway turf, higher contents of broadleaf weeds were found on turfgrass plots treated with the low N rate. No significant differences between wear treatments were found under fairway conditions. It is possible that the reduction of plant vigour and density in composted sludge treated plots may have reduced the ability of turfgrass in these plots to compete against broadleaf weeds.

On both experiment sites, dollar spot incidence was significantly higher in Windsor compost than in sulfur-coated urea or Milorganite treated plots (Table 3). Differences between SCU and Milorganite were not significant. Significantly higher dollar spot incidence was found on both experiment sites on plots treated with the low N rate. The incidence was significantly higher on plots where no wear was applied. Dollar spot incidence in composted sludge treated plots may be in part attributed to the lower nitrogen levels in plant tissue. Dest and Guillard (1987) reported that dollar spot incidence was significantly greater in turfgrass plots that did not receive nitrogen treatments compared to nitrogen treated plots.

Table 3. Dollar spot incidence and broadleaf weed infestation in putting green turf.

N SOURCE	DOLLAR SPOT†	BROADLEAF WEEDS‡
SCU	0.31	0.50
Milorganite	0.43	0.50
Windsor	2.31	1.31
LSD 5%	0.46	0.55
N LEVEL		
Low	1.41	0.66
High	0.62	0.87
LSD 5%	0.38	NS
WEAR		
Yes	0.62	0.75
No	1.41	0.79
LSD 5%	0.38	NS

† Evaluated on 90-09-25 with a 0-5 scale, where 0=no sign of disease and 5=highly infected (≥40% of plot).

‡ Evaluated on 90-08-23 with a 0-5 scale, where 0=no weeds and 5=heavily infested (≥40% of plot).

Nitrogen Availability in Thatch and Soil

Exchangeable ammonium-N levels were significantly higher in the thatch layer of sulfur-coated urea and Milorganite treated plots than those treated with the composted sludge (Table 4 presents representative data). Sulfur-coated urea produced in general higher levels of exchangeable ammonium-N. Levels of exchangeable ammonium-N in the thatch layer collected from SCU treated plots 10 days after most recent fertilization were 5 times higher than those from Milorganite and 17 times higher than those from the composted sludge (Table 4). Significantly higher levels of exchangeable ammonium-N in the thatch layer were found in those plots treated with the high N rate in comparison to the low N rate. The effect of wear on exchangeable levels of ammonium-N in the thatch layer seemed to be highly dependent on the type of nitrogen source and secondly on the N rate. It appears that the release properties of SCU and Milorganite were changed possibly by the mechanical action of the wear machine. The N release of the Windsor composted sewage sludge was not affected by the wear treatments since the form of N in the compost is mainly in an organic form which has to be mineralized before it can be absorbed by plants.

Sulfur-coated urea treated plots produced the highest levels of nitrate-N in the thatch layer (Table 4). Differences between Milorganite and the composted sludge were not significant. The high N rate produced significantly higher nitrate-N levels in the thatch layer than the low N rate, especially on the first 5 to 10 days after most recent fertilization. The low nitrate-N levels found in the thatch layer were not surprising. Hurto et al. (1980) reported that the total porosity of thatch was greater than that measured from silt loam soil and concluded that the major portion of these pores were macropores.

Table 4. Soil and thatch exchangeable ammonium-N and nitrate-N in putting green turf.

N SOURCE	SOIL AMMONIUM-N†	SOIL NITRATE-N†	THATCH AMMONIUM-N‡	THATCH NITRATE-N‡
	(mg kg^{-1})			
SCU	23.44	3.93	146.93	16.67
Milorganite	23.15	3.52	29.73	2.12
Windsor	20.62	3.17	8.37	1.21
LSD 5%	NS	0.59	17.82	NS
N LEVEL				
Low	21.97	3.29	36.71	1.15
High	22.84	3.79	86.65	12.19
LSD 5%	NS	8.48	14.55	NS
WEAR				
Yes	22.79	3.50	63.33	4.27
No	22.02	3.58	60.03	9.06
LSD 5%	NS	NS	NS	NS

† Collected on 89-10-02 (17 days after most recent fertilization)
‡ Collected on 89-09-25 (10 days after most recent fertilization)

Thatch was regarded as physically analogous to sand with a comparably high potential for nutrient leaching due to rapid water percolation toward the thatch-soil interface.

Soil nitrate-N levels were significantly different among N sources. Sulfur-coated urea treated plots produced significantly higher nitrate-N levels in the soil rootzone than Milorganite or the composted sludge (Table 4). Differences between these two organic N sources were not significantly different. The high N rate produced significantly higher levels of nitrate-N in the soil than the low N rate in only one sampling date. Differences between the two N rates for the other sampling dates were not significant. Wear treatments did not have a significant effect on soil nitrate-N levels on either experiment site.

Exchangeable ammonium-N levels in soil were significantly different among N sources. However there was not a consistent pattern. The high N rate produced significantly higher levels of exchangeable ammonium-N in the soil rootzone than the low N rate in only one sampling date. Differences between these two N rates for the other sampling dates were not significant. No significant effects of wear treatments were found on either experiment site.

Thatch and Soil pH

The pH of the thatch layer was significantly affected by the type of N source used during the course of the experiment. Thatch pH was reduced drastically by sulfur-coated urea and slightly by Milorganite (Table 5 presents representative data). Thatch pH from composted sludge treated plots does not appear to be reduced. Neither N levels nor wear treatments had a significant effect on thatch pH on either experiment site. The pH of the soil rootzone was also affected by the type of N source used. Results indicate that soil pH was reduced on sulfur-coated urea and Milorganite but not on composted sludge treated plots. As in the thatch layer, sulfur-coated urea produced the lowest pH readings in the soil rootzone. Neither N rates nor artificial wear treatments had a significant effect on the soil pH on either experiment site.

It is evident that the thatch layer was more susceptible to changes in pH than the soil rootzone.

Table 5. Soil and thatch pH and thatch accumulation under putting green turf.

N SOURCE	SOIL pH†	THATCH pH†	THATCH ACCUMULATION (mm) ‡
SCU	6.40	4.93	12.29
Milorganite	6.69	6.45	11.25
Windsor	6.96	6.88	12.27
LSD 5%	0.17	0.26	0.80
N LEVEL			
Low	6.73	6.19	11.83
High	6.64	5.99	12.04
LSD 5%	NS	NS	NS
WEAR			
Yes	6.66	6.16	11.48
No	6.70	6.02	12.38
LSD 5%	NS	NS	0.65

† Samples collected on 90-10-02.
‡ Samples collected on 90-10-31.

The possible differences between these two systems to resist changes in pH may be attributed to a higher buffering capacity and cation exchange capacity of the soil. Danneberger (1984) reported that on an undisturbed basis the cation exchange capacity of thatch was extremely low. If the two systems were to be compared on a volume basis, the CEC of thatch would be lower than that of soil (Hurto, 1978).

Botanical Composition

Population levels of annual bluegrass and creeping bentgrass were significantly affected by the type of N source used. Creeping bentgrass levels in composted sludge treated plots were significantly higher than those receiving sulfur-coated urea or Milorganite (Table 6 presents representative data). Sulfur-coated urea had significantly higher creeping bentgrass population levels than Milorganite treated plots. The N rate did have a significant effect on botanical composition. Higher annual bluegrass contents were observed in those plots treated with the high N rate. There were no significant differences between wear and non-wear treated plots.

Higher annual bluegrass population levels in relation to creeping bentgrass levels obtained from sulfur-coated urea and Milorganite could be the result of higher amounts of available nitrate-N, which enable annual bluegrass to compete more aggressively against bentgrass under these conditions. It has been suggested that the ability of annual bluegrass to compete against creeping bentgrass is decreased when a high NH_4^+/NO_3^- ratio is present in the soil solution (Eggens and Wright, 1985; Eggens et al. 1989). Low annual bluegrass levels observed in composted sludge treated plots may be due to the low fertility levels and also to the high NH_4^+/NO_3^- ratios present in those plots. Higher annual bluegrass levels in relation to those of creeping bentgrass have been observed as a result of high N fertilization rates (Dest and Guillard, 1987; Kohlmeier and Eggens, 1983). Artificial wear may also significantly increase annual bluegrass population levels in turfgrass plots (Canaway, 1981; Kohlmeier and Eggens, 1983). However, in this study wear treatments did not favour annual bluegrass growth. This could be the result of the type of wear machine used in this experiment, where the set of rollers only applied vertical compaction force, rather than applying horizontal friction which can cause tearing and crushing of turfgrass, as in earlier studies.

Table 6. Creeping bentgrass population levels (%) in putting green turf†.

	Dates of assesment		
N SOURCE	89-05-15	90-07-18	90-09-08
SCU	95.48	70.66	74.50
Milorganite	94.52	66.66	71.50
Windsor	96.98	79.41	85.12
LSD 5%	NS	3.46	2.83
N LEVEL			
Low	95.25	72.61	78.50
High	96.07	71.89	75.58
LSD 5%	NS	NS	2.31
WEAR			
Yes	96.03	71.39	78.00
No	95.29	73.11	76.08
LSD 5%	NS	NS	NS

† Population levels as a percentage of the total population of creeping bentgrass and annual bluegrass.

Thatch Accumulation

Thatch accumulation was significantly affected on both experiment sites by the type of N source used. Thatch accumulation was significantly greater in sulfur-coated urea and Windsor plots than in Milorganite treated plots (Table 5). Differences between SCU and Windsor were not significantly different. Thatch accumulation in high N treated plots was significantly higher than in low N plots. On both experiment sites, the effect of artificial wear treatments on thatch accumulation was significant. Lower thatch accumulation occurred in turfgrass plots that received wear treatments as compared to non-wear plots.

Thatch accumulation under sulfur-coated urea treated plots is probably the result of more N available more rapidly which promoted faster growth. The excessive acidification of the thatch layer which might have reduced microbial activity and thatch decomposition may also have contributed to thatch accumulation. Thatch accumulation caused by the composted sludge is not the result of excessive plant growth, but rather the accumulation of organic matter from the compost in the top of the thatch layer. Kohlmeier and Eggens (1983) reported that thatch accumulation was significantly reduced by wear treatments and they concluded that this effect was mainly due to the reduction of plant growth as measured by clipping yields. In this experiment, plant growth was not affected by wear treatments, therefore it can not be concluded that plant injury was the reason for reduced thatch accumulation. Rather this may have been an effect of compaction, reducing the percentage of total pore space and air-filled porosity of the thatch layer. Canaway (1981) observed that artificial wear treatments increased soil bulk density (10%), reduced total pore space (12%) and air-filled porosity (58%).

CONCLUSION

Turfgrass growth rates in response to the application of the Windsor composted sewage sludge were inferior to those obtained from sulfur-coated urea and Milorganite. On turfgrass areas under high management, the composted sewage sludge would not supply the fast growth and meet the demands for high quality playing areas. Its use is feasible if another N source such as SCU is used as a N supplement. In this way the use of composted sewage sludge on turfgrass may represent an attractive disposal alternative. The environmental advantages of composting sewage sludge compared to other disposal methods cannot be ignored.

ACKNOWLEDGEMENTS

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REFERENCES

Bremner, J. M., and C. S. Mulvaney. 1982. Total N, inorganic forms of N and organic forms of N. In A. L. Page, R. H. Miller, and D. R. Keeney (ed). Methods of soil analyses part II. Chemical and microbiological properties, 2nd edition. Am. Soc. of Agron., Madison, WI.

Canaway, P. M. 1981. Wear tolerance of turfgrass species. J. Sports Turf Res. Inst. 57:65-82.

Danneberger, T. K.., A. J. Turgeon, and T. R. Peck. 1984. Effects of sample preparation and pH on the cation exchange capacity of thatch. Agron. J. 76:155-156.

Dest, W. M., and K. Guillard. 1987. Nitrogen and phosphorus nutritional influence on bentgrass-annual bluegrass community composition. J. Amer. Soc. Hort. Sci. 112(5):769-773.

Eggens, J. L., and C. P. M. Wright. 1985. Nitrogen effects on monostands and polystands of annual bluegrass and creeping bentgrass. HortScience 110(5):609-611.

Eggens, J. L., C. P. M. Wright, and K. Carey. 1989. Nitrate and ammonium nitrogen effects on growth of creeping bentgrass and annual bluegrass. HortScience 24(6):952-954.

Elliot, H. A. 1986. Land application of municipal sewage sludge. Journal of soil and water conservation 41(1):5-10.

Environment Canada. 1984. Manual for land application of treated municipal wastewater and sludge. Manual EPS 6-EP-84-1.

Givan, C. V. 1979. Metabolic detoxification of ammonia in tissues of higher plants. A review. Phytochemestry 18:375-382.

Grandstedt, R. C., and Huffaker, R. C. 1982. Identification of the leaf vacuole as a major nitrate storage pool. Plant Physiol. 70:410-413.

Hurto, K. A. 1978. Impact of thatch on herbicide activity and its characterization as a turfgrass growing medium. Ph. D. thesis, Univ. Of Illinois, Urbana, Ill.

Hurto, K. A., A. J. Turgeon, and L. A. Spomer. 1980. Physical characteristics of thatch as a turfgrass growing medium. Agron. J. 72:165-168.

Johnson, G. V. 1974. Simple procedures for quantitative analysis of turfgrass color. Agron. J. 66:457-459.

Keeney, D. R., and Nelson, D. W. 1982. Nitrogen inorganic forms. In A. L. Page, R. H. Miller, and D. R. Keeney (ed). Methods of soil analyses part II. Chemical and microbiological properties, 2nd edition. Am. Agron. Soc. Madison, WI.

Kohlmeier, G. P., and J. L. Eggens. 1983. The influence of wear and nitrogen on creeping bentgrass turf. Can. J. Plant Sci. 63:189-193.

Mc Lean, E. O. 1982. Soil pH and lime requirement. In A. L. Page, R. H. Miller, and D. R. Keeney (ed). Methods of soil analyses part II. Chemical and microbiological properties, 2nd edition. Am. Agron. Soc. Madison, WI.

Reuter, D. J., and J. B. Robinson. 1986. Plant analysis and interpretation manual. Inkata press propietary, Melbourne, Australia.

SAS Institute Inc. 1985. SAS/STAT ™ Guide for personal computers 6th Edition. Cary, North Carolina, USA.

Sabey, B. R., R. L. Pendleton, and B. L. Webb. 1990. Effect of municipal sewage sludge application on growth of two reclamation shrub species in cppper mine spoils. J. Environ. Qual. 19:580-586.

Sharma, G, C., A. J. Patel, and D. A. Mays. 1976. Effect of sulfur-coated urea on yield, N uptake, and nitrate content in turnip greens, cabage and tomato. J. Amer. Soc. Hort. Sci. 101(2):142-145.

Snedecor, G. W., and W. G. Cochran. 1989. Statistical methods. 8th Edition. Iowa State University press. 503pp.

Tester, C. F., L. L. Sikora, J. M. Taylor and J. F. Parr. 1982. Nitrogen utilization by tall fescue from sewage sludge compost amended soils. Agron. J. 74:1013-1018.

Tester, C. F. 1989. Tall fescue growth in greenhouse, growth chamber and field plots amended with sewage sludge compost and fertilizer. Soil Science 148(6):452-458.

Thomas, R. L., R. W. Sheard, and J. R. Moyer. 1967. Comparison of conventional and automated procedures for Nitrogen, Phosphorus and Potassium analysis of plant material using a single digest. Agron. J. 59:240-243.

EFFECTS OF RINGER AND OTHER LAWN AMENDMENTS ON TURFGRASS

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ABSTRACT

The turf amendments Ringer Lawn Restore, Ringer Greens, Ringer Turf, ammonium nitrate, sulfur-coated urea, Windsor sewage sludge, Milorganite, Bovamura, Sandaid and Alginate were evaluated on a creeping bentgrass green and a Kentucky bluegrass lawn for their effects on turfgrass quality, microbial activity, and disease incidence. Although statistically significant differences were not observed among most of the fertilizers, the results of the first field season indicated that the Ringer products performed in a manner similar to the inorganic nitrogen fertilizers ammonium nitrate and sulfur-coated urea by increasing microbial populations in turfgrass, thatch and soil. Plots treated with Ringer products had a poorer turf quality than those treated with ammonium nitrate or sulfur-coated urea, but better than most plots treated with other lawn amendments. Regular application (every four weeks) of Ringer greens or ammonium nitrate on the creeping bentgrass green significantly suppressed dollar spot disease compared to the other amendments or the inoculated control (no amendment). However none of the materials gave acceptable levels of control for dollar spot disease throughout the test period, which may be due to the high disease pressure from our artificial inoculations. This study will continue over the next two years.

INTRODUCTION

Societal concerns regarding environmental quality are prompting the development and use of various kinds of turf amendments particularly organic amendments. These amendments come from a number of sources and their features may include slow release of nutritive components, protection from or enhancement of the turfgrass microflora, or addition of different types of living or non-living organic elements. Relatively little research has been done on those materials in comparison to simpler inorganic fertilizers. One reason could be their complexity which makes them difficult to compare and characterize. Their site of action in thatch and soil layers is inherently difficult to study.

