TABLE OF CONTENTS

TURFGRASS MANAGEMENT AND RENOVATION

WEED CONTROL AND GROWTH REGULATION

TURFGRASS PATHOLOGY

PESTICIDE RESIDUES

EVALUATION OF SPECIES AND CULTIVARS

TURFGRASS EXTENSION

GUELPH
TURFGRASS
INSTITUTE

INTRODUCTION

Members of the Guelph Turfgrass Institute are pleased to present their Annual Report for 1990. 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 extensive work on **turfgrass seed production (perennial ryegrass, tall fescue, Kentucky bluegrass)** by E. E. Gamble, M. H. Peppard, G. W. Anderson, R. Harris, and V. M. Mares Martins. Aspects of turfgrass management and renovation covered include studies by J. L. Eggens, N. McCollum and K. Carey of **soil temperature and seed germination of tall fescue and perennial ryegrass** and **turf renovation by sodding**. Research on the **phytotoxicity to turfgrass of sodium formate as a deicer** by G. Lumis, T. Bates, G. Hofstra, and K. Carey, and on development of **management software for turf areas** K. Carey and J. L. Eggens rounds out the management chapter. J. C. Hall and K. Sagan present extensive work on **Weed Control in Turf, 1990** and **Plant Growth Regulators, 1990**, summarizing 19 projects. Turfgrass pathology research presented includes studies on **fungicide trials for dollarspot control** by GTI's new pathologist, T. Hsiang. F. C. Vaughn and M. K. Sears continue their work on **evaluation of insecticides for control of European chafer.** Several aspects of a new and developing research project in **integrated pest management (IPM) for turf** are presented by A. Anderson and S. Dean. Environmental concerns are addressed by reports on exposure to 2,4-D (**Homeowner, professional applicator and bystander exposure to 2,4-dichlorophenoxyacetic acid (2,4-D)** by S. A. Harris, K. R. Solomon, C. S. Bowhey, and G. R. Stephenson) and toxicity of 2,4-D (**Toxicology update on 2,4-D**, by K. R. Solomon and I. C. Munro), and by a project **monitoring pesticide leaching from bentgrass micro-greens** by A. Anderson, S. Dean, N. Chapman, B. Ripley. We continue to evaluate species and cultivars, including new trials of **bentgrass cultivars managed as fairway and putting green turf**, and **tall fescue** cultivars. Results of these, and continuing trials of **fine fescue** cultivars, **perennial ryegrass** cultivars, **Kentucky bluegrass** cultivars, and **sports turf mixtures** are reported by J. L. Eggens, N. McCollum and K. Carey. In the area of soils and nutrition - continuing work on **composted sewage sludge as a fertilizer** on bentgrass putting green and fairway type turf is reported by J. L. Eggens, E. Eguiza, and K. Carey. Last, but not least, Annette Anderson has prsesented a 1990 Seasonal Summary of **turf extension**, as well as a description of the **Turf Industry Survey** currently being conducted.

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 1990 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

Ag-Turf Chemicals Inc.
BASF Canada Inc.
Beaconsfield Golf Club
Brouwer Turf Equipment Ltd.
Canagro
Chemagro Ltd.
Chemlawn Inc.
Chevron Chemical Co.
Chipman Inc.
Ciba-Geigy Canada Ltd.
City of Guelph
Compact Sod
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Dow Chemical Canada
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O. M. Scotts and Sons
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Otto Pick and Sons Seeds Ltd.
Plant Products Co. Ltd.
Rothwell Seeds
So-Green Corp.
Soil Enrichment Systems, Inc.
Speare Seeds
Stauffer Chemical Company of Canada Ltd.
The Guelph Cemetery Commission (Woodlawn Cemetery)
Turf Care (Division of RMC Equipment Ltd.)
Union Carbide

The Guelph Turfgrass Institute

The turfgrass industry has expanded dramatically in the past decade. Housing booms, increased leisure activities and altered lifestyles have led to rapid (although not always uninterrupted!) development in all sectors. Sod growers have been pressed to respond to the soaring demand for residential and industrial lawns. The leisure industry has had to scramble for more and better trained people to construct and maintain better sports fields and provide golf courses that are aesthetically pleasing and technically challenging. Lawn care service companies have multiplied in response to public needs.

At the same time that the industry has grown, environmental concerns have increased the challenges to reduce inputs of energy, water and management chemicals, and to continue to operate in an environmentally sound manner.

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 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:

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

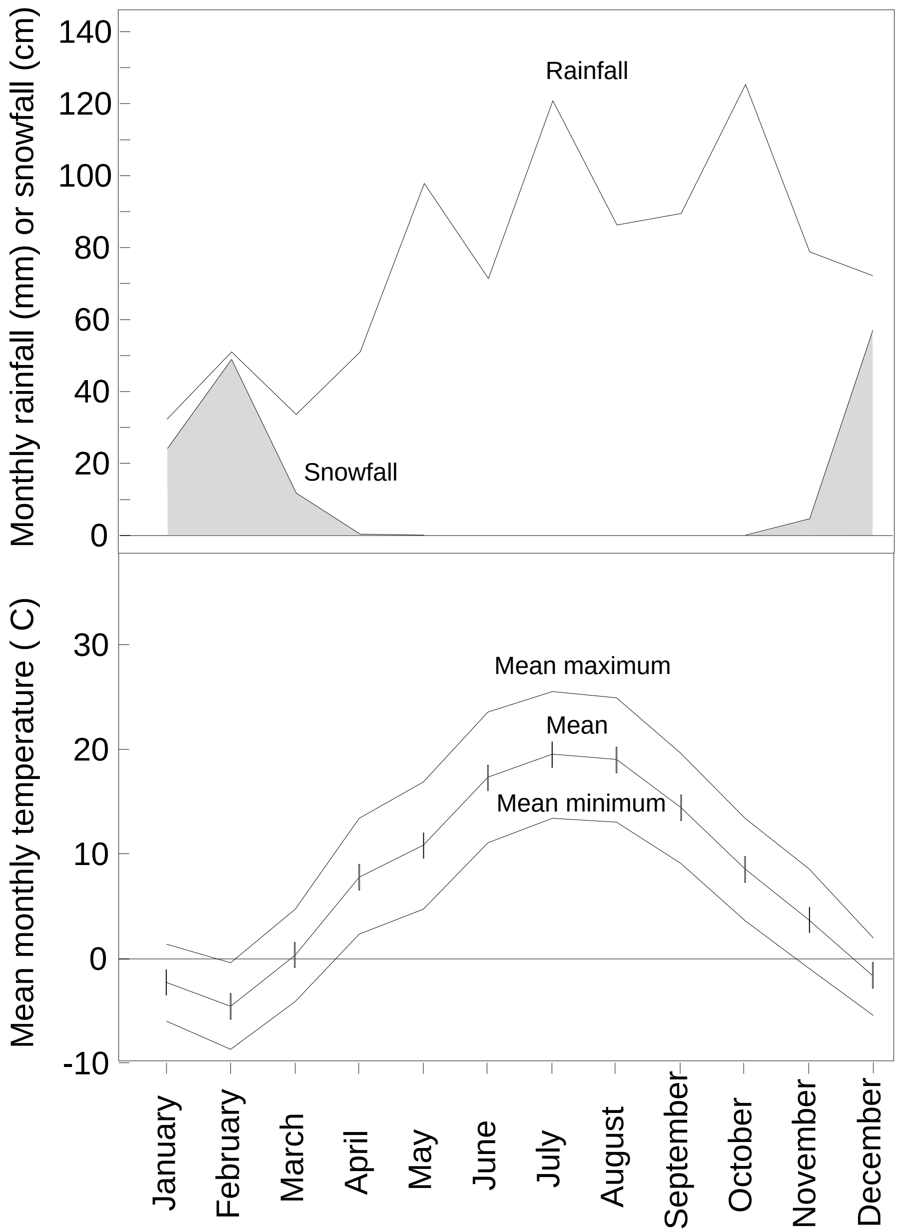
Members of the Guelph Turfgrass Institute

The staff of the Guelph Turfgrass Institute includes the director, other university faculty (nine 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. Annette Anderson	Ontario Ministry of Agriculture and Food, Horticultural Science
Dr. Tom Bates	Land Resource Science
Dr. Ken Carey	Horticultural Science
Dr. Jack Eggens	Horticultural Science
Dr. Ed Gamble	Crop Science
Dr. Tom Hsiang	Environmental Biology
Mr. Norman McCollum	Guelph Turfgrass Institute
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

1990 WEATHER DATA, GUELPH

In order to assist in interpretation of some the material presented in the research reports, we are presenting, beginning with the 1990 Annual Report, a summary of weather data. We were not able to assemble complete yearly information for the Cambridge Research Station in time for this year - in future years we will have more precise information. The following figure represents weather recorded at the University of Guelph Arboretum, on campus at the University and about 20 miles east of the Cambridge Research Station.



SOILS AND NUTRITION

NUTRITIONAL STATUS OF TURF GRASSES

Thomas E. Bates
Department of Land Resource Science

OBJECTIVES

1. To determine the response of turf grasses to potassium and the relation of response to soil test and plant analysis values.
2. To determine the usefulness and limitations of soil testing and plant analysis for prediction of nutrient requirements of turf grasses.

REASONS FOR THIS RESEARCH

Soil and plant tissue were analysed from 46 golf greens in 1987 and 1988 and 24 nursery sod fields in 1989. Samples were also analysed from this project in 1988. From those analyses it appears that plant analysis can be useful for estimating requirements of both macro- and micronutrients but we need more information on the variability of results through the season. We also need to compare plant analysis results with soil tests as means of predicting requirements. It seems probable that soil tests for potassium may not be very useful on sandy soils where clippings are removed as most of the applied potassium is likely to be removed in the crop. The survey of golf greens provided some indication of this. These trials are intended to provide information on these topics as well as providing information on the effects of applied potassium. The bentgrass green cut at 5 mm height with clippings removed and the Kentucky bluegrass cut at 3.2 cm height with clippings left on should provide the extremes of management. They would be expected to respond to potassium quite differently both in amount required and perhaps in the number of applications required per year.

METHODS

In the spring of 1989 two trials were set out on a Lisbon loamy sand soil at the Cambridge research station. The one trial was on a creeping bentgrass stand which had been cut at approximately 5 mm height and managed as a green for several years. The second trial was on a Kentucky bluegrass stand which had been maintained as a lawn, cut at approximately 3.2 cm height with clippings left on, for a number of years. In 1989 muriate of potash was applied at rates supplying 0, 30, 60, 120 and 240 kg K/ha^{-1} yr^{-1} (0, 0.3, 0.6, 1.2 and 2.4 kg/100 m^2) to both trials. In one set of treatments these rates were divided into 3 applications per year from May to October, and in a second set of treatments the rates were divided into seven applications per year. In 1990 rates were increased to 0, 50, 100, 200 and 400 kg K ha^{-1} yr^{-1} with applications in the one set of treatments reduced from three to two and in the other set reduced from seven to four applications. Each treatment was replicated six times in a randomized complete block design. The bentgrass continued to be cut daily at 5 mm height six or seven times per week, less in spring and fall, with all clippings removed. The bluegrass continued to be cut every five or six days, less in spring and fall, at 3.2 cm height with clippings returned except when collected for growth measurements. Sprinkler irrigation was applied to both trials as required. Phosphorus in these soils was quite adequate but nitrogen as sulfur coated urea was applied as required.

RESULTS AND DISCUSSION

Soil test potassium values were adequate in the spring of 1989 in both trials but on this loamy sand soil it was expected that soil K would be depleted rapidly where grass clippings were removed and no potassium was applied.

There was no apparent response to potassium in growth rates, colour or annual bluegrass in the stand throughout 1989 or 1990. In October 1990 severe wear was applied to half of each plot consisting of 10 passes of a tractor mounted roller twice a week throughout the month. The colour and general condition of the sward deteriorated appreciably where wear was applied but potassium treatments had no apparent effect. This will be further evaluated in the spring of 1991.

Soil test potassium was higher with high rates of potassium application in both the bentgrass, Tables 1 to 3, and the bluegrass, tables 4 to 6, as one would expect. It is not understood why the potassium soil tests tended to increase from fall 1989 to spring of 1990, Tables 1 and 2 and Tables 4 and 5. There was a very marked decrease in soil test potassium in the bentgrass trial from spring of 1990 to fall 1990 and this was more severe at low rates of potassium. This was expected because of potassium removal in the clippings. A similar but less extreme pattern was apparent in the bluegrass, Tables 5 and 6 at low rates of potassium. At high rates of potassium the soil test increased in the bluegrass trial as would be expected where only three clippings per season were removed for yield measurement and chemical analysis.

A marked response to applied potassium is predicted at the lower soil test levels, 60 to 80, in the bentgrass, Table 3, based on OMAF fertilizer recommendations. In the bluegrass, a moderate potassium response is predicted at the lowest soil test level, 117, Table 6. Perhaps these responses will appear in 1991.