Nitrate leaching from fertilizers, especially fast-release nitrogen-fertilizers is a significant source of nitrate contamination of ground water in urban areas where turfgrass is the major living ground cover. Frequently application of inorganic fertilizers such as ammonium nitrate can change the soil pH and consequently may alter the soil microbial populations (Potter *et al*. 1989, Shah *et al.* 1990). Recently developed slow-release nutrient fertilizers -- Ringer products (Ringer Lawn Restore, Ringer Greens Restore and Ringer Turf Restore) are derived from hydrolysed poultry feather meal, blood meal, wheat germ, sulfate of potash and bone meal. These products contain naturally occurring selected proprietary stains of *Bacillus subtilis* and *Bacillus species* with other selected soil microbes related to *Trichoderma viride*. Soil microorganisms plays very important roles in decomposing thatch and breaking down nutrients to make them available to the turfgrass.

The objective of this research is to evaluate and compare the effects of Ringer products and other lawn amendments on turfgrass quality, microbial activity in soil, thatch, and grass and on suppression of dollar spot and brown patch diseases. We report here on the results of the first of three field seasons.

MATERIALS AND METHODS

Treatments and experiment layouts

The experimental plots are located at the Cambridge Research Station which is 20 km west of Guelph, Ont. The creeping bentgrass green and Kentucky bluegrass lawn have been established for eleven years on sandy loam soil under management similar to that for golf course greens and home lawns respectively. Three Ringer products and seven other lawn amendments were evaluated on Kentucky bluegrass and creeping bentgrass (Table 1). A total of 23 treatments were conducted on creeping bentgrass (Table 2) and ten treatments were conducted on Kentucky bluegrass lawn (Table 3). Treatments were applied at label rates (Table 1) to 1 x 2 m plots, and laid out in a randomized complete block design with 4 replications on both lawn and green.

Table 1. Amendment application rate and distributor. Treatments were first applied 4 June 1991 and repeated every 4 weeks.

Fertilizer/Distributor	Rate (kg product /100 m^2)
Ringer Greens Restore (10-2-6)	4.5
Ringer Lawn Restore (9-4-4)	4.5
Ringer Turf Restore (10-2-6)	4.9
Ringer Corporation, 9959 Valley View Road	
Minneapolis, Minnesota 55344	
Milorganite (6-2-0) (on greens)	4.9
Milorganite (6-0-0) (on lawns)	7.4
Milorganite Division, MMSD Milwauke, WI	
Bovamura (on greens)	1.4 L
Bovamura (on lawns)	0.5 L
Farmura LTD. Kent, England.	
Distributed by PBI/Gordon Corporation, Kansas	
Ammonium nitrate (34-0-0)	1.3
C.F. Industries Inc. Chicago, Ill	
Sulfur-coated urea (35-0-0)	1.5
Brussels Agromart Ltd. Brussels, ON N0G 1H0	
60% N from Sulfur-coated urea	
Sewage sludge	4.9
Department of Public Works, Windsor, Ont.	
Alginate (1-0-2, Norwegian kelp meal)	10
Imported by Bio-corp International	
225 Bradwick Dr. Unit 2, Concord, Ont.	
Sandaid (1-0-2, Granular sea plant meal)	10
Emerald Isle Ltd, 2153 Newport Rd.	
Ann Arbor, MI 48113	

Table 2.Treatments applied to creeping bentgrass plots

Ammonium nitrate	Ringer Turf
Ammonium nitrate + *Rhizoctonia*[1]	Ringer Turf + *Rhizoctonia*
Ammonium nitrate + *Sclerotinia*[2]	Ringer Turf + *Sclerotinia*
Bovamura	Ringer Greens
Bovamura + *Rhizoctonia*	Ringer Greens + *Rhizoctonia*
Bovamura + *Sclerotinia*	Ringer Greens + *Sclerotinia*
Control 1	Sandaid
Control 2 + *Sclerotinia*	Sandaid + *Rhizoctonia*
Control 3 + *Rhizoctonia*	Sandaid + *Sclerotinia*
Milorganite	Sewage sludge
Milorganite + *Sclerotinia*	Sulfur-coated Urea
Milorganite + *Rhizoctonia*	

1 *Rhizoctonia solani* is the causal organism of brown patch disease.
2 *Sclerotinia homoeocarpa* is the causal organism of dollar spot disease.

Table 3.Treatments applied to Kentucky bluegrass plots

Alginate	Ringer Lawn
Ammonium Nitrate	Ringer Turf
Bovamura	Sandaid
Control	Sewage Sludge
Milorganite	Sulfur-coated Urea

Before the fertilizers were first applied, thatch thickness was measured and the microbial populations were estimated as baseline measurements. All fertilizers and amendments were applied every four weeks starting on June 5 on the green and June 12 on the lawn until snowfall. Application dates for the creeping bentgrass green were: 5 June, 3 July, 31 July, 28 August, 25 September, and 19 November. Applicaton dates for the Kentucky bluegrass lawn were: 12 June, 10 July, 7 August, 3 September, 2 October and 26 November.

Evaluation of turfgrass quality

Turfgrass colour, density and uniformity were evaluated every two weeks starting on June 12, 1991. Ratings of 1 to 9 were used to visually evaluate the turfgrass quality. A rating of 1 represents very poor turf quality, a rating of 5 represents acceptable turf quality, and a rating of 9 represents very good turfgrass quality.

Evaluation of dollar spot, brown patch diseases

The inoculum was prepared by incubating the fungus on autoclaved cereal grains for 2-3 weeks. The inoculum was dried overnight and chopped with a mixer into very small particles (<1 mm). Inocula from five strains of the fungus were mixed together, and 2 g of the mixed inoculum was evenly applied to each plot. Inoculation of dollar spot disease (*Sclerotinia homoeocarpa*) was done in creeping bentgrass green on June 12 and again on July 10 to increase the inoculum pressure. Inoculation of Brown patch disease (*Rhizoctonia solani*) was done on June 12 and July 24.

After four weeks of the first inoculation, disease evaluation was conducted every two weeks for four months by counting the number of dollar spots. Dollar spots of larger than 1 cm in diameter were counted. Brown patch disease symptoms were not observed on creeping bentgrass plots in 1991.

A separate experiment was conducted to evaluate the effects of Ringer Lawn Restore, Ringer Turf Restore and 26 fungicides on dollar spot disease. Ringer products were applied at the same rates as previous experiment. All fungicides were applied at the labelled rates. Fertilizer effects on dollar spot and brown patch diseases were not evaluated in Kentucky bluegrass lawn.

Collection of samples and measurement of moisture contents and thatch thickness

Samples of Soil, thatch and grass were tested for microbial populations every eight weeks during the growing season as well as a base test. Samples were collected with a root core sampler (2 cm in diameter x 10 cm depth) eight weeks after the first application on both green and lawn. Five plugs were sampled from each plot and sealed in small plastic bags. All samples were brought back to the lab and stored at 4EC shortly after sampling. Dilution plates were made within three days of sampling.

Thatch thickness was measured and recorded from each sample plug. One gram of soil (2 cm below soil-thatch interface), thatch or grass from the mixture of five plugs was placed into autoclaved 35 mL test tubes with 10 mL autoclaved distilled deionized water (addH_2O). Over 5 g of thatch and soil of the mixture from each plot was placed into paper bags separately for oven drying at 105EC overnight. The samples were allowed to cool for one hour before reweighing. Moisture was calculated on a percent dry weight basis as:

Moisture = [(Wet Weight - Dry Weight) / Dry Weight] x 100%.

Nine uninoculated treatments on the creeping bentgrass green experiment were measured for thatch thickness and tested for the number of bacteria and fungi colonies using the dilution plate technique. The same test procedure was used for both creeping bentgrass green and Kentucky bluegrass lawn experiments except that thatch, soil and grass on lawn were sampled using a slab soil sampler (10 x 2 cm).

Dilution plate procedures

One gram of soil, thatch or grass from a mixture of the five plugs subsampled from each plot was respectively mixed with 10 mL of autoclaved distilled deionized water (add H_2O) in 35 mL test tubes on a vortex mixer (Vortex Genie Model 550-G) for 10 seconds. For each sample, one mL of the suspension was transferred with micro-pipettes and autoclaved tips to a 35 ml test tube containing 9 mL addH_2O. Following this procedure, a series of 10^{-3} to 10^{-7} dilutions were made for each sample.

Starting from the most dilute suspension of each series, the suspensions were vortex mixed for five seconds, and then 1 mL of suspension was placed into a 9 cm petri-dish. Pipette tips were replaced after each dilution series. For the bacteria test, 10^5, 10^6 and 10^7 dilution series were used for dilution plates. For the fungi test, 10^4, 10^5 and 10^6 dilution series were used.

Bacteria and fungi media used for dilution plates were made following procedure presented in Black *et. al.* (1965) with modifications based on past methods and experience. After autoclaving and cooling to $45^{o}C$, approximately 15 mL of media were poured into the dilution plates and control plates contained 1 mL addH_2O.

The plates were incubated for 4 days at room temperature before counting. From each dilution series, one plate with the optimum number of colonies (between 30 and 300) was counted and used for statistical analysis.

Statistical analyses

All data were first analyzed using Proc Univariate procedure of SAS package. Single data points which were obvious outliers were treated as missing data. The number of colonies of bacteria and fungi were transformed with a log scale [log (x + 1)] before statistical analysis (Acea and Carballas 1990). Analysis of variance and Duncan's Multiple Range Test were applied if significant differences were found.

Data from nine uninoculated treatments were used for the analyses of turfgrass quality, microbial populations, and thatch thickness. Data from eight treatments inoculated with dollar spot disease inoculum were analyzed for their effects on suppressing the development of dollar spot disease.

RESULTS

Effect on turfgrass quality

Plots treated with ammonium nitrate and sulfur-coated urea produced significantly higher grass quality throughout the test on the creeping bentgrass green than any of the other treatments. Plots treated with Ringer products gave higher grass quality ratings than the control or plots treated with Bovamura, Milorganite, Sandaid or Sewage sludge (Table 4). No visual differences were found on Kentucky bluegrass lawn throughout the field season.

Table 4. Fertilizer source effect on turfgrass quality (colour, density and uniformity)

	Turfgrass quality ratings					
Treatment	6/12[1]	26-Jun	10-Jul	24-Jul	7-Aug	21-Aug
Ammonium nitrate	9.0a[2]	9.0a	9.0a	9.0a	9.0a	9.0a
Sulfur-coated urea	9.0a	9.0a	9.0a	9.0a	9.0a	9.0a
Ringer Turf	6.8b	7.5ab	7.5ab	8.5a	7.5b	7.8b
Ringer Lawn	6.0b	7.5ab	7.5ab	8.5a	7.0bc	7.5bc
Control	6.0b	6.0a	6.0b	6.5b	7.0bc	6.5cd
Bovamura	6.0b	7.5a	6.0b	6.0b	6.0c	6.0d
Milorganite	6.0b	6.0a	6.0b	7.0b	6.0c	6.5cd
Sewage sludge	6.0b	6.0b	6.0b	6.0b	7.0bc	6.0d
Sandaid	6.0b	6.0a	6.0b	6.0b	6.0c	6.0d

1 (Month/Day) Fertilizers were first applied on June 5,1991.
2 Evaluation scores were from 1 to 9: 1-very poor; 5-acceptable; 9-very good.
Means followed by the same letters within a column are not significantly different at $p = 0.05$.

Effect on microbial activity No significant differences were found between the plots from the baseline test. Creeping bentgrass treated with Ringer Greens, Ringer Turf, ammonium nitrate and sulfur-coated urea had significantly higher bacteria and fungi populations than those treated with Bovamura, Milorganite, Sewage sludge, Sandaid, or the control eight weeks after first application (Table 5). Kentucky bluegrass treated with Ringer Greens had a significant higher bacteria population than those treated with ammonium nitrate, but neither was significantly different from the control. Few significant differences were found in thatch and soil layers for most of the treatments in Kentucky bluegrass lawn (Table 6).

Table 5. Fertilizer effect on microbial populations and moisture contents in creeping bentgrass green eight weeks after first application (propagules per gm of dry soil).

	Bacteria (x 10^6)			Fungi (x 10^4)			Moisture[1]	
Treatment	Grass	Thatch	Soil	Grass	Thatch	Soil	Thatch	Soil
Ammonium nitrate	397ab[2]	197ab	59ab	179a	81a	27a	1.04ab	0.19a
Ringer Turf	397ab	197ab	59ab	109ab	54ab	13ab	1.14ab	0.19a
Sulfur-coated urea	146abc	240a	98a	98ab	44ab	13ab	1.08ab	0.18a
Ringer Greens	485a	217ab	66ab	89ab	73a	22ab	1.33a	0.19a
Control	80c	120ab	36ab	66bc	44ab	11b	1.07ab	0.18a
Bovamura	119bc	161ab	49ab	60bc	44ab	12b	1.09ab	0.21a
Milorganite	80c	49b	22b	54bc	54ab	15ab	0.95b	0.19a
Sewage sludge	18c	66ab	36ab	40c	30b	13ab	0.98b	0.19a
Sandaid	18c	197ab	49ab	33c	44ab	16ab	1.14ab	0.20a

1 Moisture content is calculated on a dry weight basis.
2 Means with the same letters within a column are not significantly different at p = 0.05.

Table 6. Fertilizer effect on microbial populations and moisture contents in Kentucky bluegrass lawn eight weeks after first application (propagules per gram dry soil)

	Bacteria (x 10^6)			Fungi (x 10^4)			Moisture[1]	
Treatment	Grass	Thatch	Soil	Grass	Thatch	Soil	Thatch	Soil
Ammonium nitrate	89b[2]	359ab	59b	54a	120a	20ab	0.60a	0.19a
Ringer Turf	197ab	294ab	59b	49a	89a	18ab	0.78a	0.18a
Sulfur-coated urea	132ab	397ab	89ab	49a	73a	16ab	0.66a	0.19a
Ringer Lawn	485a	884a	89ab	54a	60a	13ab	0.63a	0.18a
Control	397ab	266ab	59ab	54a	60a	20ab	0.59a	0.17a
Bovamura	120ab	197b	66ab	36a	98a	13ab	0.63a	0.22a
Milorganite	146ab	294ab	80ab	49a	98a	27a	0.59a	0.20a
Sewage sludge	98ab	266ab	80ab	54a	89a	15ab	0.57a	0.18a
Sandaid	146ab	325ab	132a	44a	89a	20ab	0.67a	0.19a
Alginate	197ab	325ab	89ab	54a	81a	12b	0.62a	0.17a

1 Moisture is calculated on a dry weight basis.
2 Means with the same letters within a column are not significantly different at p = 0.05.

Effect on suppressing dollar spot and brown patch diseases

Ringer products were found to significantly reduce the number of infection centres of dollar spot disease (*S. homoeocarpa*) by the eighth week after inoculation in the creeping bentgrass green compared to the inoculated control (Table 7, Fig. 1). However, in comparison to fungicides, Ringer products did not show adequate control of dollar spot disease (see companion article in this report).

Symptoms of brown patch disease (*Rhizoctonia solani*) did not developed at all on creeping bentgrass even though the plots were inoculated twice.

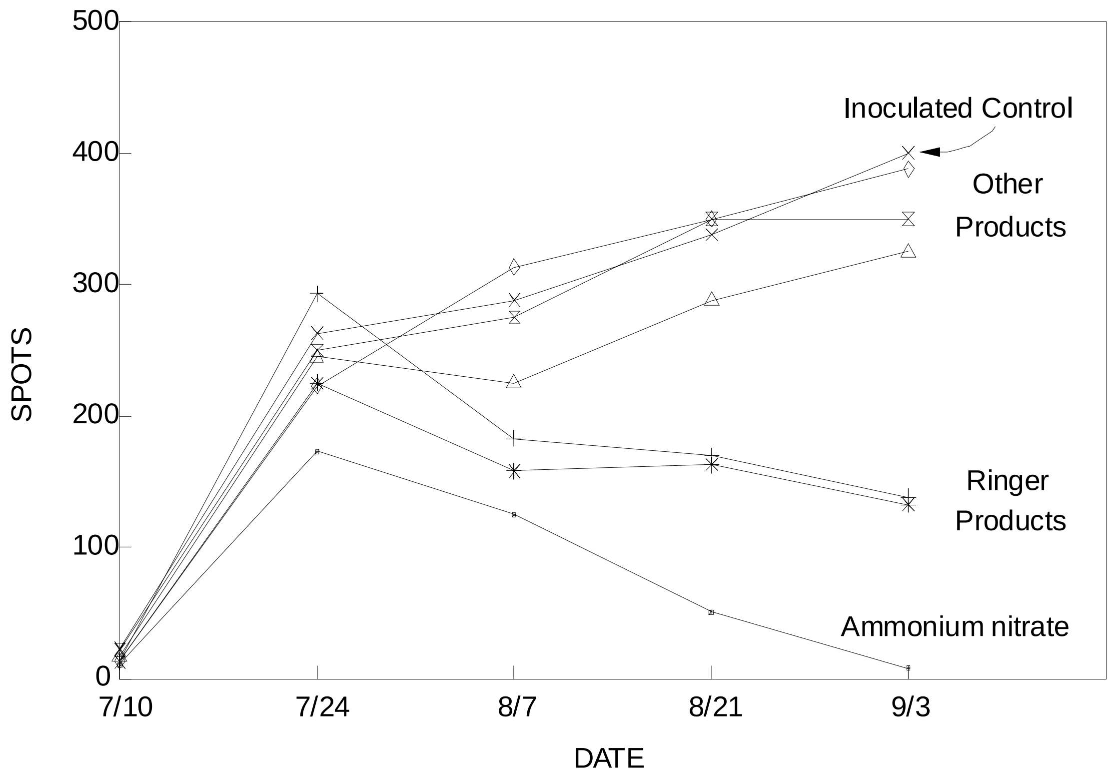
Table 7. Fertilizer effects on suppression of dollar spot disease on creeping bentgrass

	Number of dollar spot infection centres				
Treatment	7/10[1]	7/24	8/7	8/21	9/3
Ammonium Nitrate	11a[2]	173b	125d	51c	8d
Ringer Turf	13a	293a	183cd	170b	138c
Ringer Lawn	13a	225ab	158d	163b	133c
Control+Inoculum	23a	263ab	288ab	338a	400a
Bovamura	14a	223ab	313a	350a	388a
Milorganite	17a	245ab	225bc	288a	325b
Sandaid	22a	250ab	275ab	350a	350ab

1 Month/Day, first inoculation with *Sclerotinia homoeocarpa* on June 12.

2 Means with the same letter(s) within a column are not significantly different at P = 0.05.

Figure 1. Effects of Ringer products, ammonium nitrate and other amendments on dollar spot disease incidence.