In all the soil test potassium readings, Tables 1 to 6, there is a higher test where potassium was applied more frequently. This was a surprise. It may be that more leaching of potassium occurred on this sandy soil where potassium was applied in less frequent and hence larger amounts for any one annual rate.

Table 1. Soil test K from bentgrass sampled during October 1989 and receiving various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	30	60	120	240	
			Soil test K (ppm)			
3 times	--	95	95	101	110	100
7 times	--	100	106	120	157	120
Mean	--	98	100	110	133	

Note: Significance levels (Pr > F) were 0.001 for method, 0.001 for rate and 0.003 for method x rate, and c.v. was 12.3%.

Table 2. Soil test K from bentgrass sampled during the spring of 1990 and receiving various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	50	100	200	400	
		Soil test K (ppm)				
2 times	--	170	180	176	189	179
4 times	--	186	187	213	252	210
Mean	173	178	183	195	221	

Note: Significance levels (Pr > F) were 0.001 for method, 0.003 for rate and 0.09 for method x rate, and c.v. was 14.4%.

Table 3. Soil test K from bentgrass sampled during the fall of 1990 and receiving various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	50	100	200	400	
	Soil test K (ppm)					
2 times	--	70	66	76	105	78
4 times	--	61	71	97	152	95
Mean	57	64	68	87	128	

Note: Significance levels (Pr > F) were 0.001 for method, 0.001 for rate and 0.001 for method x rate, and c.v. was 16.8%.

Table 4. Soil test K from bluegrass sampled during October 1989 and receiving various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	30	60	120	240	
	Soil test K (ppm)					
3 times	--	113	118	117	130	119
7 times	--	114	112	131	166	131
Mean	--	114	115	124	148	

Note: Significance levels (Pr > F) were 0.01 for method, 0.001 for rate and 0.006 for method x rate, and c.v. was 11.5%.

Table 5. Soil test K from bluegrass sampled during the spring of 1990 and receiving various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	50	100	200	400	
	Soil test K (ppm)					
2 times	--	179	205	196	176	189
4 times	--	180	170	240	190	195
Mean	212	180	188	219	183	

Note: Significance levels (Pr > F) were 0.55 for method, 0.04 for rate and 0.06 for method x rate, and c.v. was 18.1%.

Table 6. Soil test K from bluegrass sampled during the fall of 1990 and receiving various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	50	100	200	400	
	Soil test K (ppm)					
2 times	--	137	166	181	220	176
4 times	--	154	156	196	276	196
Mean	117	146	161	188	248	

Note: Significance levels (Pr > F) were 0.04 for method, 0.001 for rate and 0.11 for method x rate, and c.v. was 17.0%.

Table 7. Concentration of K in bentgrass clippings from October 24, 1989, with various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	30	60	120	240	
	K (% dry weight)					
3 times	--	1.72	1.72	1.74	1.76	1.73
7 times	--	1.69	1.74	1.78	1.90	1.77
Mean	1.68	1.70	1.73	1.76	1.83	

Note: Significance levels (Pr > F) were 0.04 for method, 0.001 for rate and 0.04 for method x rate, and c.v. was 3.8%.

Table 8. Concentration of K in bentgrass clippings from May 28, 1990, with various rates and methods of K fertilizer application

Method of Application	Rate of K Application (kg ha^{-1} yr^{-1})					Mean
	0	50	100	200	400	
	K (% dry weight)					
2 times	--	1.88	1.95	1.92	2.12	1.97
4 times	--	1.93	2.06	2.11	2.36	2.11
Mean	1.81	1.91	2.00	2.02	2.24	

Note: Significance levels (Pr > F) were 0.001 for method, 0.001 for rate and 0.16 for method x rate, and c.v. was 5.0%.

Clippings from both the bentgrass and bluegrass trials will be analysed from samples taken in June (bluegrass only) and October (bent grass only) 1989 and May or June, July and September 1990. Only preliminary data are currently available for the July and September 1990 analyses.

In the bentgrass, potassium rate increased the potassium concentration in the clippings, Tables 7 and 8, as expected but in the bluegrass the rate effect was not significant Table 9 & 10. Method of application was also significant for the bentgrass with the larger number of applications resulting in slightly greater concentrations in the clippings. Potassium concentrations in the bluegrass are appreciably higher than in the bentgrass. This could be due to differences between the two sites but it is thought to be largely due to the removal of clippings in the bentgrass and not removing most of them from bluegrass.

Differences due to treatments are much smaller in the potassium concentration in clippings than in the potassium soil tests.

All of the clipping potassium concentrations are well above the critical concentrations published by OMAF. A quick examination of the Sept. 1990 clipping data suggest that concentrations of potassium in the bentgrass clippings are probably lower than in earlier cuttings but still above critical concentrations.

Soil tests and plant tissue concentrations of magnesium, manganese and zinc were measured in these trials and were little affected by treatment. They will be examined more fully when all the 1990 plant analysis results are available.

Table 9. Concentration of K in bluegrass clippings from June 26, 1989, with various rates and methods of K fertilizer application

Method of Application	Rate of K Application ($kg\ ha^{-1}\ yr^{-1}$)					Mean
	0	30	60	120	240	
	K (% dry weight)					
3 times	--	2.88	2.82	2.76	2.89	2.84
7 times	--	2.72	2.89	2.92	2.88	2.85
Mean	2.68	2.80	2.86	2.84	2.89	

Note: Significance levels (Pr > F) were 0.77 for method, 0.53 for rate and 0.08 for method x rate, and c.v. was 5.2%.

Table 10. Concentration of K in bluegrass clippings from June 20, 1990, with various rates and methods of K fertilizer application

Method of Application	Rate of K Application ($kg\ ha^{-1}\ yr^{-1}$)					Mean
	0	50	100	200	400	
	K (% dry weight)					
2 times	--	2.48	2.63	2.54	2.60	2.56
4 times	--	2.53	2.53	2.55	2.68	2.57
Mean	2.54	2.50	2.58	2.54	2.64	

Note: Significance levels (Pr > F) were 0.84 for method, 0.41 for rate and 0.70 for method x rate, and c.v. was 7.8%.

CONCLUSIONS

The soil used in these studies has a loamy sand texture and was expected to be depleted of potassium rather quickly when clippings were removed. It has shown a surprising ability to supply potassium to the grass. It seems likely that this is due to the build up of slowly available, non-exchangeable (not measured by soil test) potassium during previous years of liberal potassium fertilization. Other information leads the author to believe that it probably takes over 10 years of fertilization for this to occur.