Effect on thatch thickness

There were minor differences in thatch thickness between treatments except a few overlaps on both creeping bentgrass green and Kentucky bluegrass lawn (Table 8). Longer terms are required to make conclusions on the effects of amendments on thatch thickness.

Table 8. Fertilizer source effect on thatch thickness of the creeping bentgrass green and the Kentucky bluegrass lawn

	Thatch thickness (mm)	
Treatment	Green	Lawn
Control	16.4c[1]	17.8a
Ringer Lawn	19.3a	15.8a
Milorganite	18.9a	16.3a
Sandaid	18.4ab	15.2ab
Ammonium nitrate	18.3ab	16.0a
Sewage sludge	18.2ab	16.3a
Sulfur-coated urea	18.1ab	11.8c
Ringer Turf	17.7abc	15.6ab
Bovamura	16.9bc	12.3bc

[1] Means with the same letters within a column are not significantly different at p = 0.05.

OVERVIEW

Ammonium nitrate, sulfur-coated urea, and Ringer products had some similar effects on the creeping bentgrass green in the first growing season experiment. However, unlike ammonium nitrate, Ringer lawn and Ringer turf are slow-release organic fertilizers. Definitive conclusions on the long term effects of amendments on turfgrass, thatch and soil of creeping bentgrass under greens conditions and Kentucky bluegrass under lawn conditions cannot be made at this time.

LITERATURE CITED

Acea, M.J. and T. Carballs (1990). Principal components analysis of the soil microbial population of humid zone of galicia (spain). Soil Biol. Biochem. 22:749-759.

Black, C.A., D.D. Evans, L.E. Ensminger, J.L.White, and F.E. Clark (1965). Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. pp. 1460-1466. American Society of Agronomy, Inc. Madison, Wisconsin, USA.

Potter, A.D., S.D. Cockfield and T.R. Morris (1989). Ecological side effects of pesticide and fertilizer use in turfgrass. In: A.P. Leslie and R. Metcalf (ed.). Integrated Pest Management for Turfgrass and Ornamentals. pp33-44. U.S. EPA. Office of Pesticide Programs, Field Operations Division. Washington D.C.

Shah, Z., W. A. Adams and C.D.V. Haven (1990). Composition and activity of the microbial population in an acidic upland soil and effects of liming. Soil Biol. Biochem. 22:257-263.

SOIL TEMPERATURE AND SEED GERMINATION OF TALL FESCUE AND PERENNIAL RYEGRASS

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Tall fescue (cv Jaguar) and perennial ryegrass (cv Competitor) have been seeded into replicated 10 m^2 strips at the Cambridge Research Station, to study the effects of timing of seeding and soil temperatures on seed germination rate. The first seeding was on August 8, 1990, and subsequent seedings were done at one week intervals until November 14, 1990. Nitrogen and potassium were applied in a split plot design to determine the effects of these nutrients on germination and establishment.

Tall fescue is more sensitive to reduced soil temperatures than perennial ryegrass. Seedings after the end of September show delayed or reduced germination. Ratings based on observations in 1991 are presented below.

Table 1. Ratings for cover and color in Jaguar tall fescue and Competitor perennial ryegrass seeded at various times early through late fall.

Species		Cover[1]	Spring color[2]	Summer color[2]
Perennial ryegrass		8.0	8.3	7.0
Tall fescue		7.3	7.2	6.5
	LSD 5%	0.37	0.48	0.27
Seeding date - 1990				
Aug. 15		10.0	7.5	6.8
Aug. 22		10.0	8.0	6.4
Aug. 8		10.0	8.5	7.8
Sep. 5		10.0	7.5	6.6
Aug. 29		10.0	7.5	6.4
Sep. 26		9.2	7.5	6.0
Sep. 12		9.0	7.5	6.1
Oct. 3		7.1	8.5	6.6
Oct. 24		6.2	-	6.8
Nov. 14		5.3	-	6.0
Oct. 31		5.1	-	6.8
Oct. 10		4.6	-	7.4
Oct. 17		4.5	-	6.9
Nov. 7		4.1	-	7.0
	LSD 5%	1.00	1.00	0.72

[1] Rated visually 0 to 10, 10 = 100% cover. Mean of 3 evaluations: 91-05-06, 91-06-17, 91-07-18.
[2] Rated visually 0 to 9, 9 = darkest green. Spring evaluation 91-05-06, summer evaluation 91-06-17.

MANAGEMENT SOFTWARE FOR TURF AREAS

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Department of Horticultural Science

We are developing microcomputer based software to assist turf managers in tracking management procedures (irrigation, fertilization, pesticides, etc.), scheduling routine management, and predicting potential problems based on the history of the turf and current data such as rainfall, temperature, humidity, etc.

A prototype implementation is being developed based on the Cambridge Research Station plots. Data recorded over the last five years for various research projects have been linked to the base map. Figures 1,2, and 3 give an idea of what the software package looks like on-screen, though without the color.

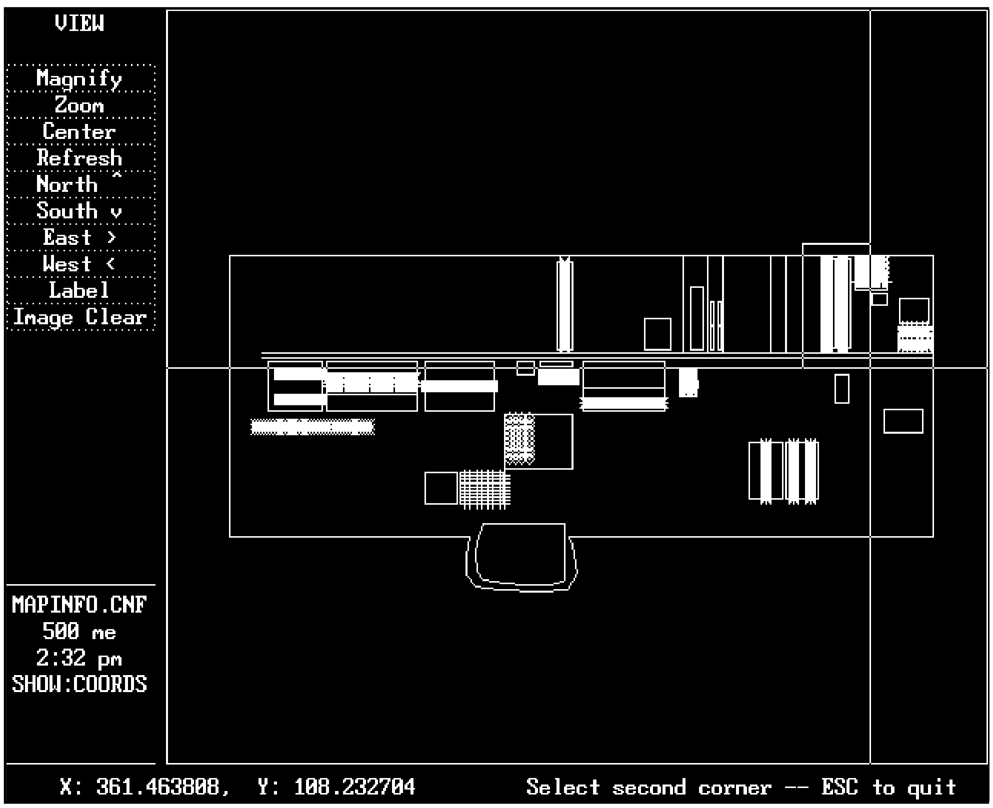

Figure 1. Base map of the Cambridge Research Station in the geographic turf management package. The area above and to the left of the cross-hairs is magnified in Figure 2.

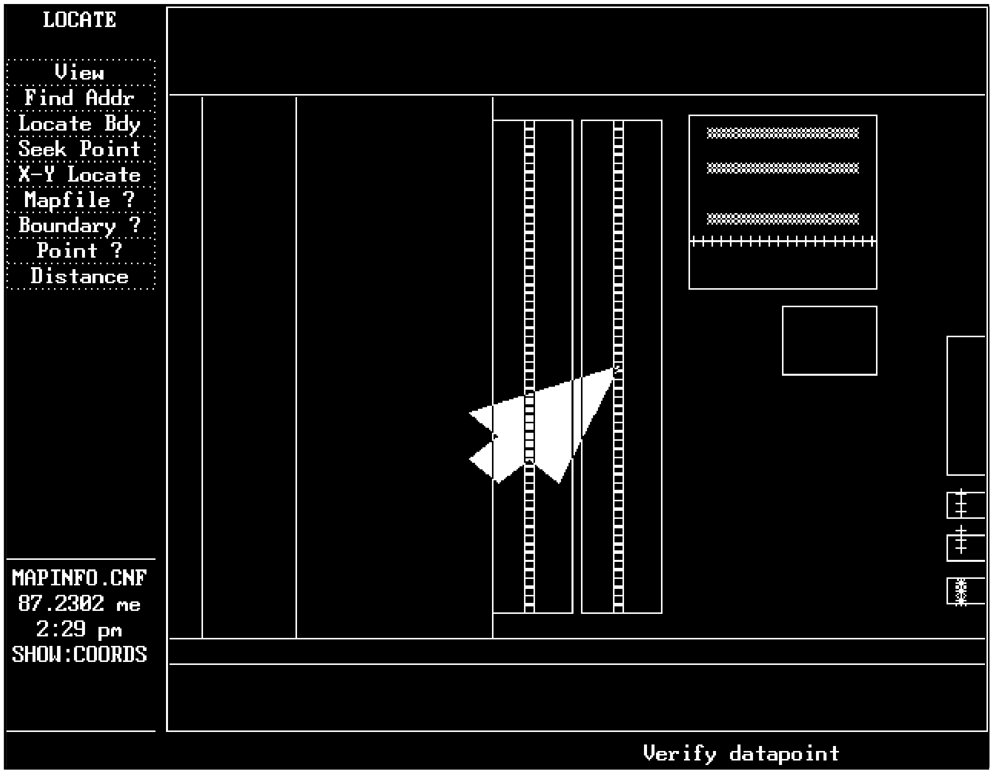

Figure 2. Zoomed view of the NTEP bentgrass cultivar trial plots. The large arrow indicates one replicate.

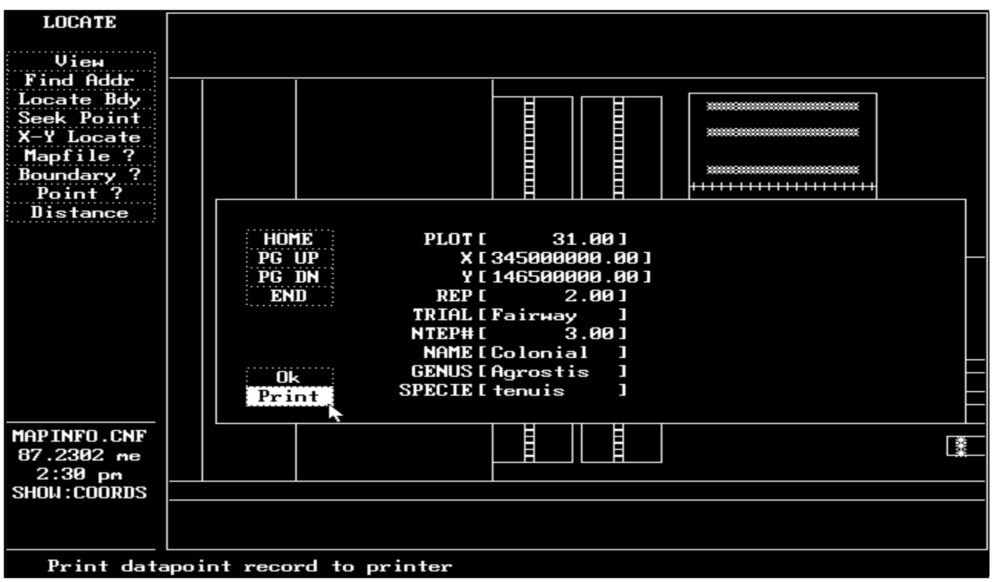

Figure 3. Data from a database file pulled on screen. Data corresponds to the plot selected, and can be edited and used for various other applications.

The next phase will involve writing specific applications in the mapping system to simplify data entry and retrieval, and to use the data stored to run management applications such as stress prediction from climate and irrigation data, or scheduling of routine management such as fertilizer and pesticide application.

As the new GTI research plots at the Guelph Research Station are developed, we will implement the first working version of the software to assist in managing the site.

The software is implemented for an IBM "standard" (640 K RAM, EGA or VGA color graphics) microcomputer, with some mass storage (hard disk) capability. The specific configuration we are using is a 386sx processor at 16 MHz, with a removable 44 Mbyte Bernoulli Box disk storage. The geographic mapping system is MapInfo Desktop Mapping Software.

NON-CHEMICAL WEED CONTROL. I. CHOICE OF SPECIES/CULTIVAR AND NITROGEN FERTILITY.

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OBJECTIVE

The choice of which turfgrass species or cultivar is planted, and the nitrogen fertility regime which is used in the maintenance of the turf will have significant effects on the invasion of the turf by broadleaf weeds. Previous research, reported in the 1990 GTI Annual Research Report, had demonstrated that in established Kentucky bluegrass turf weed infestation can be affected by fertility and mowing heights (Figure 1). The experiment reported here is one of a series designed to study non-chemical weed control further. In this case we are examining the effects of various nitrogen fertility regimes on 21 cultivars of six fine turf species. The experiment was begun in 1989; three years of observations are summarized here.

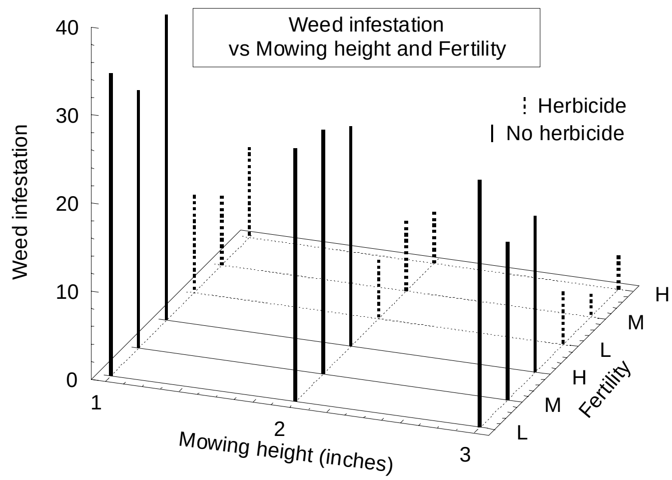

Figure 1. The effects of mowing height, fertility, and herbicide on weed infestation in established Kentucky bluegrass turf.

METHODS

Twenty-one cultivars of six turf species were used in the experiment: America, Banff, Baron, Haga, Nassau, and Touchdown Kentucky bluegrass (*Poa pratensis*); Blazer, Fiesta II, Gator, Palmer, Repell, and Yorktown II perennial ryegrass (*Lolium perenne*); Agram and Victory Chewings fescue (*Festuca rubra* var. *commutata*); Biljart, Spartan, and Tournament hard fescue (*Festuca longifolia*); Fortress creeping red fescue (*Festuca rubra*); and Houndog, Mustang, and Rebel II tall fescue (*Festuca arundinaceae*). The cultivars were seeded July 18, 1989 in 1 x 32 m strips, with 2 replicates in a randomized block design. Beginning in 1990, four fertility treatments were split in 6 x 42 m blocks across the cultivar strips. The four fertility treatments were: **no N** fertility, **0.5 kg N 100 m^{-2}** applied as a dormant application in November, **1 kg N 100 m^{-2}** applied as a split treatment with 0.5 kg in May and 0.5 kg as a dormant application in November, and **1 kg N 100 m^{-2}** applied as a split treatment with 0.25 kg in May, 0.25 kg in August, and 0.5 kg as a dormant application in November. Plots were mowed regularly at 4 cm and irrigated to prevent drought stress. No herbicides were used on the plots at any time. Plots were rated visually for germination and establishment. Broadleaf weed infestation was also rated visually on a scale of 0 to 5, with 5 being a heavy infestation (more than 50% of the plot area). Observation dates were 89-08-18, 89-09-07, 89-10-16, 90-06-12, 90-06-21, 90-07-08, 90-08-09, 90-08-22, 90-09-04, 90-10-23, 91-05-24, 91-05-29, 91-06-17, 91-07-18, 91-07-19, 91-08-13, 91-09-05, 91-09-18, and 91-10-16. The visual broadleaf weed estimates were checked against area-quadrat estimates to ensure reliability. Data were also collected on grass weed infestation, and on the species composition of the broadleaf weed populations. These detailed data are not presented here.

RESULTS

Three years of observations indicated relatively little change in the overall weed frequency (Figure 2). There were, however, significant differences among the turfgrass species in susceptibility to weed invasion (Figure 3). Kentucky bluegrass was the least resistant species, followed by the fine fescues. Both tall fescue and perennial ryegrass were relatively resistant to broadleaf weed invasion. The difference in resistance among the species at this stage is largely a result of the differences in rates of germination and establishment, which correlate very well with weed infestation (Figure 4). Kentucky bluegrass and the fine fescues germinate and form a dense stand relatively slowly, and broadleaf weeds are easily able to get established in the new turf.

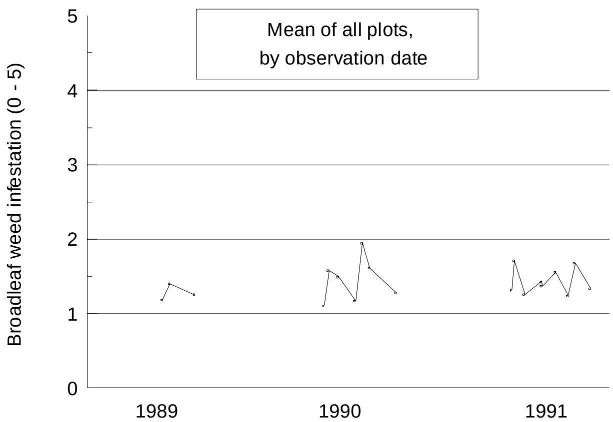

Figure 2. Average broadleaf weed infestation of turfgrass plots over three years.

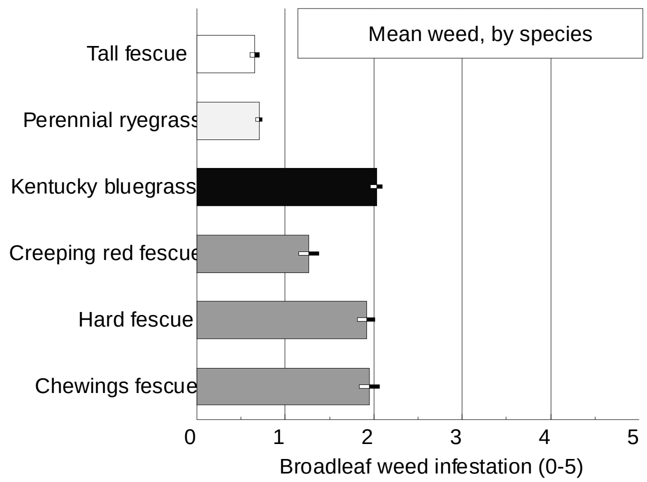

Figure 3. Broadleaf weed infestation in turfgrass species. Data presented are means of all 19 observation dates.

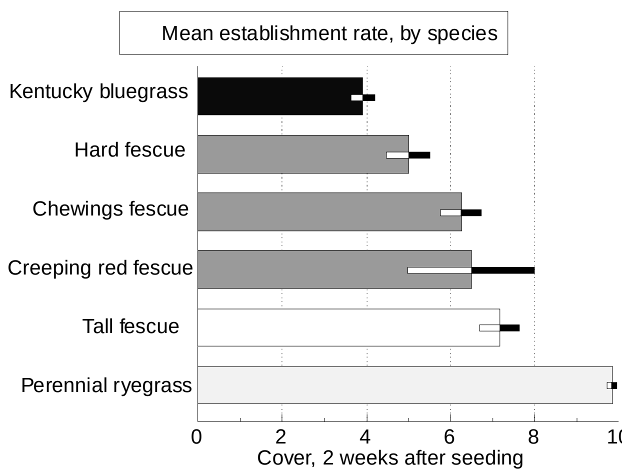

Figure 4. Mean establishment rate in turfgrass species as estimated by cover two weeks after seeding.

There was generally very little difference in resistance to broadleaf weeds among cultivars of the same species (Figure 5), with the exception of Agram and Victory Chewings fescue. The nitrogen fertility regimes had a significant effect on weed resistance in all species (Figure 6). Increasing the nitrogen rate and improving the regime by splitting the applications over two dates reduced the weed infestation in all species. Kentucky bluegrass showed the strongest response to improved fertility. The other three turfgrasses showed less response, the fine fescues remaining relatively weedy and the tall fescues and perennial ryegrasses relatively weed-free under improved fertility.

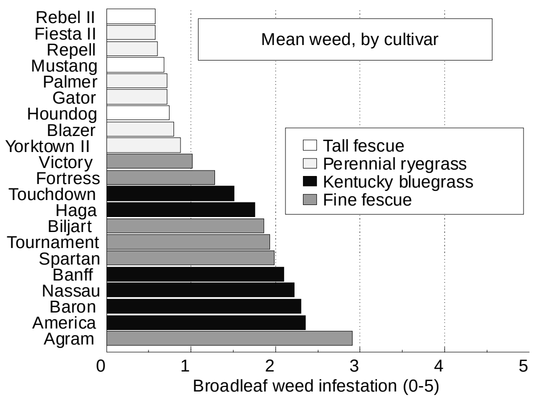

Figure 5. Broadleaf weed infestation in turfgrass cultivars.

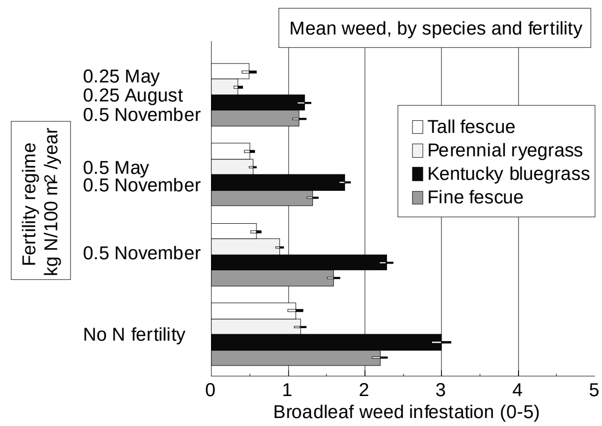

Figure 6. The effect of nitrogen fertility regimes on broadleaf weed infestation in turfgrass species.

CONCLUSIONS

Preliminary indications are that significant improvement in non-chemical weed control is possible with species/cultivar selection and proper fertility regimes. Selection of improved cultivars and proper seeding rates and timing will likely be the most critical factors, since reduced weed infestation is closely connected with rapid germination and establishment of the turfgrass sward. Other experiments, described elsewhere in this report, are underway to determine the effects of some of the other factors such as mowing height and overseeding which may improve non-chemical weed control.

NON-CHEMICAL WEED CONTROL. II. EFFECTS OF MOWING HEIGHT, FERTILITY, AND RENOVATION IN ESTABLISHED TURF

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OBJECTIVE

A series of three experiments were begun in 1991, designed to study the effects of various cultural practices on weed infestation in established home lawn type turf. The treatments involve nitrogen fertility, mowing height, and renovation by overseeding applied independently.

METHODS

Plots were laid out in an old mixed species turf (Kentucky bluegrass, annual bluegrass, bentgrass, fine fescue) at the Cambridge Research Station. Mowing height, fertility, and overseeding experiments are in adjacent plots. All plots received a standard maintenance regime, except for the respective treatment applications. The standard regime included weekly mowing at 4 cm., 200 kg N ha^{-1} applied in a split application of 50 kg May, 50 kg July, 50 kg September, and 50 kg dormant, and no irrigation. The treatment units were 2 x 3 m plots, replicated 4 times. A reclamation treatment (summer 2,4-D / MCPP / MCPA at label rate) was applied to half the plots; no herbicide will be used subsequent to the initial reclamation.

Mowing height. Three weekly mowing height treatments were applied to the mowing plots. Mowing was done with a rotary mower on a garden tractor. The height treatments were 2.5, 5, and 7 cm.

Nitrogen fertility. Three N fertility regimes were applied to the fertility plots. No N fertility was applied to one set of replicates, the standard ("proper") application of 200 kg N ha-1 split as above was applied to a second set. The third set of replicates received "improper" fertility, that is, 200 kg N ha-1 split into three applications of 66.6 kg each, one in June, one in July, and one in August.

Overseeding. The overseeding experiment will be carried out in 1992. Three preparation treatments will be used: overseeding with no preparation, hand raking and overseeding, and slit-disc overseeding.

RESULTS

The reclamation treatment significantly reduced broadleaf weed infestation in all plots. There were no significant effects in 1991 from the mowing or fertility treatments. Given the nature of the control methods, it is unlikely that differences will appear until later in 1992.

NON-CHEMICAL WEED CONTROL. III. NEWLY SEEDED TURF

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OBJECTIVE

This experiment is designed to study the effects of choice of various types of seed mixtures in controlling weeds without chemicals in newly established lawns (starting from bare soil).

METHODS

Plots were established in bare soil, cultivated and levelled, at the Cambridge Research Station. Eight different turfgrass seed sources were used, as well as a bare soil control, and a sodded treatment (commercial Kentucky bluegrass sod). Treatment units were 3 x 4 m plots, replicated four times. The seed sources are listed in Table 1. Seeding was done July 31, 1991.

Treatment	Details
Seed	
Lawn mix *#1*	"Main components: bluegrass, fine leafed fescues"
Lawn mix *#2*	"Kentucky bluegrass, Creeping red fescue, Annual ryegrass"
Lawn mix *#3*	"May contain only: Creeping red fescue, Chewings fescue sheeps fescue, hard fescue"
Lawn mix *#4*	"30% Liberty Kentucky bluegrass, 30% #1 Kentucky bluegrass, 30% Pennlawn creeping red fescue, 10% Omega II perennial ryegrass
Perennial ryegrass	*Repell*
Perennial ryegrass	Common
Kentucky bluegrass	*Princeton*
Kentucky bluegrass	#1 sod mix
Others	
Sod	(Kentucky bluegrass)
Bare soil	

There were significant differences among the various seed sources in germination rate and rate of development of dense cover (Table 2). Samples taken in spring 1992 will determine the botanical composition of the plots in terms of turfgrass components as indicated in the starting mixture, as well as weed invasion.

Table 2. Establishment of various seeding treatments.

Treatment		% cover 91-08-26	% cover 91-09-25
Sod		100	100
Perennial ryegrass *Repell*		88	95
Perennial ryegrass Common		80	90
Lawn mix *#1*		68	80
Lawn mix *#4*		60	73
Lawn mix *#2*		60	75
Kentucky bluegrass #1 Sod mix		53	70
Lawn mix *#3*		45	63
Kentucky bluegrass *Princeton*		38	55
Bare soil		0	35
	LSD 5%	15.8	12.2

WEED CONTROL IN TURF, 1991

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SUMMARY

Preemergence control of crabgrass in turf.

Chlorthal dimethyl, bensulide, trifluralin and the emulsifiable concentrate formulations of Mon-15100 gave excellent season-long control of crabgrass. Granular applications of Mon-15111 and HJ00190 gave good season-long crabgrass suppression. Fall applications of Mon-15151 EC, Mon-15111 FG, Mon-15152 G gave excellent season-long control of crabgrass.

Postemergence control of crabgrass.

Postemergence control of crabgrass at the one-to three-leaf stage and early-tiller stage of development was good this year. Mon-15151 EC and Mon-15111 FG gave good crabgrass control up to 12 weeks after treatment. The low rate of Mon-15151 EC and Hoe-033171 EC did not give good season long crabgrass control. Hoe-033171 when combined with bensulide, chlorthal dimethyl or trifluralin gave excellent season-long control but alone did not give good season long crabgrass control. Hoe-033171 combined with the insecticides chlorpyrifos, carbaryl or diazinone lead to reduced crabgrass control. The addition of surfactant to Mon-15151 EC did not significantly increase crabgrass control at the 1-3 leaf stage. HC9101, HC9102, HC9153, Hoe-033171 EC and HC9136 alone and with chlorthal dimethyl gave excellent control of crabgrass at the 1-6 leaf stage. Mon-15151 was not as effective at this stage of crabgrass growth. Mon-15151 EC combined with Hoe-033171 EC gave excellent crabgrass control at the 1-3 tiller stage; however, alone neither gave satisfactory control of crabgrass. In some cases the HC91 series caused slight damage to the turfgrass but the turf recovered quickly.

Phytotoxicity of herbicides when applied to turfgrass species.

Linuron caused severe damage to perennial ryegrass and tall fescue. Both species recovered fully nine and four weeks after application, respectively. Germination of kentucky bluegrass and perennial ryegrass was not reduced when seeded 4, 8, and 12 weeks after application of Mon-15104 EC or Mon-15152.

Selective control of annual bluegrass.

Fall application of Mon-15100 formulations gave poor annual bluegrass control in bentgrass swards. However, sequential fall applications of Mon-15100 formulations significantly reduced the amount of annual bluegrass in bentgrass. A fall application of ethofumesate gave good annual bluegrass control in the following spring but did not give good season long control.

Broadleaf weed control.

Clopyralid / triclopyr alone or when combined with chlorsulfuron or MCPA / MCPP / dicamba as well as chlorsulfuron alone or combined with 2,4-D amine plus MCPA amine gave good to excellent control of broadleaf weeds. Applications of Mon-18744, Mon-18729 and Mon-18730 through the Expedite application system provided excellent broadleaf weed control.

MON-1500 FORMULATION COMPARISONS FOR PREEMERGENCE CONTROL OF CRABGRASS IN KENTUCKY BLUEGRASS.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates** - 4;

AT APPLICATION:
Date and method - 2705-PRE;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002LP;
Date of assessment - 1807; 3008; 1809.

	Treatment	Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)		
			6	12	16
1	Control	0.00	0	0	0
2	MON-15151 EC	0.14	63	80	67
3	MON-15151 EC	0.28	100	100	100
4	MON-15151+2,4-D / MCPP / dicamba[a]	0.28+1.85	100	100	100
5	MON-15151+MCPP / MCPA / dicamba[b]	0.28+2.00	100	100	100
6	MON-15151 EC	0.35	100	100	100
7	MON-15151 EC	0.42	100	100	100
8	HJ 20-3-8 F	0.14	0	0	0
9	HJ 20-3-8 F	0.28	0	0	0
10	HJ00190 FG	0.14	0	51	45
11	HJ00190 FG	0.28	88	75	84
12	MON-15111 FG	0.28	38	71	53
13	chlorthal-dimethyl[c]	10.00	100	100	100
14	chlorthal-dimethyl[c]	15.00	100	100	100
15	bensulide[d]	11.00	100	88	80
16	bensulide[d]	14.00	88	92	84
17	Hoe-033171	0.20	0	24	18
18	chlorsulfuron[e]	0.011	0	0	0
19	chlorsulfuron[e]	0.022	0	0	0

WAT=weeks after treatment; [a]2,4-D / MCPP / dicamba-385 / 75 / 19 g / l; [b]MCPP / MCPA / dicamba-200 / 100 / 18 g / l; [c]chlorthal-dimethyl-750 g / kg WP Fermenta; [d]bensulide-480 g / l EC Chipman; [e]chlorsulfuron-75 g / kg WG Dupont; emulsifiable concentrate; F-fertilizer; FG-fertilizer granule; WP-wettable powder; WG-wettable granule.

Crabgrass germinated the second week in June and preemergent treatments were applied May 27. Good crabgrass suppression was achieved with the MON-15100 formulations, chlorthal-dimethyl and bensulide 16 weeks after application. Hoe-033171, HJ 20-3-8 and chlorsulfuron gave poor control of crabgrass. No injury occurred to the Kentucky bluegrass.

EFFICACY OF QUINCLORAC GRANULAR FERTILIZER FOR THE PREEMERGENCE CONTROL OF CRABGRASS.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 0306-PRE;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 2406; 0608.

Treatment		Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)	
			4	12
1	Control	0.00	0	0
2	S-3681[a]	0.0851	100	100
3	S-3692[b]	0.0851	100	100

WAT=weeks after treatment; [a]S-3681-carrier 28-3-3 FG; [b]S-3692-carrier 32-4-5 FG; FG-fertilizer granule.