The small difference in soil test potassium and clippings potassium concentrations between treatments in the bluegrass trial leads one to conclude that little potassium is required to maintain turf grasses where the clippings are returned provided the potassium supply is adequate as is raised to adequate concentrations initially. More attention should be given to this in turf fertilization programs.

In the bentgrass study the soil test K concentrations dropped much more quickly than the potassium concentrations in clippings where potassium was not applied. The interpretation of this will be given more thought when all the data are available.

In both trials, soil test potassium readings, and in the bentgrass the clippings potassium concentrations, were higher when potassium was applied frequently, 4 to 7 times per season, than when it was applied less frequently. In this loamy sand it is possible that more potassium was leached from the root zone when the higher rates associated with less frequent applications. The soil test samples were taken to 15 cm depth on the bluegrass but only 7.5 cm depth on the bentgrass. Root systems are expected to be shallower on the bentgrass because of cutting height.

THE USE OF COMPOSTS, INCLUDING THAT FROM IRRADIATED SEWAGE SLUDGE, ON TURF GRASS

Thomas E. Bates and Paul Vanderwerf
Department of Land Resource Science

The project was initiated in 1990 and will run through 1991. It is funded by Nordion International, makers of gamma ray irradiators for sterilization, with an interest in the use of irradiated sewage sludge.

OBJECTIVE

1. To determine positive and negative effects and suitable rate of application of composted irradiated sewage sludge, composted cattle manure and composted leaves were applied to Kentucky bluegrass managed as a home lawn and creeping bentgrass managed as a putting green.

METHODS

Field trials are in progress at the Cambridge Research Station.
The three composts are applied at rates supplying 10, 20, 30 and 40 tonnes of solids ha^{-1} each year along with sufficient fertilizers to supply the recommended amounts of nutrients. The higher rates of compost supply more than recommended amounts of some nutrients. These treatments will be compared with a check treatment receiving only chemical fertilizers.

Heavy metal concentrations in the crops will be monitored as well as nutrient content and many other aspects of turf quality.

This project forms the basis for Paul Vanderwerf's M.Sc. thesis studies, a full report should be ready by December 31, 1991.

COMPOSTED SEWAGE SLUDGE AS A FERTILIZER ON BENTGRASS PUTTING GREEN AND FAIRWAY TYPE TURF

J. L. Eggens, E. Eguiza, and K. Carey
Department of Horticultural Science

Composted sewage sludge (City of Windsor experimental waste recovery plant, Windsor, Ontario) is being evaluated as a general turf fertilizer on bentgrass putting green and fairway type turf.

Plots in mature creeping bentgrass-annual bluegrass putting green and fairway type turf at the Cambridge Research Station received one of the three nitrogen treatments (sulphur-coated urea, Milorganite 6-2-0 or Windsor composted waste). Nitrogen was applied at two rates, 57.6 kg N ha^{-1} yr^{-1} and 115.2 kg N ha^{-1} yr^{-1}. Heavy wear was applied to half the plots.

Plots are being evaluated for botanical composition, wear tolerance and recuperative potential, thatch buildup and degradation, soil compaction, soil NH_4 and NO_3, tissue N, and turf functional features (color, density, quality). Data indicate that on putting green turf the Windsor compost is slightly less effective than the other N sources at maintaining color, equal to or better than the other treatments in maintaining general appearance, and equal to all other treatments except the high rate of SCU at promoting growth as measured by clipping yield. On fairway type turf, there were both N source and N level effects on color, general appearance and dollar spot infection, with the ranking generally SCU better than Milorganite better than Windsor compost. All plots had color and general appearance within the acceptable range by visual evaluation.

Analysis of the nitrogen balance (NO_3^- and NH_4^+ in soil, thatch and tissue samples, total N) is in progress. Preliminary analysis suggests that there is litte difference among the sources in their effect on tissue NH_4^+, but that SCU is a better source for tissue NO_3^- than Milorganite, which is in turn superior to the sewage sludge compost (Table 1). The very slow release or mineralization of the nitrogen in the

Table 1. Tissue nitrogen in putting green turf.

N Source	Tissue NH_4-N (mg/kg)		Tissue NO_3-N (mg/kg)	
	89-08-17[1]	89-08-28[2]	89-08-17[1]	89-08-28[2]
SCU	55.08	117.60	179.18	35.34
Windsor compost	68.02	127.60	0.18	12.12
Milorganite	47.46	101.90	5.98	23.30
LSD 5%	11.28	[3]	25.16	NS
N Level				
1X	63.44	91.89	10.57	24.25
2X	56.93	87.95	112.99	22.47
LSD 5%	9.21	9.73	20.54	29.20

[1] Tissue sampled 9 days after most recent fertilizer application 89-08-08.
[2] Tissue sampled 20 days after most recent fertilizer application 89-08-08.
[3] Missing values preclude a single LSD value; means separation produce two groups: Milorganite and SCU = Windsor compost

compost is evident in the soil and thatch nitrogen levels following application (Tables 2 and 3).

Table 2. Soil nitrogen under putting green bentgrass-annual bluegrass turf										
N Source	Soil NH_4-N (mg/kg)					Soil NO_3-N (mg/kg)				
	08-23 [1]	09-25 [2]	10-02 [3]	10-11 [4]	10-18 [5]	08-23	09-25	10-02	10-11	10-18
SCU	13.27	18.23	23.44	11.68	6.06	13.30	9.57	3.93	4.01	10.62
Windsor compost	13.75	19.69	23.15	16.72	6.38	11.55	3.09	3.52	5.49	10.40
Milorganite	13.28	14.30	20.63	14.31	6.38	10.84	3.12	3.18	3.58	9.90
LSD 5%	5.58	8.57	4.32	3.93	2.03	3.25	8.98	0.73	3.74	1.06
N Level										
1X	11.97	15.16	21.97	14.02	5.93	12.47	3.48	3.29	4.01	10.10
2X	14.90	19.65	22.84	14.46	6.62	11.32	7.03	3.79	4.71	10.52
LSD 5%	3.75	5.76	2.90	2.64	1.37	2.19	6.04	0.49	2.52	0.72

[1] Sampled 15 days after fertilizer application - 89-08-08
[2] Sampled 10 days after fertilizer application - 89-09-15
[3] Sampled 17 days after fertilizer application - 89-09-15
[4] Sampled 26 days after fertilizer application - 89-09-15
[5] Sampled 31 days after fertilizer application - 89-09-15