Excellent crabgrass control was achieved with both treatments up until 12 weeks after application. No injury occurred to the Kentucky bluegrass.

POSTEMERGENCE CONTROL OF CRABGRASS AT THE 1-3 LEAF STAGE.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates** - 4;

AT APPLICATION:
Date and method - 1406-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 0907; 1308; 1309.

Treatment		Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)		
			4	8	12
1	Control	0.00	0	0	0
2	Mon-15151 EC	0.14	77	67	43
3	Mon-15151 EC	0.28	100	97	80
4	Mon-15151+2,4-D / MCPP / dicamba[a]	0.28+1.85	100	100	82
5	Mon-15151+MCPP / MCPA / dicamba[b]	0.28+2.00	100	97	87
6	Mon-15151 EC	0.35	100	97	83
7	Mon-15151 EC	0.42	100	97	91
8	Mon-15111 FG	0.28	92	63	67
9	Mon-15111 FG	0.35	100	87	50
10	Mon-15111 FG	0.42	100	87	83
11	Hoe-033171 90 EC	0.20	100	63	48
12	Hoe-033171 90 EC+trifluralin[c]	0.20+2.2	100	100	94
13	trifluralin[c]	2.2	100	100	85
14	chlorsulfuron[d]	0.011	26	0	0
15	chlorsulfuron[d]	0.02	23	0	0

WAT=weeks after treatment; [a]2,4-D / MCPP / dicamba-385 / 75 / 19 g / l; [b]MCPA / MCPP / dicamba-200 / 100 / 18 g / l; [c]trifluralin-500 g / l EC Hoechst; [d]chlorsulfuron-75 g / kg WG Dupont; EC-emulsifiable concentrate; FG-fertilizer granule; WG-wettable granule.

All treatments except chlorsulfuron gave good control of crabgrass at the 1-3 leaf stage 4 weeks after application. The low rate of Mon-15111, Mon-15151 and Hoe-033171 no longer gave adequate crabgrass control 12 weeks after treatment. Hoe-033171 + trifluralin and trifluralin alone gave excellent long term control of crabgrass but slight injury occurred to the turf. All plots recovered after 2 weeks.

SURFACTANT COMPARISONS FOR THE POSTEMERGENCE CONTROL OF CRABGRASS AT THE 1-3 LEAF STAGE.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 1406-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 1107; 1308; 1309.

Treatment		Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)		
			4	8	12
1	Control	0.00	0	0	0
2	Mon-15151 EC	0.28	92	79	76
3	Mon-15151+Agrol 90	0.28+0.5%	100	87	83
4	Mon-15151+Assist	0.28+0.5%	97	90	87
5	Mon-15151+Enhance	0.28+0.5%	100	87	86
6	Mon-15151 EC	0.42	97	98	94
7	Mon-15151+Agrol 90	0.42+0.5%	100	98	94
8	Mon-15151+Assist	0.42+0.5%	100	100	97
9	Mon-15151+Enhance	0.42+0.5%	100	100	96
10	Hoe-033171 90 EC	0.20	100	83	29
11	Hoe-033171+trifluralin[a]	0.20+2.2	100	100	99

WAT=weeks after treatment; [a]trifluralin-500 g/l EC Hoechst; EC-emulsifiable concentrate.

Mon-15151 gave excellent control of crabgrass at the 1-3 leaf stage of growth 12 weeks after application. When surfactant was added to Mon-15151 control was slightly increased but not significantly. Hoe-033171 gave excellent control 8 weeks after treatment but control was significantly reduced at 12 weeks. Trifluralin, when added to Hoe-033171, caused slight injury to the turf but resulted in excellent control of crabgrass up to 12 weeks after application. The turfgrass completely recovered 2 weeks after application.

DACTHAL AND HOE-033171 FOR THE CONTROL OF CRABGRASS AT THE 1-3 LEAF STAGE.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 1406-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 1107; 1308; 1309.

Treatment		Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)		
			4	8	12
1	Control	0.00	0	0	0
2	chlorthal-dimethyl[a]	10.00	73	57	51
3	chlorthal-dimethyl[a]	15.00	67	53	49
4	Hoe-033171 90 EC	0.10	100	83	24
5	Hoe-033171 90 EC	0.15	91	83	49
6	Hoe-033171 90 EC	0.20	97	89	53
7	chlorthal-dimethyl+Hoe-033171	10.00+0.10	100	100	94
8	chlorthal-dimethyl+Hoe-033171	10.00+0.15	100	100	97
9	chlorthal-dimethyl+Hoe-033171	10.00+0.20	100	100	95
10	chlorthal-dimethyl+Hoe-033171	15.00+0.10	100	100	94
11	chlorthal-dimethyl+Hoe-033171	15.00+0.15	100	100	82
12	chlorthal-dimethyl+Hoe-033171	15.00+0.20	100	100	97

WAT=weeks after treatment; [a]chlorthal-dimethyl-750g / kg WP Fermenta; EC-emulsifiable concentrate; WP-wettable powder.

Four weeks after application, Hoe-033171 alone and combined with chlorthal-dimethyl gave excellent control of crabgrass. Chlorthal-dimethyl alone was not as effective but still gave good crabgrass control. Twelve weeks after application, Hoe-033171 and chlorthal-dimethyl applied separately no longer gave good control but when applied together gave very good crabgrass control. No injury occurred to the Kentucky bluegrass.

POSTEMERGENCE CONTROL OF CRABGRASS AT THE 1-6 LEAF STAGE.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 2606-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 2407; 3008.

Treatment		Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)	
			4	9
1	Control	0.00	0	0
2	HC9101	0.09	93	80
3	HC9102	0.09	100	81
4	HC9136	0.09	100	80
5	Hoe-033171 90 EC	0.20	100	73
6	HC9153	2.09	100	100
7	HC9154	2.09	78	56
8	HC9136+chlorthal dimethyl[a]	0.09+15.5	100	94
9	trifluralin[b]	2.00	61	44
10	HC9115	0.115	100	89
11	Mon-15151 EC	0.28	41	17

WAT=weeks after treatment; [a]chlorthal dimethyl-750 g/kg WP Fermenta; [b]trifluralin-500 g/l EC Hoechst; EC-emulsifiable concentrate; WP-wettable powder.

HC9101, HC9102, HC9153, HC9115, Hoe-033171 and HC9136 alone and combined with chlorthal dimethyl gave excellent control of crabgrass at the 1-6 leaf stage 9 weeks after treatment. HC9154, Mon-15151 and trifluralin alone were not as effective. Slight injury occurred to the turf up to 5 weeks after application with HC9153, HC9154 and trifluralin.

POSTEMERGENCE CONTROL OF CRABGRASS AT THE 1-3 TILLER STAGE.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass and crabgrass mixed stand;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 0807-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 3007; 1309.

Treatment		Dose kg ai ha^{-1}	% Reduction of crabgrass (WAT)	
			3	9
1	Control	0.00	0	0
2	Mon-15151 EC+Hoe-033171 90 EC	0.28+0.05	100	80
3	Mon-15151 EC+Hoe-033171 90 EC	0.28+0.10	100	93
4	Mon-15151 EC	0.42	22	25
5	Mon-15151 EC+Hoe-033171 90 EC	0.42+0.05	95	88
6	Mon-15151 EC+Hoe-033171 90 EC	0.42+0.10	95	94
7	Hoe-033171 90 EC	0.05	70	0
8	Hoe-033171 90 EC	0.10	98	63
9	Hoe-033171 90 EC	0.20	100	74
10	linuron[a]	1.75	84	0
11	linuron[a]	2.00	98	20

WAT=weeks after treatment; [a]linuron-480 g/l EC Hoechst; EC-emulsifiable concentrate.

Four weeks after application Hoe-033171 alone and combined with Mon-15151 gave excellent control of crabgrass, Mon-15151 alone gave poor control. However, 10 weeks after application Hoe-033171 at the lowest dose alone no longer gave good crabgrass control except when combined with Mon-15151. Linuron caused severe damage to the turf as there was a large percentage of annual bluegrass in this area which was eradicated by linuron. Crabgrass grew inundated in the linuron treated plots.

CONTROL OF BROADLEAF WEEDS IN TURF.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 2 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 2305-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 2305; 0506; 1906; 2307.

Treatment		Dose kg ai ha^{-1}	Weed Counts (no. 4 m^{-2})			
			0	2	4	9
1	Control	0.00	12	10	13	12
2	clo / tri EC[a]	0.72	15	2	0	0
3	clo / tri EC[a]	0.828	13	2	0	0
4	clo / tri EC[a]+agrol 90	0.36+0.25%	15	4	2	1
5	clo / tri EC[a]+agrol 90	0.54+0.25%	20	3	2	2
6	clo / tri EC[a]+agrol 90	0.72+0.25%	16	2	0	1
7	clo / tri SN[b]	0.828	14	2	1	0
8	clo / tri RTU[c]	----	13	2	2	3
9	2,4-D / MCPA / dicamba[d]	1.69	19	3	1	0
		LSD:		**3.8**	**3.1**	**4.0**

WAT=weeks after treatment; [a]clo / tri-clopyralid / triclopyr 270 / 90 g / l EC; [b]clo / tri-69 g / l SN; [c]clo / tri-4 g / l RTU; [d]2,4-D / MCPA / dicamba-190 / 100 / 18 g / l SN; EC-emulsifiable concentrate; SN-solution; RTU-ready to use.

All herbicides provided excellent control of broadleaf weeds (mostly dandelion) at all times after application. No injury occurred to the Kentucky bluegrass.

BROADLEAF WEED CONTROL IN TURF.

Experiment location - Cambridge Research Station;
Crop - Kentucky bluegrass;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 2 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 2305-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002LP;
Date of assessment - 2305; 0506; 1906; 2309.

Treatment		Dose kg ai ha^{-1}	Weed Counts (no. 4 m^{-2}) (WAT)			
			0	2	4	9
1	Control	0.00	17	14	10	11
2	chlorsulfuron[a]	0.011	18	2	0	1
3	chlorsulfuron[a]	0.022	24	2	1	1
4	chlorsulfuron[a] +clo/tri EC[b]	0.011 +0.72	19	2	0	1
5	chlorsulfuron[a] +clo/tri EC[b]	0.011 +0.828	24	2	0	1
6	chlorsulfuron[a] +clo/tri EC[b]	0.022 +0.72	25	2	0	1
7	chlorsulfuron[a] +clo/tri EC[b]	0.022 +0.828	15	1	1	0
8	2,4-D[c]	1.20	12	1	1	1
		LSD:		**4.2**	**1.9**	**2.8**

WAT-=weeks after treatment; [a]chlorsulfuron-75 g/kg DF Dupont; [b]clo/tri-clopyralid/triclopyr-270/90 g/l EC Greencross; [c]2,4-D-470 g/l; DF-dry flowable; EC-emulsifiable concentrate.

All herbicides provided excellent control of broadleaf weeds (mostly dandelion) at all times after application. No injury occurred to the Kentucky bluegrass.

THE EFFECT OF DITHIOPYR ON THE ESTABLISHMENT OF KENTUCKY BLUEGRASS AND PERENNIAL RYEGRASS SEEDED 12 WEEKS AFTER TREATMENT.

Experiment location - Cambridge Research Station;
Crop - Perennial ryegrass, Kentucky bluegrass;
Soil type - sandy loam;
Planting date - 140890;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION: Date and method
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
- 250590-POST;
Date of assessment - 110990(T1); 081190(T2); 110491(T3); 240691(T4); 300791(T5).

Application Date: 250590

	Treatment	Dose kg ai ha^{-1}	% Germination of Perennial Ryegrass									
			T1		T2		T3		T4		T5	
			B[a]	S[a]	B	S	B	S	B	S	B	S
1	Control	0.00	25	10	54	45	88	81	100	100	100	100
2	Mon-15104EC	0.42	16	11	55	38	83	83	98	98	100	100
3	Mon-15104	0.56	16	11	54	40	84	79	100	100	100	100
4	Mon-15104	1.12	18	10	53	39	83	80	99	98	100	100
5	Mon-15152FG	0.28	13	10	51	40	83	80	99	99	100	100
6	Mon-15152	0.56	16	10	50	39	79	78	98	98	100	100
7	chlorthal dimethyl[b]	11.60	21	11	49	39	83	84	99	96	100	100

Application Date: 250590

	Treatment	Dose kg ai ha^{-1}	% Germination of Kentucky bluegrass					
			T3		T4		T5	
			B	S	B	S	B	S
1	Control	0.00	48	35	95	95	100	100
2	Mon-15104EC	0.42	45	35	95	95	100	100
3	Mon-15104	0.56	48	30	95	95	100	100
4	Mon-15104	1.12	51	35	95	95	100	100
5	Mon-15152FG	0.28	40	31	95	95	100	100
6	Mon-15152	0.56	19	16	87	85	100	100
7	chlorthal dimethyl[b]	11.60	40	31	95	95	100	100

[a]plots 1 x 2 m; 1 x 1 B=broadcast seeded; 1 x 1 m S=slit seeded. Treatments were applied then the plots were treated with glyphosate Aug. 14/90 to kill the turf, reseeded Sept.12/90.
[b]chlorthal dimethyl-750 g/kg WP Fermenta; EC-emulsifiable concentrate; FG-fertilizer granule; WP-wettable powder.

Kentucky bluegrass did not significantly germinate until the following spring after application, therefore plots were not rated until 1991. Early 1991 the high rate of Mon-15152 seemed to reduce germination of the Kentucky bluegrass but by mid summer all treatments in both turf species were completely germinated regardless of the reseeding method.

THE EFFECT OF DITHIOPYR ON THE ESTABLISHMENT OF KENTUCKY BLUEGRASS AND PERENNIAL RYEGRASS 8 WEEKS AFTER TREATMENT.

Experiment location - Cambridge Research Station;
Crop - Perennial ryegrass, Kentucky bluegrass;
Soil type - sandy loam;
Planting date - 140890;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 220690 -POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 110990(T1); 081190(T2); 110491(T3); 240691(T4); 300791(T5).

Application Date: 220690

	Treatment	Dose kg ai ha^{-1}	% Germination of Perennial Ryegrass									
			T1		T2		T3		T4		T5	
			B[a]	S[a]	B	S	B	S	B	S	B	S
1	Control	0.00	18	11	44	40	79	78	95	95	100	100
2	Mon-15104 EC	0.42	11	11	44	40	84	85	100	100	100	100
3	Mon-15104	0.56	16	11	45	38	83	79	98	98	100	100
4	Mon-15104	1.12	18	10	45	38	83	83	100	100	100	100
5	Mon-15152 FG	0.28	15	10	43	36	82	80	98	98	100	100
6	Mon-15152	0.56	18	11	45	31	78	76	98	98	100	100
7	chlorthal dimethyl[b]	11.60	10	10	44	38	84	79	95	96	100	100

Application Date: 220690

	Treatment	Dose kg ai ha^{-1}	% Germination of Kentucky bluegrass					
			T3		T4		T5	
			B	S	B	S	B	S
1	Control	0.00	33	30	95	95	100	100
2	Mon-15104 EC	0.42	26	30	95	95	100	100
3	Mon-15104	0.56	23	24	95	95	100	100
4	Mon-15104	1.12	23	18	95	95	100	100
5	Mon-15152 FG	0.28	24	24	95	95	100	100
6	Mon-15152	0.56	13	11	83	85	100	100
7	chlorthal dimethyl[b]	11.60	39	34	95	95	100	100

[a]plots 1 x 2 m; 1 x 1 B=broadcast seeded; 1 x 1 m S=slit seeded. Treatments were applied then the plots were treated with glyphosate Aug. 14/90 to kill the turf, reseeded Sept.12/90.
[b]chlorthal dimethyl-750 g/kg WP Fermenta; EC-emulsifiable concentrate; FG-fertilizer granule; WP-wettable powder.

Kentucky bluegrass did not significantly germinate until the following spring after application, therefore plots were not rated until 1991. Early 1991 the high rate of Mon-15152 seemed to reduce germination of the kentucky bluegrass but by mid summer all treatments in both turf species were completely germinated regardless of the reseeding method.

THE EFFECT OF DITHIOPYR ON THE ESTABLISHMENT OF KENTUCKY BLUEGRASS AND PERENNIAL RYEGRASS SEEDED 4 WEEKS AFTER APPLICATION.

Experiment location - Cambridge Research Station;
Crop - Perennial ryegrass, Kentucky bluegrass;
Soil type - sandy loam;
Planting date - 140890;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION: Date and method - 240790-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 110990(T1); 081190(T2); 110491(T3); 240691(T4); 300791(T5).

Application Date: 240790

Treatment		Dose kg ai ha^{-1}	% Germination of Perennial Ryegrass									
			T1		T2		T3		T4		T5	
			B[a]	S[a]	B	S	B	S	B	S	B	S
1	Control	0.00	11	10	28	24	80	74	95	95	100	100
2	Mon-15104 EC	0.42	10	10	26	23	81	73	95	95	100	100
3	Mon-15104	0.56	11	11	26	26	81	79	95	95	100	100
4	Mon-15104	1.12	10	10	28	21	78	73	94	94	100	100
5	Mon-15152 FG	0.28	13	10	24	24	75	75	89	89	100	100
6	Mon-15152	0.56	9	10	31	24	78	71	80	80	100	100
7	chlorthal dimethyl[b]	11.60	10	11	30	24	79	71	94	94	100	100

Application Date: 240790

Treatment		Dose kg ai ha^{-1}	% Germination of Kentucky bluegrass					
			T3		T4		T5	
			B	S	B	S	B	S
1	Control	0.00	33	31	95	95	100	100
2	Mon-15104 EC	0.42	36	28	95	95	100	100
3	Mon-15104	0.56	28	21	95	95	100	100
4	Mon-15104	1.12	24	28	94	94	100	100
5	Mon-15152 FG	0.28	33	26	89	89	98	100
6	Mon-15152	0.56	16	13	80	80	99	100
7	chlorthal dimethyl[b]	11.60	33	28	94	94	98	100

[a]plots 1 x 2 m; 1 x 1 B=broadcast seeded; 1 x 1 m S=slit seeded. Treatments were applied then the plots were treated with glyphosate Aug. 14/90 to kill the turf, reseeded Sept.12/90.
[b]chlorthal dimethyl-750 g/kg WP Fermenta; EC-emulsifiable concentrate; FG-fertilizer granule; WP-wettable powder.

Kentucky bluegrass did not significantly germinate until the following spring after application, therefore plots were not rated until 1991. Early 1991 the high rate of Mon-15152 seemed to reduce germination of the kentucky bluegrass but by mid summer all treatments in both turf species were completely germinated regardless of the reseeding method.

TOLERANCE OF TALL FESCUE AND PERENNIAL RYEGRASS TO VARIOUS HERBICIDES.

Experiment location - Cambridge Research Station;
Crop - Tall fescue(TF), Perennial ryegrass(PR);
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 2606-POST;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 0207; 3007; 2708.

Treatment		Dose kg ai ha^{-1}	Injury (0-10) (WAT)							
			1		2		4		8	
			PR	TF	PR	TF	PR	TF	PR	TF
1	Control	0.00	0	0	0	0	0	0	0	0
2	HC9101	0.09	0	0	0	0	0	0	0	0
3	HC9102	0.09	0	0	0	0	0	0	0	0
4	HC9136	0.09	0	0	0	0	0	0	0	0
5	Hoe-033171 90 EC	0.20	0	0	0	0	0	0	0	0
6	HC9153	2.09	0	0	0	0	0	0	0	0
7	HC9154	2.09	0	0	0	0	0	0	0	0
8	HC9136 + CHD[a]	0.09 + 15.5	0	0	0	0	0	0	0	0
9	trifluralin[b]	2.00	0	0	0	0	0	0	0	0
10	HC9115	0.115	0	0	0	0	0	0	0	0
11	Mon-15151 EC	0.28	0	0	0	0	0	0	0	0
12	linuron[c]	2.00	7	7	6	1	3	0	0	0

WAT=weeks after treatment; [a]CHD=chlorthal dimethyl-750 g/kg WP Fermenta; [b]trifluralin-500 g/l EC Hoechst; [c]linuron-480 g/l EC Hoechst; EC-emulsifiable concentrate; WP-wettable powder; PR-perennial ryegrass; TF-tall fescue.

One week after application of linuron, injury to the perennial ryegrass and tall fescue was evident. The tall fescue and perennial ryegrass fully recovered four and nine weeks after application, respectively . No other treatments caused injury to the perennial ryegrass or tall fescue.

ANNUAL BLUEGRASS CONTROL IN BENTGRASS.

Experiment location - Cambridge Research Station;
Crop - Bentgrass;
Soil type - sandy loam;
Planting date - established turf;
Plot size - 1 x 2 m;
Experimental design - randomized complete block; **Replicates -** 4;

AT APPLICATION:
Date and method - 151090;
Equipment - bicycle sprayer;
Volume - 700 L ha^{-1};
Pressure - 200 kPa;
Tips - SS8002SP;
Date of assessment - 221090(T1); 150591(T2); 190691(T3); 090891(T4).

	Treatment	Dose kg ai ha^{-1}	% Reduction of Annual bluegrass			
			T1	T2	T3	T4
1	Control	0.00	0	0	0	0
2	Mon-15151 EC	0.56	0	0	0	0
3	Mon-15151 EC	0.84	0	12	13	23
4	Mon-15151 EC	1.12	0	28	19	0
5	Mon-15152 FG	0.56	0	0	32	0
6	Mon-15152 FG	0.84	0	33	42	0
7	ethofumesate[a]	0.84	0	82	35	13
8	ethofumesate[a]	1.12	0	84	48	16

[a]ethofumesate - 180 g/l EC; EC-emulsifiable concentrate; FG-fertilizer granule.

No control of annual bluegrass resulted in the fall following application. In the spring of the following year, fair annual bluegrass control resulted with the application of Mon-15151 at the two higher rates and the high rate of Mon-15152. Ethofumesate gave excellent control of annual bluegrass in the early spring but none of the treatments gave good season long control. No injury to the bentgrass resulted from any of these treatments.

INCIDENCE AND IMPACT OF NECROTIC RING SPOT DISEASE OF TURFGRASS IN SOUTHERN ONTARIO.

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INTRODUCTION

The patch diseases of turfgrasses are among the newer diseases causing concern to the turfgrass industry throughout North America. In the early 1980's, one of these diseases, Necrotic Ring Spot (caused by *Leptosphaeria korrae* Walker & Smith) was separated from the Fusarium Blight Complex, which was a troublesome and highly controversial disease and particularly damaging to Kentucky bluegrass (*Poa pratensis*). Although there are reports concerning Necrotic Ring Spot (NRS) from bordering American States, very little is known about its incidence and distribution in Ontario. Before conducting local studies on chemical and cultural control of this disease, it is important to determine the local pathogen involved, the relative importance of NRS, and its impact on the turfgrass industry in Ontario.

The purpose of this study was to investigate the incidence of Necrotic Ring Spot in turfgrasses of southern Ontario over a two year period beginning in spring of 1991. There were two major objectives during the first year: (1) to confirm the causal agent of NRS as *L. korrae* in Ontario; and (2) to determine incidence of NRS in Ontario through written survey and field isolations.

METHODS

Surveys and Field Specimens

A question-and-answer survey was drawn up and sent to turfgrass industry associations and OMAF Turfnotes (Annette Anderson) for distribution to Golf Course Superintendents, Park Supervisors, Sod Farm managers, and Lawn care companies to request information on their dealings with turfgrass patch diseases. The survey also requested specimens of patch disease samples to be sent to the University of Guelph for our isolations. Other isolates were obtained from the Pest Diagnostic Advisory Clinic here at the University of Guelph, and also from Annette Anderson, the OMAF Turf Extension Specialist. Confirmed specimens were obtained from the British Columbia Ministry of Agriculture (Leslie MacDonald) for comparisons with our isolates.

Isolations

Following the methods of Hammer (1988), numerous isolations were made of fungi from roots in diseased patches. The technique involved root washes of up to 24 hours, followed by 1 min surface sterilization in 1% silver nitrate, a 30 sec rinse in 5% NaCl and then a final wash in autoclaved distilled water. The root pieces were then blotted dry and placed on 1/5 strength potato dextrose in 2% agar amended with 30 ppm streptomycin. After 7 to 10 days, hyphal tips were transferred to full strength potato dextrose agar (PDA).

RESULTS

From the survey, there were 32 responses by Fall 1991: 6% homeowners, 65% lawn care companies, 26% golf and country clubs, and 3% sod farms. These reports came from counties all over southern Ontario. One question in the survey asked: "Is disease a serious problem?" Of the respondents, 97% said yes. A following question asked: "Are NRS/patch diseases a serious problem?"; 65% said yes. We will obtain more responses to the survey throughout this study, and will present a full tabulation of the results at a later date.

We currently have 42 isolates that resemble *Leptosphaeria korrae* in growth rate, and mycelium colour in culture. These characteristics include a relatively slow radial growth rate (3.0 mm/day) on PDA, and a grey floccose mycelium which is very dark on the underside. By growing the pure isolates on tall fescue seed, we have managed to induce sexual fruiting of 7 of these cultures, and have made positive identification of these isolates as *Leptosphaeria korrae*.

CONCLUSION

The fungus *Leptosphaeria korrae* is present in Ontario. The disease which is called "Fusarium blight" or "Frog-eye" on Kentucky bluegrass lawns is likely caused by this fungus in Ontario. From the distribution of survey respondents, this disease is common throughout southern Ontario.

FUTURE WORK

For the remainder of the first year, and through the second, we plan to develop a faster method to identify the pathogen, and to investigate the pathogenic variation of the fungus (host range and cultivar resistance in laboratory tests). Long-term work with this disease involves chemical and cultural management of the disease including field tests for cultivar resistance.

LITERATURE CITED

Hammer, W. 1988. Factors affecting the *in vitro* growth, production of pseudothecia, and pathogenicity of *Leptosphaeria korrae*. M.Sc. Thesis, Department of Plant Pathology, Washington State University.

CHEMICAL TRIALS FOR DOLLAR SPOT DISEASE CONTROL, SUMMER, 1991

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ABSTRACT

Thirty chemical and control treatments were evaluated on a 14-year-old sward of creeping bentgrass in Southern Ontario during June, July and August, 1991. The fungicides tested included: Daconil 2787, Rovral Green, Thiram 80WP, Tersan 1991 WP50, and Dyrene 50WP, which are registered and recommended for use to control dollar spot disease of turfgrass in Ontario. Twenty-two other chemicals provided by Green Cross, ICI Chipman, ISK Biotech (formerly Fermenta ASC), Ringers Corp., and Rohm & Haas were also tested at various rates. The following chemicals gave excellent control of dollar spot disease and showed efficacy well beyond their recommended spray intervals: Rovral Green, Tersan 1991, ASC66791 at two rates, ASC66825 at 24 or 48 g/100m^2, Daconil 2787 at 192 mL/100m^2, Banner 130EC at two rates, Banner 1.8% G at 419 g/100m^2, and Myclobutanil 40% at 12 g a.i./100m^2. These chemicals showed very good control during the application periods, but had shorter yet acceptable periods of residual activity: ASC66518 at 110 gm/100m^2 and Nustar at 1 g a.i. /100m^2. These chemicals had borderline efficacy results: Dyrene 50WP, ASC66825 at 12 g/100m^2, Daconil WDG at 106 gm/100m^2, and Myclobutanil 40% at 6 g a.i./100m^2. These showed little or no control of dollar spot disease: Thiram 80WP, Daconil 2787 at 96 mL/100m^2, Daconil WDG at 53 g/100m^2, Banner 1.8%G at 224 g/100m^2, Captan 80WP, Captan+Nustar, Fore 80%, Ringer green, and Ringer Lawn. No phytotoxicity was observed.

METHODS

Twenty-seven chemical treatments were evaluated on a 14-year-old sward of creeping bentgrass (*Agrostis palustris*) at the Cambridge research station of the University of Guelph near Cambridge, Ontario. Turfgrass cultural treatments were similar to those used for maintenance of golf course putting greens in Ontario. Experimental design consisted of a randomized complete block design with 4 replications. Each treatment plot measured 1 x 2 m. The disease dollar spot, caused by *Sclerotinia homoeocarpa* (syn.: *Lanzia* or *Mollerodiscus* sp.), was evaluated in fungicide trials. Inoculum was prepared by incubating the fungus on autoclaved cereal grains (chicken scratch) for 2-3 weeks. The inoculum was dried overnight and chopped with a mixer into small particles. Inocula from 5 strains of the fungus were mixed together, and 2 g were evenly applied to each plot. Inoculum was applied 2 days after spraying.

Fungicide treatments were first applied on 19 June 1991, with a wheel-mounted compressed air boom sprayer at 140 kPa. Fungicides were re-applied on a 14-day, 21-day, or 4-week schedule according to their label over a 10-week period. Dollar spot disease was evaluated weekly for 12 weeks, by estimating number of infection centres. Significant yellowing due to phytotoxicity was noted if present. Analysis of variance was performed with PROC ANOVA in SAS®. When a significant treatment effect was found, mean separation was done with the test of least significant difference (LSD). Ten spots/2m^2 was used as the criterion for efficacious control of dollar spot disease.

RESULTS & DISCUSSION

Counts for dollar spot disease in the 1 by 2 m plots are presented in Table 1. No phytotoxicity was observed. The first chemical applications occurred on June 19, with inoculations of *Sclerotinia homoeocarpa* following 2 days later. The last ones were conducted on August 14, but plots were monitored for four weeks afterwards to examine residual effects. For inoculated plots, disease pressure was high from July 24 onward. Among the standards, Rovral Green, Tersan 1991 and Daconil 2728 (at 192 mL/100m^2) showed very good control of dollar spot disease. Thiram 80WP showed no control, and Dyrene 50WP did not provide acceptable control throughout the entire experiment and showed a residual activity period of 14 days. Tersan 1991 showed efficacy even 6 weeks after last application, when the experiment was terminated. Rovral Green and Daconil 2787 (at 192 mL/100m^2) showed control even 4 weeks after last application when the experiment was terminated.

For the ISK Biotech chemicals, ASC66791 at both rates and ASC66825 at 24 or 48 g/100m^2, showed very good control throughout the experiment with full residual activity even 4 weeks after last application (when the experiment was terminated). ASC66825 at 12 g/100m^2, ASC66518 at 110 g/100m^2, and Daconil WDG at 106 g/100m^2 showed acceptable levels of control (marginal in some cases) during the application period, and residual activity was two weeks for latter two; for ASC66825 at 12 g/100m^2, which is a 3-week interval formulation, residual control was adequate up to 4 weeks. ASC66518 at 56 g/100m^2, Daconil 2787 at 96 mL/100m^2, and Daconil WDG at 53 g/100m^2 did not provide acceptable control under our test conditions with high inoculum potential.

For the Green Cross chemicals, Banner at all rates except 1.8% G at 224 g/100m^2 provided very acceptable control during the test period and even for 4 weeks after last spray when the experiment was terminated.

For the ICI Chipman materials, only Nustar at 1.0 g a.i. /100m^2 provided acceptable control during the application period. Residual activity for this chemical was approximately two weeks after last application. Captan 80WP and Captan with Nustar at the tested rates did not provide control of dollar spot disease.

For the Rohm & Haas chemicals, Fore 80% at 200 g a.i./100m^2 did not provide acceptable control, but Myclobutanil at both 6 and 12 g a.i./100m^2 provided acceptable control, showing 4 and 6 weeks of residual activity respectively.

The Ringer Corporation treatments were fertilizers. These formulations did not provide acceptable control of dollar spot disease.

CONCLUSIONS

The following chemicals gave excellent control of dollar spot disease and showed efficacy well beyond their recommended spray intervals: Rovral Green, Tersan 1991, ASC66791 at two rates, ASC66825 at 24 or 48 g/100m^2, Daconil 2787 at 192 mL/100m^2, Banner 130EC at two rates, Banner 1.8% G at 419 g/100m^2, and Myclobutanil 40% at 12 g a.i./100m^2.

These chemicals showed very good control during the application periods, but had shorter yet acceptable periods of residual activity: ASC66518 at 110 gm/100m^2 and Nustar at 1.0 g a.i./100m^2.

These chemicals showed borderline control of dollar spot disease: Dyrene 50WP, ASC66825 at 12 g/100m^2, Daconil WDG at 106 gm/100m^2, and Myclobutanil 40% at 6 g a.i./100m^2.

These showed little or no control of dollar spot disease: Thiram 80WP, Daconil 2787 at 96 mL/100m^2, Daconil WDG at 53 g/100m^2, Banner 1.8%G at 224 g/100m^2, Captan 80WP, Captan+Nustar, Fore 80%, Ringer green, and Ringer Lawn.

TABLE 1. Counts of dollar spot disease and spray schedule during 12 weeks beginning 19 June, 1991. All chemically treated plots were inoculated with *Sclerotinia homoeocarpa*, and counts are expressed as number of infection centres in a 1 m by 2 m plot.