Table 3. Thatch nitrogen under putting green bentgrass-annual bluegrass turf								
N Source	Thatch NH_4-N (mg/kg)				Thatch NO_3-N (mg/kg)			
	09-25 [1]	10-02 [2]	10-11 [3]	10-18 [4]	09-25	10-02	10-11	10-18
SCU	146.93	44.83	37.38	88.98	16.67	0.33	2.62	8.24
Windsor compost	8.38	28.49	29.95	47.66	2.13	0.21	2.35	3.73
Milorganite	29.74	44.83	51.86	88.98	1.22	2.83	2.12	4.39
	21.65	33.80	20.67	25.85	21.28	3.05	0.78	7.58
N Level								
1X	36.71	45.34	39.09	75.47	1.15	1.59	2.35	4.27
2X	86.66	37.01	40.37	75.84	12.19	0.66	2.38	6.65
	14.55	22.72	13.89	17.37	14.30	2.05	0.53	5.09

[1] Sampled 10 days after fertilizer application - 89-09-15
[2] Sampled 17 days after fertilizer application - 89-09-15
[3] Sampled 26 days after fertilizer application - 89-09-15
[4] Sampled 31 days after fertilizer application - 89-09-15

Particularly in the thatch, both Milorganite and SCU produced higher levels of NO_3^- and NH_4^+. The difference between the effects of the fertilizers in thatch and in soil is reflected in the pH measurements (Table 4), where again the differences are more pronounced in the thatch layer. The medium term effects of the sources on thatch is not large (Table 5).

Table 4. pH under bentgrass-annual bluegrass putting green turf (sampled 90-10-02).		
N Source	Thatch	Soil
SCU	4.94	6.41
Windsor compost	6.89	6.96
Milorganite	6.46	6.69
LSD 5%	0.33	0.21
N Level		
1X	6.19	6.73
2X	6.00	6.64
LSD 5%	0.22	0.14

Table 5. Thatch thickness (mm) under bentgrass-annual bluegrass putting green turf.					
N Source	89-05-26	89-10-18	90-08-16	90-10-12	90-10-31
SCU	5.52	12.21	10.19	10.42	12.29
Windsor compost	5.46	10.25	10.58	10.21	12.27
Milorganite	5.17	12.58	9.25	9.19	11.25
LSD 5%	0.77	0.84	0.91	0.86	0.97
N Level					
1X	5.40	11.68	9.75	9.72	11.83
2X	5.36	11.68	10.26	10.15	12.04
LSD 5%	0.52	0.57	0.62	0.59	0.66

The data presented here is preliminary. Completed analyses will produce similar data for fairway type turf, and for both putting green and fairway turf for two growing seasons. Nitrogen data will also be correlated with color, general appearance and yield data.

FATE OF SLOW-RELEASE NITROGEN FERTILIZERS APPLIED TO SAND-BASED TURFGRASS ROOTZONES

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BACKGROUND

One of the most widespread contaminants of surface and groundwater is nitrate, and application of nitrogen fertilizers to soil has been proposed as the main source. The impact of nitrogen fertilizer practices on the quality of surface and groundwater supplies is a major concern of the turfgrass industry. Leaching of nitrate from fertilizers applied to turfgrass has been implicated as a significant source of nitrate contamination of groundwater in suburban areas where turfgrass is a major land use.

Nitrogen fertilizer management practices (N rate, fertilizer source and timing) highly influence N leaching losses. In addition, most newer golf courses and athletic fields and those presently under construction are using USGA specifications. Thus, the N fertilizer management systems which have been developed in the past on soil-based rootzones will not necessarily apply to these newer all sand-based rootzones.

The objective of this research was to evaluate the performance of slow-release nitrogen fertilizers applied to bluegrass and bentgrass on sand-based rootzones. The knowledge obtained from this research will provide information on the development of management practices to minimize the impact of turfgrass fertilization on water quality.

EXPERIMENTAL PROCEDURES

i. Research site:

This research was conducted at the Cambridge Research Station on established bentgrass and bluegrass research plots constructed on sand-based rooting zones. There were two research sites for each grass. The individual treatment plots were 3 m X 1 m and each treatment was replicated three times.

ii. Nitrogen fertilizer sources:

a. Slow-release nitrogen fertilizers

Nitroform (38-0-0) Noram
Vitorganic (LS) (10-2-0)
Vitorganic (PS) (8-2-0)
Organiform (25-0-0)
Milorganite (6-0-0)
Isobutylidenediurea (IBDU) (31-0-0)
Nutralene (40-0-0)
Sulphur-coated urea mini (35-0-0) Pursell
Methylene urea (28-0-0) (slow-release liquid)
Resin coated urea/potassium nitrate (24.5-0-0) Pursell
Resin coated urea (40.4-0-0) Pursell
Polymer coated urea (44-0-0) C-I-L
Nutricote (16-10-10)
Nutricote microprills (14-8-12)
ESSO 1
ESSO 2

b. Fast-release nitrogen fertilizers

Urea mini (46-0-0)
Ammonium nitrate (34-0-0)
Ammonium sulphate (21-0-0)
Calcium nitrate (15.5-0-0)

c. Other treatments

Kelp meal (1-0-2) (applied at 10 kg/100 m_2)
Fluiton converter
Hydro-Fix and BioFix
Bioplus

iii. Method of application:

The seasonal rate of application of the slow-release nitrogen fertilizers was 2 kg N/100 m^2. This was made as a single application on June 1. A split application was made on June 1 and on August 15 at a rate of 1 kg N/100 m^2 at each application. All plots received a basal dressing of phosphorus and potash at 750 g P_2O_5 and 1500 g K_20/100 m^2.

The fast-release nitrogen fertilizers were applied every 3-4 weeks, starting in June 1, at seasonal rates ranging from 1 to 4 kg N/100 m^2. This was done to provide a nitrogen fertilizer response surface for evaluating the performance of the slow-release fertilizers.

The other treatments were applied as recommended.

iv. Evaluation:

The performance of the slow-release fertilizers was evaluated by visual ratings of grass colour and quality using a scale of 0 (no response), 1 (some response) and 2 (good response). This was done every 3 weeks, just before the second split application and in the late fall. Yield measurements were taken in the early August sampling. The incidence of disease (dollar spot) was also noted.

RESULTS

Preliminary results of this study are reported in Table 1. All of the slow-release fertilizers performed reasonably well. The early-season response to nitrogen fertilizer application was better for the single application of 2 kg/100m^2 compared with the split application which had received 1 kg/100m^2. However, most of the slow-release fertilizers did not give a late-season response with the single season application. The split fertilizer application consistently showed a better response in the late fall. The significance of this response on spring green-up will be evaluated. This study will be repeated in 1991 season.