TREATMENTS	RATE ($/100m^2$)	INTERVAL	DATE 6/19	6/26	7/3	7/10	7/17	7/24	7/31	8/7	8/14	8/21	8/28	9/4	9/11
CONTROLS															
Uninoculated 1			1	0	1	1	1	2	5	3	7	11	11	21	23
Uninoculated 2			1	1	1	1	1	3	5	5	10	15	16	24	27
Inoculated	100 g	6/21	1	1	2	1	1	11	49	10	71	75	96	94	80
Dyrene 50WP	125 g	14 days	1	0	1	1	1	8	23	6	1	2	5	13	14
Rovral Green	200 mL	14 days	0	0	1	1	1	9	0	2	0	2	1	1	2
Tersan 1991 50WP	30 g	21 days	0	0	0	0	0	1	0	1	0	0	1	0	2
Thiram 80WP	90 g	14 days	1	1	2	2	2	11	43	13	52	71	85	100	70
ISK BIOTECH															
ASC66518	56 gm	14 days	1	0	0	1	1	7	12	3	17	24	33	41	59
ASC66518	110 gm	14 days	1	1	1	0	0	4	4	2	2	2	5	10	21
ASC66791	85 gm	14 days	2	0	0	0	0	2	1	1	0	0	2	0	0
ASC66791	170 gm	14 days	0	1	0	1	1	1	2	1	1	0	1	0	0
ASC66825	12 gm	21 days	1	1	0	1	1	0	6	10	1	6	9	16	18
ASC66825	24 gm	21 days	1	1	0	0	0	2	1	0	2	1	0	2	2
ASC66825	48 gm	21 days	1	1	0	0	0	4	1	2	1	0	0	1	0
Daconil 2787	96 mL	14 days	1	1	2	1	1	7	12	5	24	30	50	79	75
Daconil 2787	192 mL	14 days	2	1	2	0	0	3	2	1	0	2	3	4	9
Daconil WDG	53 gm	14 days	1	1	1	1	1	7	30	13	17	35	40	63	60
Daconil WDG	106 gm	14 days	2	1	3	1	1	10	6	4	10	8	4	16	21
GREEN CROSS															
Banner 130 EC	31 mL	14 days	1	0	0	0	0	0	0	0	0	1	0	0	0
Banner 130 EC	58 mL	14 days	0	0	0	0	0	3	1	1	0	1	1	0	0
Banner 1.8% G	224 g	14 days	0	0	1	0	0	5	18	8	21	18	18	21	29
Banner 1.8% G	419 g	14 days	2	1	2	2	2	3	4	2	4	3	3	3	2
ICI CHIPMAN															
Captan 80WP	113 g a.i.	14 days	1	0	3	2	2	9	33	17	60	66	81	92	66
Captan+Nustar	56.5+0.5 g a.i	14 days	0	1	2	1	1	9	36	15	36	43	71	75	70
Nustar	1.0 g a.i.	14 days	1	0	1	0	0	5	4	2	2	2	6	13	19
ROHM & HAAS															
Fore 80%	200 g a.i.	14 days	3	1	2	2	2	12	27	13	49	45	54	61	69
Myclobutanil 40%	6 g a.i.	21 days	1	1	1	0	0	2	10	1	1	4	7	13	19
Myclobutanil 40%	12 g a.i.	21 days	2	0	0	1	1	3	1	2	0	1	1	1	3
RINGERS CORP.															
Ringer Green	4.5 kg	4 weeks	1	0	1	1	1	4	23	2	55	60	64	75	73
Ringer Lawn	4.9 kg	4 weeks	1	0	1	1	1	7	32	4	62	66	96	69	59
LSD (P = 0.05)			**2.2**	**1.4**	**2.6**	**1.6**	**1.6**	**6.4**	**15.1**	**11.0**	**20.8**	**25.3**	**34.3**	**39.4**	**25.3**

SPRAY SCHEDULE	6/19	6/26	7/3	7/10	7/17	7/24	7/31	8/7	8/14	8/21	8/28	9/4	9/11
14 day schedule	yes		yes		yes		yes		yes				
21 day schedule	yes			yes			yes						
4 week schedule	yes				yes				yes				

RESISTANCE OF BENTGRASS CULTIVARS TO DOLLAR SPOT DISEASE, SUMMER 1991

T. Hsiang and A. Mueller
Department of Environmental Biology

INTRODUCTION

As part of the National Turfgrass Evaluation Program, cultivars of bentgrass are being evaluated at the University of Guelph. These plantings provide an excellent opportunity for the evaluation of cultivar disease resistance.

METHODS

Nineteen cultivars of bentgrass were evaluated for resistance to dollarspot disease at the Cambridge Research Station of the University of Guelph near Cambridge, Ontario. The species and their cultivars are browntop bentgrass (*Agrostis capillaris*): Egmont; Colonial bentgrass (*Agrostis tenuis*): Tracenta, Bardot, Allure; creeping bentgrass (*Agrostis palustris*): Cobra, SR 1020, Forbes 89-12, Carmen, Penneagle, TAMU 88-1, Providence, Emerald, National, Normarc 101, Putter, Penncross, 88.CBL, WVPB 89-D-15; and dryland bentgrass (*Agrostis castellana*): BR 1518. Cultivars were arranged in randomized block design of 1 x 2 m plots, with 3 replications. The grass was maintained at a putting green height (7 mm).

Dollar spot disease is caused by the fungus *Sclerotinia homoeocarpa* (syn.: *Lanzia* or *Moellerodiscus* sp.). To ensure an even inoculum pressure, the fungus was applied to all plots. Inoculum was prepared by incubating 5 strains of the fungus, on autoclaved cereal grains (chicken scratch) for 2-3 weeks in mason jars. After drying overnight, the inoculum was chopped up in an Osterizer blender into small particles. The 5 strains of fungus were mixed together, and 2 g were evenly applied to each 1 x 2 m test plot.

Inoculum was first applied June 21, 1991 to initiate disease. Evaluations were made by weekly estimations of the number of disease infection centres. Disease rating commenced on July 10, 1991 and continued weekly for 17 weeks until October 30, 1991. Analysis of variance was performed using PROC ANOVA in SAS®. When a significant cultivar effect was found in the ANOVA, mean separation was done with the test of least significant difference (LSD).

RESULTS AND DISCUSSION

Counts for dollar spot disease in the 1 x 2 m test plots are presented in Table 1. Dollarspot disease incidence increased slowly up to July 24, after which disease pressure was high for the next 13 weeks until October 30. After the third week (July 24), there were statistically significant differences between the cultivars. Overall the cultivars Allure, Bardot, Tracenta, BR 1518 and Egmont showed the best dollarspot resistance throughout the 1991 field season. These are all the cultivars of species other than creeping bentgrass. The cultivars with the worst performance were: Carmen, 88.CBL, SR 1020, Forbes 89-12, Putter, and Emerald.

Table 1. Counts of dollar spot disease among creeping bentgrass cultivars during 17 weeks beginning July 10, 1991. All plots were inoculated with *Sclerotinia homoeocarpa*, and counts are expressed as the number of infection centres in 1 x 2 m subplots.

Cultivar	Week / Date																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	7/10	7/17	7/24	7/31	8/7	8/14	8/22	8/28	9/4	9/11	9/18	9/25	10/2	10/9	10/16	10/23	10/30
BR 1518	2	0	9	9	43	23	35	67	80	78	97	57	40	55	45	37	57
CARMEN	2	8	49	37	113	52	100	130	160	163	227	147	90	113	93	85	130
TRACENTA	1	2	10	7	33	29	43	73	67	87	110	70	47	40	37	30	43
PUTTER	2	12	54	37	107	50	83	147	173	150	210	127	78	92	90	70	98
SR 1020	3	6	49	34	100	45	72	125	133	160	210	120	93	128	107	100	110
PROVIDENCE	0	5	38	26	80	33	73	110	136	133	187	103	58	82	73	50	70
BARDOT	2	1	18	5	63	21	30	63	63	60	83	45	30	45	30	25	33
PENNCROSS	2	4	24	18	90	35	78	113	130	140	217	110	43	62	62	37	72
PENNEAGLE	1	4	34	23	87	40	63	103	123	110	180	93	43	77	58	43	83
EGMONT	2	0	19	13	50	35	37	63	57	73	100	67	35	50	45	42	60
NORMARC 101	7	4	34	23	77	38	67	97	157	117	180	117	60	83	82	53	78
FORBES 89-12	1	4	55	43	112	57	99	137	153	157	220	110	72	103	103	65	90
WVBP 89-D-15	0	2	33	21	100	43	83	120	147	150	233	110	60	80	67	45	73
NATIONAL	0	3	34	20	73	37	72	110	117	137	210	80	40	60	67	45	67
88.CBL	4	8	36	32	100	45	103	173	163	170	227	160	88	103	90	82	110
COBRA	0	4	34	22	100	38	73	133	147	153	207	110	55	90	63	57	90
EMERALD	1	9	38	37	100	38	77	123	150	150	240	143	73	107	83	73	123
TAMU 88-1	2	4	27	26	90	40	70	100	140	133	227	123	73	110	100	70	105
ALLURE	1	1	5	3	27	16	37	52	52	52	62	53	35	45	32	29	42
LSD (p=0.05)	N.S.	N.S.	19.2	21.6	51.9	N.S.	43.1	57.2	61.1	42.3	73.9	59.5	30.3	42.3	29.9	26.2	41.8

EVALUATION AND COMPARISON OF AGRI-DIAGNOSTICS AND NEOGEN TURF DISEASE DETECTION SYSTEMS.

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INTRODUCTION

Agri-Diagnostics (2611 Branch Pike, Cinnaminson, NJ, 08077, 800-322-KITS) produces serological kits called "Reveal" for the detection of the following turfgrass diseases: dollar spot, brown patch, and pythium blight. Based on the results of the serology test, the kit makes recommendations regarding the application of fungicides. This form of disease monitoring relies on detection of the pathogen prior to symptom development.

Neogen (620 Lesher Place, Lansing, MI, 48912, 517-372-9200) has developed an environmental monitoring device called the "Envirocaster". The external sensors measuring temperature, relative humidity, rainfall, leaf wetness, sunlight, etc. are connected to a computer which integrates this information, and gives control recommendations based on disease models for the brown patch and dollar spot diseases. This form of disease monitoring involves the use of prediction models using physical/environmental variables which are thought to be critical in the epidemiology of the diseases.

We evaluated these two systems experimentally on adjacent field plots at the Cambridge Research Station of the University of Guelph.

METHODS

The following treatments were evaluated in a Randomized Complete Block Design.

- Non-sprayed control
- Standard spray schedule (Daconil 2728F, 190 mL/100m^2)
- Neogen Brown Patch prediction plot
- Neogen Dollar Spot prediction plot
- Reveal Brown Patch prediction plot
- Reveal Dollar Spot prediction plot

There were four replicates per treatment, with plots of 1 x 2 m. Reveal kit tests were performed weekly on the Reveal plots (random), and also on adjacent plots that had been inoculated with dollar spot or brown patch at the beginning of the season (biased). The Neogen Envirocaster was checked several times each week for disease prediction.

Fungicide applications of Daconil 2728F were applied at the rate of 190 mL/100m^2 according to standard spray schedules (14 day intervals) for the scheduled spray control plots. Fungicide was also applied to the prediction plots when the prediction systems forecasted a high risk. For example, fungicide was applied to the Agri-Diagnostic dollar spot plots when the Reveal Kit predicted a high risk of dollar spot.

The treatments were continued over 4 months (July through October), with weekly evaluation of disease incidence. Disease assessment was based on the number of infection centres of each disease.

RESULTS & DISCUSSION

Brown Patch Disease

No brown patch disease occurred on the test plots during the 1991 field season. From 27 June until 26 September, there were no positive predictions of brown patch disease by the Neogen Envirocaster except for 28 August. The Agri-Diagnostic Reveal kits gave negative disease predictions except for one caution level reading on 22 July.

Brown patch disease was not severe during the 1991 summer season in our locality. Both the Neogen and Agri-Diagnostic systems performed well in their predictions of brown patch disease, in that they did not call for control actions when there were no outbreaks. However, a greater disease pressure is required to fully evaluate these systems to ensure against false negatives, which would occur if the systems predict no disease while disease is actually occurring. This scenario of a false negative is much more dangerous to a turf manager since it would call for no control measures when controls are actually required.

Dollar Spot Disease

From 27 June until 26 September, there were no positive predictions of dollar spot disease by the Neogen Envirocaster. The disease prediction model for dollar spot disease was not specifically developed for local conditions, and further fine-tuning of the model may be required for assurance of the dollar spot disease prediction results of the Neogen Envirocaster in our area.

The results of the Agri-Diagnostic Reveal kits for dollar spot disease are presented in Table 1.

Table 1: Agri-Diagnostic Reveal Kit readings[1] for dollar spot disease.

Date	Random	Biased
06/27	0	1
07/05	2	
07/10	3	0
07/18	0	0
07/22	5	11
08/01	9	23
08/06	3	
08/12	10	9
08/16	10	0
08/23	7	15
08/28	0	6
09/06		24
09/26	2	15
10/04	0	0
10/09	0	0
10/16	0	0
10/25	0	7
10/30	0	3

[1]The scale for readings is: 0-13 low range; 13-23 caution range; 23-33 danger range; and 33-80 extreme range.

Considering the Reveal kit readings and environmental conditions, we used these predictions to spray for dollar spot disease at two times: after 1 August and after 6 September. Dollar spot disease incidence is shown in Figure 1.

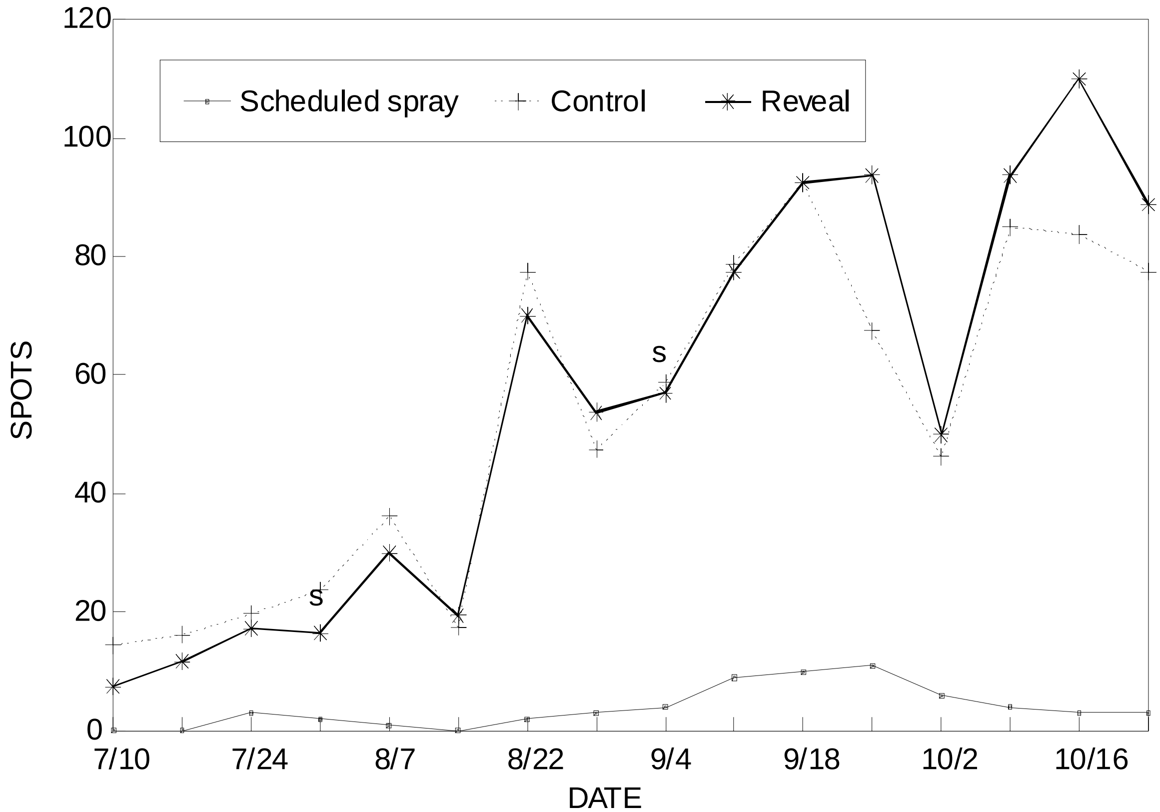

Figure 1. Counts of dollar spot infection centres on test plots (1 x 2m). The scheduled spray plots had bi-weekly applications of Daconil 2728F. Samples were taken from the Reveal plots for use in the Reveal tests for dollar spot disease prediction. The control plot did not receive fungicide applications during the test. The symbol "S" above the reveal line refer to fungicide sprays due to positive predictions of disease by Reveal kits.

The two spray applications after Reveal predictions of dollar spot disease unfortunately did not seem to be efficacious (symbol S in Figure 1). In any case, the incidence of positive prediction of disease by the Reveal system, was below an acceptable level: disease was widespread and increasing when there were predictions of no pathogen activity. Future testing and refinement of our sampling procedures may improve our confidence in the predictive ability of Agri-Diagnostic Reveal kit readings for dollar spot disease.

EVALUATION OF BENTGRASS CULTIVARS MANAGED AS FAIRWAY AND PUTTING GREEN TURF

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Twenty cultivars of bentgrass are being evaluated as fairway or putting green turf on native soil rootzones. The species and their cultivars are browntop bentgrass (*Agrostis capillaris*): Egmont; Colonial bentgrass (*Agrostis tenuis*): Tracenta, Bardot, Allure; creeping bentgrass (*Agrostis palustris*): Cobra, SR 1020, Forbes 89-12, Carmen, Penneagle, TAMU 88-1, Providence, Emerald, National, Normarc 101, Putter, Penncross, Pennlinks, 88.CBL, 88.CBE, WVPB 89-D-15; and dryland bentgrass (*Agrostis castellana*): BR 1518. The plots were seeded at 2.2 g m^{-2} on August 23, 1990. Evaluations for the 1991 season include spring and summer color, quality, cover, annual bluegrass infestation, and quintozene damage ratings. Rankings based on 1991 data are given below (Tables 1 to 4). Data on resistance to dollar spot infection is presented in another paper elsewhere in this report.

Fairway turf. All cultivars are represented in the fairway trial except 88-CBE and Pennlinks.

Table 1. Ratings for color[1] in bentgrass cultivars - fairway turf.

Cultivar	Spring color	Cultivar	Summer color
Tracenta	8.4	88.CBL	8.6
88.CBL	8.1	Providence	8.3
Egmont	8.1	Forbes 89-12	8.0
Bardot	7.7	Cobra	7.7
Forbes 89-12	7.7	Normarc 101	7.7
Providence	7.7	Penncross	7.3
BR 1518	7.6	WVPB 89-D-15	7.3
WVPB 89-D-15	7.5	Penneagle	7.2
Cobra	7.5	SR 1020	7.1
Allure	7.3	Carmen	7.0
TAMU 88-1	7.2	Tracenta	7.0
SR 1020	7.2	Putter	7.0
Penncross	7.1	TAMU 88-1	6.9
Normarc 101	7.0	BR 1518	6.8
Putter	6.8	Bardot	6.6
Penneagle	6.7	National	6.6
Carmen	6.6	Emerald	6.5
Emerald	5.9	Egmont	6.3
National	5.7	Allure	6.3
LSD 5%	0.58		0.67

[1] Color rated visually 0 to 9, 9 = darkest green, 5 = acceptable color. Means of 3 evaluations: spring 91-04-17, 91-05-13, 91-05-24; summer 91-06-17, 91-07-18, 91-08-26

Table 2. Ratings for annual bluegrass[1] infestation in bentgrass cultivars - fairway turf.

Cultivar	Annual bluegrass
BR 1518	3.1
Allure	2.8
Tracenta	1.9
88.CBL	1.7
Bardot	1.7
Emerald	1.7
National	1.7
Egmont	1.4
WVPB 89-D-15	1.4
Normarc 101	1.3
Cobra	1.3
Carmen	1.2
Penneagle	1.2
Penncross	1.1
TAMU 88-1	1.0
SR 1020	1.0
Putter	1.0
Providence	0.8
Forbes 89-12	0.7
LSD 5%	0.73

[1] Infestation rated visually 0 to 10, 10 = 50% of plot area infested; mean of 3 evaluations: 91-05-24, 91-06-17, 91-07-18

Table 3. Ratings for cover[1] of bentgrass cultivars - fairway turf.

Cultivar	Cover
88.CBL	10.0
National	10.0
WVPB 89-D-15	10.0
Penncross	10.0
Penneagle	10.0
Emerald	10.0
Putter	10.0
Forbes 89-12	10.0
Normarc 101	10.0
TAMU 88-1	10.0
Cobra	9.7
Providence	9.7
SR 1020	9.7
Tracenta	9.3
BR 1518	9.3
Bardot	9.3
Carmen	9.3
Egmont	9.0
Allure	8.3
LSD 5%	0.82

[1] Cover rated visually 0 to 10, 10 = 100% of plot area covered. Evaluated 91-05-13.

Table 4. Ratings for quality[1] of bentgrass cultivars - fairway turf.

Cultivar	Quality
Putter	7.8
Providence	7.6
Forbes 89-12	7.4
National	7.4
Emerald	7.2
Normarc 101	7.1
Penneagle	7.1
88.CBL	7.1
TAMU 88-1	7.1
Bardot	6.9
WVPB 89-D-15	6.8
Penncross	6.8
Cobra	6.7
SR 1020	6.7
Carmen	6.6
Tracenta	6.4
Egmont	6.1
BR 1518	5.8
Allure	5.6
LSD 5%	0.70

[1] Quality rated visually 0 to 10, 10 = best, 5 = acceptable. Means of 4 evaluations: 91-05-13, 91-06-17, 91-07-18, 91-08-26

Table 5. Ratings for fungicide (quintozene) damage[1] of bentgrass cultivars - fairway turf.

Cultivar	Quintozene damage
Egmont	3.0
Tracenta	2.7
Bardot	2.3
Allure	2.0
BR 1518	1.3
88.CBL	0.0
Carmen	0.0
Emerald	0.0
Forbes 89-12	0.0
Cobra	0.0
Normarc 101	0.0
Penncross	0.0
Penneagle	0.0
Providence	0.0
Putter	0.0
SR 1020	0.0
TAMU 88-1	0.0
National	0.0
WVPB 89-D-15	0.0
LSD 5%	0.66

[1] Damage rated visually 0 to 3, 3 = severe yellowing. Rated 91-08-26.

Putting green turf. All cultivars are represented in the putting green trial except TAMU 88-1 and Penneagle.

Table 6. Ratings for color[1] in bentgrass cultivars - putting green turf.

Cultivar	Spring color	Cultivar	Summer color
88.CBE	8.2	88.CBL	8.9
Forbes 89-12	8.2	Forbes 89-12	8.5
88.CBL	7.9	WVPB 89-D-15	8.4
Tracenta	7.8	88.CBE	8.3
Egmont	7.7	Penncross	8.3
WVPB 89-D-15	7.5	Normarc 101	8.0
Pennlink	7.5	Cobra	7.8
Cobra	7.4	Providence	7.7
Providence	7.4	Pennlinks	7.4
Normarc 101	7.3	Emerald	7.3
BR 1518	7.3	Putter	7.1
Bardot	7.2	SR 1020	7.1
SR 1020	7.1	National	7.0
Putter	6.8	Carmen	6.9
Penncross	6.7	BR 1518	6.6
Allure	6.7	Tracenta	6.5
Carmen	6.6	Bardot	6.2
Emerald	6.0	Allure	6.0
National	6.0	Egmont	5.9
LSD 5%	0.59		0.81

1 Color rated visually 0 to 9, 9 = darkest green, 5 = acceptable color. Means of 3 evaluations: spring 91-04-17, 91-05-13, 91-05-24; summer 91-06-17, 91-07-18, 91-08-26

Table 7. Ratings for annual bluegrass[1] infestation in bentgrass cultivars - putting green turf.

Cultivar	Annual bluegrass
BR 1518	2.3
Allure	1.9
Carmen	1.6
88.CBL	1.6
Tracenta	1.4
Cobra	1.1
SR 1020	1.0
National	1.0
WVPB 89-D-15	1.0
88.CBE	1.0
Pennlink	0.9
Egmont	0.9
Bardot	0.9
Providence	0.8
Forbes 89-12	0.8
Penncross	0.6
Emerald	0.4
Normarc 101	0.3
Putter	0.0
LSD 5%	1.04

[1] Infestation rated visually 0 to 10, 10 = 50% of plot area infested; mean of 3 evaluations: 91-05-24, 91-06-17, 91-07-18

Table 8. Ratings for cover[1] of bentgrass cultivars - putting green turf.

Cultivar	Cover
88.CBE	10.0
88.CBL	10.0
National	10.0
Normarc 101	10.0
Penncross	10.0
Forbes 89-12	10.0
Cobra	10.0
Egmont	10.0
Emerald	10.0
Putter	10.0
Allure	9.7
Pennlinks	9.7
Providence	9.7
BR 1518	9.7
WVPB 89-D-15	9.7
Tracenta	9.3
Bardot	9.3
Carmen	9.0
SR 1020	9.0
LSD 5%	0.69

[1] Cover rated visually 0 to 10, 10 = 100% of plot area covered. Evaluated 91-05-13.

Table 9. Ratings for quality[1] of bentgrass cultivars - putting green turf.

Cultivar	Quality
Putter	8.6
Pennlinks	8.1
SR 1020	7.9
Normarc 101	7.9
Providence	7.8
Forbes 89-12	7.8
Bardot	7.7
National	7.7
Emerald	7.6
Penncross	7.6
Cobra	7.5
88.CBL	7.4
Egmont	7.4
WVPB 89-D-15	7.4
88.CBE	7.4
Carmen	7.1
Allure	7.0
Tracenta	6.8
BR 1518	6.1
LSD 5%	0.7

[1] Quality rated visually 0 to 10, 10 = best, 5 = acceptable. Means of 4 evaluations: 91-05-13, 91-06-17, 91-07-18, 91-08-26

Table 10. Ratings for fungicide (quintozene) damage[1] of bentgrass cultivars - putting green turf.

Cultivar	Quintozene damage
Bardot	1.0
Tracenta	1.0
Allure	1.0
BR 1518	1.0
Egmont	1.0
88.CBE	0.0
Cobra	0.0
Carmen	0.0
Emerald	0.0
Forbes 89-12	0.0
National	0.0
Normarc 101	0.0
Penncross	0.0
Pennlinks	0.0
Providence	0.0
Putter	0.0
SR 1020	0.0
88.CBL	0.0
WVPB 89-D-15	0.0
LSD 5%	0.00

[1] Damage rated visually 0 to 3, 3 = severe yellowing. Rated 91-08-26.

Table 11. Summary of bentgrass ratings[1] by species.

Species	Fairway turf		Species	Putting green turf	
Annual bluegrass					
Dryland	3.1	a	Dryland	2.3	a
Colonial	2.1	b	Colonial	1.4	b
Browntop	1.4	c	Browntop	0.9	b
Creeping	1.2	c	Creeping	0.9	b
Spring color					
Browntop	8.1	a	Browntop	7.7	a
Colonial	7.8	ba	Dryland	7.3	a
Dryland	7.6	ba	Colonial	7.2	a
Creeping	7.1	b	Creeping	7.2	a
Summer color					
Creeping	7.4	a	Creeping	7.8	a
Dryland	6.8	ba	Dryland	6.6	b
Colonial	6.6	ba	Colonial	6.2	b
Browntop	6.3	b	Browntop	5.9	b
Cover					
Creeping	9.9	a	Browntop	10.0	a
Dryland	9.3	ba	Creeping	9.8	a
Browntop	9.0	b	Dryland	9.7	a
Colonial	9.0	b	Colonial	9.4	a
Quality					
Creeping	7.1	a	Creeping	7.7	a
Colonial	6.3	b	Browntop	7.4	a
Browntop	6.1	b	Colonial	7.2	a
Dryland	5.8	b	Dryland	6.1	b
Quintozene damage					
Browntop	3.0	a	Browntop	1.0	a
Colonial	2.3	b	Colonial	1.0	a
Dryland	1.3	c	Dryland	1.0	a
Creeping	0.0	d	Creeping	0.0	b

[1] Ratings are means of evaluations as described in Tables 1 - 10. Means within columns followed by the same letter are not significantly different (5%, Duncans multiple range test).

PERENNIAL RYEGRASS CULTIVAR EVALUATION

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Perennial ryegrass cultivars (seeded 89/7/19) have been assessed for general appearance (uniformity and density), red thread resistance, spring and summer color. Rankings based on 1991 data are given below.

Table 1. Ratings for color[1] of perennial ryegrass cultivars.

Cultivar	Spring color	Cultivar	Summer color
2H7	8.7	Barry	8.3
Aquarius	8.7	Aquarius	8.2
Competitor	8.7	Competitor	8.2
Omega II	8.0	Nova	7.8
Saturn	8.0	2H7	7.8
Nova	7.7	Omega II	7.8
Pennant	7.3	Caliente	7.7
Sheriff	7.3	Saturn	7.7
Barry	7.3	Pennant	7.5
Caliente	7.0	Sheriff	7.0
LSD 5%	1.12		0.58

[1] Color rated visually 0 to 9, 9 = darkest green. Spring color evaluated 91-05-07; summer color mean of 2 evaluations, 91-06-17 and 91-07-19.

Table 2. Ratings for general appearance[1] of perennial ryegrass cultivars.

Cultivar	General appearance
2H7	10
Aquarius	10
Barry	10
Caliente	10
Competitor	10
Nova	10
Omega II	10
Pennant	10
Saturn	10
Sheriff	10
LSD 5%	0

[1] Rated visually 0 - 10, 10 = best. Evaluated 91-06-17.

Table 3. Ratings for red thread incidence[1] in perennial ryegrass cultivars

Cultivar	Disease
Barry	1.0
Caliente	0.7
Saturn	0.7
2H7	0.3
Aquarius	0.0
Nova	0.0
Omega II	0.0
Pennant	0.0
Competitor	0.0
Sheriff	0.0
LSD 5%	1.32

[1] Rated visually 0 - 2, 2 = moderate infection. Evaluated 91-06-17.

TALL FESCUE CULTIVAR EVALUATION

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Tall fescue cultivars (seeded in 1988 and 1990) are being assessed for general appearance (uniformity and density), color, resistance to weed infestation, disease, and drought stress. Rankings based on 1991 data are given below.

Cultivars seeded 1988

Table 1. Ratings for summer color[1] in tall fescue cultivars.

Cultivar		Summer color
Cochise		8.0
Maverick		7.3
Thoroughbred		7.3
Tribute		7.0
Mustang		7.0
Rebel II		7.0
Arid		6.7
Houndog		6.7
Jaguar		6.7
Rebel		6.3
Pacer		6.0
Chesapeake		5.3
	LSD 5%	0.74

[1] Rated visually 0 to 9, 9=darkest green. Evaluated 91-07-02.

Cultivars seeded August 3, 1990

Table 2. Ratings for color[1] of tall fescue cultivars.

Cultivar	Spring color	Cultivar	Summer color
Crossfire	9.0	MiniMustang	8.5
MiniMustang	9.0	Bonsai	8.3
Shortstop	8.7	Rebel Jr.	8.3
Emperor	8.7	Shortstop	8.3
Bonsai	8.5	Crossfire	8.2
Rebel Jr.	8.5	Emperor	8.0
Winchester	7.5	Thorough	7.7
Tribute	7.5	Tribute	7.7
Thunderbird	7.5	Mustang	7.7
Sapphire	7.3	Winchester	7.5
Mustang	7.2	Thunderbird	7.5
Thorough	7.2	Rebel II	7.3
Jaguar II	7.2	Jaguar II	7.0
Rebel II	7.0	Sapphire	7.0
Falcon	6.5	Finelawn I	6.8
Finelawn I	6.3	Falcon	6.8
Willamette	6.3	Willamette	6.8
Jaguar	6.3	Jaguar	6.8
LSD 5%	0.59		0.44

[1] Rated visually 0 to 9, 9 = darkest green. Means of 2 evaluations: spring 91-04-19, 91-05-06; summer 91-06-17, 91-07-19.

Table 3. Ratings for broadleaf weed infestation[1] in tall fescue cultivars.

Cultivar	Weed
Bonsai	3.7
Sapphire	2.0
Emperor	1.0
Thorough	1.0
Shortstop	1.0
MiniMustang	1.0
Jaguar II	1.0
Rebel Jr.	1.0
Winchester	0.7
Jaguar	0.7
Mustang	0.7
Tribute	0.7
Thunderbird	0.7
Crossfire	0.3
Willamette	0.3
Falcon	0.3
Finelawn I	0.0
Rebel II	0.0
LSD 5%	0.96

[1] Rated visually 0 to 10, 10 = 50% of plot area infested. Evaluated 91-05-06.

Table 4. Ratings for texture[1] of tall fescue cultivars.

Cultivar	Texture
Tribute	7.0
Bonsai	6.7
Thunderbird	6.7
Crossfire	6.7
Shortstop	6.7
Sapphire	6.7
MiniMustang	6.7
Emperor	6.3
Willamette	6.3
Jaguar	6.3
Jaguar II	6.3
Rebel II	6.3
Winchester	6.3
Falcon	6.3
Mustang	6.0
Rebel Jr.	6.0
Thorough	6.0
Finelawn I	5.7
LSD 5%	0.84

[1] Rated visually 0 to 9, 9 = finest. Evaluated 91-07-19

SPORTS TURF MIXTURE EVALUATION

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Mixes of various ratios of seed of different turfgrass species were seeded at the Cambridge Research Station on August 18, 1988. These mixes are being evaluated for functional features. Rankings based on 1991 data are given below.

Table 1. Ratings for summer color[1] of sports turf mixtures.

Mixture	Summer color
11 (50:0:0:50)[2]	8.7
4 (75:0:0:25)	7.7
9 (50:0:0:50)	7.7
10 (25:50:0:25)	7.7
21 (30:25:0:45)	7.7
3 (20:40:20:20)	7.3
5 (30:35:10:25)	7.3
6 (50:25:0:25)	7.3
7 (75:25:0:0)	7.3
8 (25:25:25:25)	7.3
12 (60:20:0:20)	7.3
22 (10:50:0:40)	7.3
24 (20:0:80:0)	7.3
1 (50:50:0:0)	7.0
2 (75:0:25:0)	7.0
14 (25:25:50:0)	7.0
23 (15:55:0:30)	7.0
15 (10:65:0:25)	6.7
16 (80:20:0:0)	6.7
25 (0:0:100:0)	6.7
13 (0:10:90:0)	6.3
26 (0:0:80:20)	6.3
27 (0:10:90:0)	6.3
20 (0:0:100:0)	5.7
LSD 5%	1.37

[1] Rated visually 0 to 9, 9 = darkest green. Evaluated 91-06-26.
[2] Seeding mix percentage perennial ryegrass : Kentucky bluegrass : tall fescue : fine fescue.