Table 1. Performance of slow-release nitrogen fertilizers on bentgrass

Treatment	Visual evaluation of performance**		
	June 22	August 8	November 23
ESSO 1			1.5
ESSO 2			2
IBDU	1*/0+	2/1.5	0/1.5
Methylene urea (liquid)			2
RC urea/potassium nitrate-A	1	1	2
RC urea-B	1	1	2
Milorganite	1/1	2/1	0.5/1.5
Nitroform	1/1	1.5/1	0.5/1.5
Nutralene	2/2	2/1.5	0.5/2
Nutricote	1/1	2/2	0.5/2
Organiform	1/1	0.5/0.5	0/0.5
Sulphur-coated urea	2/2	2/1.5	0.5/1.5
Vitorganic (LS)	2/1	2/1	0/0.5
Vitorganic (PS)	2/1	2/1	0/1
Kelp meal	0	0	0
Fluiton converter	-	0	0
Hydro-Fix and BioFix	-	-	0
Bioplus-L	-	1	1

*single application
+split application
**Rating: 0, no response; 1, some response; 2, good response

TURFGRASS SEED PRODUCTION

PERENNIAL RYEGRASS SEED PRODUCTION - ROW WIDTH AND SEEDING RATE

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PURPOSE

To determine the most appropriate row width and seeding rate for high seed yields.
To determine the seed yield performance of perennial ryegrass over a period of years.

COMMENTS

Test 1 was established in July 1986 and test 2 in August 1987. The cultivar Fiesta was used in both tests, Annual fertilization was 300 kg ha^{-1} of 0-20-20 and 90 kg ha^{-1} of 34-0-0 applied in early September, and 270 kg ha^{-1} of 34-0-0 applied the next April. Seed yields for the various row widths and seeding rates included in the two tests are reported in table 1. Seed yields in 1988 on test 1 were reduced partly due to the low soil moisture conditions and partly to effects of Round-up applied between rows in the spring to kill seedlings developed from shattered seed from the 1987 harvest. Yields in the 3rd year of test 1 and 2nd year of test 2 were good. Over the 3 years of test 1 and 2 years of test 2 the highest mean yield occurs with the 18 cm row widths. Seed yields appeared to maximize at the 4 kg ha^{-1} seeding rate. There was no interaction between row widths and seeding rates in 1989 harvests. The higher yields of the 1989 harvest at the 18 cm row width was due to almost twice as many seed spikes m^{-2} compared to the other row widths. However, seed size was reduced slightly as was the total number of seeds per spike in both tests. Seeding rates had no effect on spike number, seed size or seeds per spike in either test in the 1989 harvest. More detailed information on the 1987 and 1988 harvests is provided by Beverly A. Raimbault, 1989. Management Practices Influencing the Seed Production of Perennial Ryegrass. M.Sc. Thesis, University of Guelph.

Table 1. Mean seed yields (kg ha^{-1}) of perennial ryegrass at several row widths and seeding rates

Width (cm)	Rate (kg ha^{-1})	Test 1				Test 2		
		1987	1988	1989	Mean	1988	1989	Mean
18		890	684	1254	943	1243	1138	1191
36		922	726	1134	927	1179	823	1001
53		739	700	930	790	1019	852	936
71		706	588	1046	780			
	1	692	647	1046	795			
	2	841	679	1095	872	1092	847	970
	4	910	697	1133	913	1168	1018	1093
	8					1192	923	1058
						1136	962	1049

PERENNIAL RYEGRASS SEED PRODUCTION - TIME AND RATE OF APPLICATION OF NITROGEN

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PURPOSE

To determine the rate of nitrogen for maximum, economie seed yield of perennial ryegrass.

To determine if the nitrogen should be applied in the fall or early spring or a combination of fall and spring applications.

COMMENTS

A seeding rate of 2 kg ha^{-1} was used in 1986 and 1987 to establish the stands of Fiesta perennial ryegrass, used for this study. Row width was 18 cm. In early September each ear 300 kg ha^{-1} of 0-20-20 was applied to the stands. In addition 4 rates of nitrogen, 0, 30, 60, and 90 kg ha^{-1} (actual) were applied at the same time using NH_4N0_3. In April an additional 4 rates of nitrogen, 0, 30, 60, and 90 kg ha-l were applied to each of the Fall nitrogen rates. The nitrogen treatments were repeated on each plot each year.

Seed yields in 1988 for test 1 were reduced partly due to low soil moisture conditions and partly to effects of Roundup applied by wick applicator to seedlings between the rows developed from shattered seed from the previous seed harvest.

Seed yields for the various nitrogen treatments in the 3rd year of test 1 compared favorably with the 1st year yields except at the lower rates of total nitrogen. Over the 5 harvest years the nitrogen application providing the highest and most economical seed yield was the combination of 30 kg ha^{-1} applied in September followed by an April application of 90 kg ha^{-1}. Although an application of 30 kg ha^{-1} in the Fall and 60 kg ha^{-1} in the spring was almost as good as the 30-90 application, other combinations of a total of 90 kg ha^{-1} nitrogen tended to be lower yielding than a total application 120 kg ha^{-1} of nitrogen. The most important nitrogen application is in the spring. The maximum rate of nitrogen applied only in the spring was 90 kg ha^{-1} which compared favorably in test 1 with the 30-90 treatment. Unfortunately a spring application of only 120 kg ha^{-1} was not tested.

The 1989 crop increased in plant height with increasing nitrogen rate as did the lodging index in test 1; however, no differences occurred in test 2. The rate and timing of nitrogen did not affect the number of spikes m^{-2} or seeds per spike. The zero nitrogen rates in both fall and spring had significantly smaller seed than the other rates in test. More detailed information on the 1987 and 1988 harvests are discussed by Beverly A. Raimbault, 1989. Management Practices Influencing the Seed Production of Perennial Ryegrass. M.Sc. thesis, University of Guelph.

Table 1. Mean seed yields over five harvest years for perennial ryegrass following fall and spring nitrogen applications.

Nitrogen Rates		Seed Yield (kg ha^{-1})					
		Test 1			Test 2		Mean of 5 Harvests
Fall	Spring	1987	1988	1989	1988	1989	
0	0	761	403	512	1018	708	680
	30	880	583	810	1068	730	814
	6	1023	654	940	980	806	881
	90	1118	804	1053	984	1020	996
30	0	902	399	701	1050	762	763
	30	1112	570	967	1071	940	932
	60	1058	654	1179	1111	1070	1014
	90	1086	660	1451	1005	108	1056
60	0	989	559	845	1067	936	879
	30	1066	703	1065	1084	976	979
	60	1110	715	1070	1051	981	985
	90	1107	741	1295	1002	968	1023
90	0	1112	580	1124	904	943	933
	30	1241	688	1219	932	1009	1018
	60	1233	709	1284	987	979	1038
	90	1319	701	1425	894	944	1057

ESTABLISHMENT OF PERENNIAL RYEGRASS WITH A COMPANION CROP

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PURPOSE

Establishment of perennial ryegrass stands in August following winter wheat or spring cereal harvest can be delayed due to the need to minimize volunteer seedling growth. Also moisture conditions in August may reduce the development of the ryegrass seedlings. This may ultimately affect winter survival of the stand.

A study was conducted in 1988 and 1989 to investigate the feasibility of establishing perennial ryegrass stands in the spring using a companion crop.

COMMENTS

A six-row barley variety was used as the companion crop in 1988 (Leger) and 1989 (OAC Kippen). In both years 2 seeding rates of barley were used as well as without a companion crop. Four seeding rates, 2, 4, 8 and 12 kg ha^{-1}, of 2 perennial ryegrass varieties, Fiesta II and Palmer were used.

In both years the barley yield was lower for the 150 seeds m^{-2} seeding rate. The yield for this seeding rate tended to decrease as the seeding rate of the perennial ryegrass increased (Table 1).

Table 1. Mean yield kg ha^{-1} of barley companion crop at four seeding rates of perennial ryegrass for 1988 and 1989.

Perennial Ryegrass seeding rate kg ha^{-1}	Barley Seeding Rate		
	150 seeds m^{-2}	300 seeds m^{-2}	Mean
2	3826	4085	3956
4	3659	3932	3796
8	3574	3996	3785
12	3506	4065	3786
mean	3641	4020	

The ryegrass plant stand was better in 1989 (Table 2) than in 1988 (Table 3). Moisture conditions were generally satisfactory in the spring of 1989, although dry after June, while dry conditions prevailed in the spring of 1988 until mid July. In both years the stand was highest for the establishment without a companion crop. Stand improved with increased seeding rate of the perennial ryegrass up to 8 kg ha^{-1} in both years. Winter survival appeared to be reduced at the 2 kg ha^{-1} seeding rate in the winter of 1988/89. Although seed yield increased with increased seeding rate of perennial ryegrass up to 8 kg ha^{-1}, the increase was not significant because of high variability in the test. Establishment with or without a companion crop did not affect seed production in the first harvest year.

Table 2. Stand and vigor of perennial ryegrass following establishment with a companion crop, 1989.

	Plant Stand[a] established	Plant vigor[b]
Cultivar		
Fiesta II	7.7	3.0
Palmer	7.8	3.0
Seeding rate for barley companion crop		
none	8.7	4.9
150 seeds m^{-2}	7.7	2.5
300 seeds m^{-2}	6.9	1.8
Seeding rate for Perennial Ryegrass		
2 kg ha^{-1}	6.8	2.5
4	7.5	2.7
8	8.3	3.3
12	8.6	3.5
LSD 0.05 rates	0.6	0.5

[a] 1 = poor stand; 9 = excellent stand. Observed 23/08/89
[b] 1 = poor vigor; 5 = high vigor. Observed 23/08/89.

Table 3. 1989 performance of 2 perennial ryegrass cultivars established with and without a companion crop in 1988.

	Plant stand[a] established	Winter survival (%)	Spring plant vigor[b]	Seed yield (kg ha^{-1})	Thousand seed weight (g)
Cultivar					
Fiesta II	3.2	60	2.6	1149	1.88
Palmer	2.7	48	2.2	983	1.83
LSD 0.05	0.2	NS	NS	NS	NS
Seeding rate for barley companion crop					
none	3.4	59	2.2	1014	1.84
150 seeds m^{-2}	2.8	53	2.5	1098	1.88
300 seeds m^{-2}	2.5	49	2.5	1084	1.83
LSD 0.05	0.5	NS	NS	NS	NS
Seeding rate for Perennial Ryegrass					
2 kg ha^{-1}	2.0	37	1.9	963	1.89
4	2.6	50	2.2	1055	1.84
8	3.4	59	2.6	1109	1.86
12	3.7	68	2.8	1135	1.83
LSD 0.05	0.5	16	0.6	NS	NS

[a] 1 = poor stand; 5 = good stand. Observed 20/10/88
[b] 1 = low vigor (1-3 leaves); 5 = high vigor (5+ tillers). Observed 23/08/89.

DATE AND RATE OF SEEDING EFFECTS ON PERENNIAL RYEGRASS WINTER SURVIVAL AND SEED PRODUCTION

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PURPOSE

The date of summer seeding of perennial ryegrass can have an effect on stand survival. It may also affect subsequent seed production. Seeding rate of the ryegrass may influence the response to date of seeding. Accordingly, a study was conducted to investigate the effect of date of seeding at various seeding rates on stand survival and seed yield.

COMMENTS

Seeding dates were August 8 and 22, and September 2, 1988. Perennial ryegrass seeding rates were 2, 4, 8, and 12 kg ha^{-1}. Two cultivars of ryegrass, Fiesta II and Palmer, were evaluated. Winter survival was highest at the August 22 planting date (Table 1). The reduced survival at the Sept. 2 date was expected but not for the August 8 date.

Winter survival increased with increased seeding rate of ryegrass up to 8 kg ha^{-1}. Plant vigour in the spring decreased with delayed seeding date and with reduced seeding rate. Seed yield was significantly reduced at the Sept. 2 seeding date and at the 2 kg ha^{-1} seeding rate. The 1989 results suggest that early spring vigour and stand survival may not necessary reflect subsequent yield performance. Yield of an adjacent stand established May 25, 1988 was 1014 kg ha^{-1} which was lower than the August 22 and August 8 seedings.

Table 1. Performance of 2 cultivars of perennial ryegrass at 3 summer seeding dates and 4 seeding rates. 1989.

	Winter survival (%)	Plant stand[a]	Plant vigor[b]	Lodging index	Seed yield (kg ha^{-1})	Thousand seed weight (g)
Cultivar						
Fiesta II	76	8.2	2.96	7.8	1224	2.22
Palmer	75	8.0	2.94	8.2	1058	2.25
LSD 0.05	NS	NS	NS	0.2	69	NS
Seeding Date						
Aug. 8	74	8.3	3.71	8.4	1176	2.20
Aug. 22	83	8.7	3.32	8.2	12OO	2.22
Sept. 2	69	7.5	1.83	7.4	1O45	2.28
LSD 0.05	11	0.4	0.29	0.3	NS	ns
Seeding Rate						
2 kg h^{-1}	54	6.5	1.77	7.1	1048	2.29
4	72	8.2	2.67	8.0	1146	2.27
8	86	8.8	3.42	8.4	1220	2.17
12	90	9.0	3.94	8.7	1148	2.20
LSD 0.05	5	0.3	0.24	0.3	90	0.10

[a] Plant stand: 1 = 1-10% of plot area covered with plants. 9 = 91-100% of plot area covered with plants observed 23/08/89.
[b] Plant vigor: 1 = low vigor (1-3 leaves); 5 = high vigor (5+ tillers). Observed 23/08/89.
[c] Lodging index: Belgium system (0.2 = none; 9 = completely lodged).

TIME AND METHOD OF HARVESTING PERENNIAL RYEGRASS

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PURPOSE

Perennial ryegrass can be harvested by direct combining or by swathing prior to combining. This study investigates the seed yield and quality following harvest by the two methods at various seed moisture contents.

COMMENTS

In 1988, the first swathing treatment at 48% head moisture content (HMC) with subsequent combining at 24 or 12% HMC and the direct combine treatment at 35% SMC gave the highest seed yields (Table 1, 2). The method of seed harvest did not appear to have a major effect on seed yield. With both harvest methods, seed yield declined at lower HMC. At the earliest swathing treatment (48% HMC) appeared to produce lower quality seed as the seed was smaller, with a higher percent green seeds, and a reduced germination compared to other harvests. This may have been due to an extremely fast dry down (24 hours) of the swathed material in 1988. Normally this dry down period would bc slower and assimilate from the leaves and stems would be moved to the stem to complete the maturing process.

In 1989 tests were conducted for each of the swath-combine method and the direct combine method on two different field stands at the Elora Research Station. In both fields the direct combine method of harvest appeared to give a higher seed yield than the swath-combine method of harvest (Tables 3, 4, 5, 6). The seed lost due to shattering was much larger for the swath-combine harvests than for the direct combine harvest. However, some of the later swathed harvests were made too late when the head moisture content was too low. Seed quality on all harvests was very good as measured by seed size and percent germination after both the 7 and 14 day count. An exception was the earliest harvest of one of the swath-combine tests which had smaller seed than later harvests and was slightly lower in percent germination. Combining swathed material dried less than 12% head moisture content appears to cause significant loss of seed resulting in low yield.

The apparent advantage in higher seed yields following direct combining compared to swathing and combining, even when done at the appropriate moisture content, in the 1989 tests contrasts with the 1988 tests which showed no influence of harvest method on seed yield. Because of the inconsistent results obtained from trials conducted in the two years, it is necessary to repeat the tests for an additional year in order to provide the proper information on harvest method to seed producers.

Table 1. Response in seed yield and quality to time of swathing and combining of perennial ryegrass. 1988.

Head Moisture Content (%)		Seed Yield ($kg\ ha^{-1}$)	Thousand Seed Weight (g)	Green Seed (%)	Germination (%)
Swathing	Combining				
48	24	1185	1.32	18	77
48	12	1143	1.35	12	81
40	15	982	1.38	12	85
35	10	932	1.45	3	88
30	16	741	1.49	1	87

Table 2. Response in seed yield and quality to time of direct combining of perennial ryegrass. 1988.

Head Moisture Content (%)	Seed Yield (kg ha^{-1})	Thousand Seed Weight (g)	Green Seed (%)	Germination (%)
35*	1160	1.44	6	93
10*	176	1.60	8	91
Total	1336			
30	1046	1.51	2	93
27	937	1.47	0	89
22	780	1.56	0	93

* Swath recombined.

Table 3. Response in seed yield and quality to time of direct combining of perennial ryegrass. 1989, Field 9.

Head Moisture Content (%)	Seed Yield (kg ha^{-1})			Thousand Seed Weight (g)		Shattered Seed Loss (kg ha^{-1})	1000 Seed Weight Shattered Seed (g)	Germination	
	Initial Combine	Recombine	Total	Initial Combine	Recombine			14 days	7 days
35	1403	-	1403	1.84	-	88	1.46	93	83
35	1469	248	1716	1.77	1.94	251	1.63	91	81
32	1534	-	1534	1.92	-	*	*	93	85
32	1704	90	1794	1.78	2.01	*	*	92	81
26	1150	-	1150	1.92	-	*	*	94	82
26	1328	107	1435	1.92	1.75	359	1.54	92	81
Mean	1431	148	1505	1.86	1.90	233	1.55	92	82
C.V.(%)	11.6	25.0	11.0	10.1	12.6	46.4	6.3	2.3	3.6
LSD 0.05	251	251	64	NS	NS	187	NS	NS	NS
LSD 0.01	347	347	97	NS	NS	NS	NS	NS	NS

* Data not collected.

Table 4. Response in seed yield and quality to time of swathing and combining of perennial ryegrass. 1989, Field 9.

Head Moisture Content (%)		Seed Yield (kg ha^{-1})	Thousand Seed Weight (g)	Shattered Seed Loss (kg ha^{-1})	1000 Seed Weight Shattered Seed (g)	Germination (%)	
Swathing	Combining					14 days	7 days
52	18	1242	1.54	119	1.17	92	74
52	10	1167	1.39	304	1.33	92	74
47	9	1341	1.70	196	1.34	95	88
35	10	893	1.69	775	1.48	95	88
32	15	739	1.76	988	1.38	97	92
32	10	679	1.77	863	1.36	98	91
Mean		1037	1.66	464	1.36	96	86
C.V.(%)		10.9	7.0	70	82	2.4	8.0
LSD 0.05		166	0.17	479	0.16	3.3	10.0
0.01		226	0.23	652	0.22	NS	140

Table 5. Response in seed yield and quality to time of direct combining of perennial ryegrass. 1989, Field 51.

Head Moisture Content (%)	Thousand Seed Yield (kg ha^{-1})			Thousand Seed Weight (g)		Shattered Seed Loss (kg ha^{-1})	Seed Weight Shattered Seed (g)	Germination (%)	
	Initial Combine	Recombine	Total	Initial Combine	Recombine			14 days	7 days
34	1420	-	1420	1.71	-	177	1.31	92	82
34	1162	145	1308	1.63	1.54	212	1.26	92	85
28	1299	-	1299	1.68	-	250	1.20	92	88
28	1398	127	1526	1.78	1.80	165	1.31	94	86
26	1306	-	1306	1.72	-	266	1.34	93	85
26	1426	72	1498	1.81	1.82	224	1.35	94	84
Mean	1335	115	1393	1.72	1.72	216	1.30	93	85
C.V.(%)	9.7	9.6	9.1	3.2	14.2	64.7	7.5	2.7	4.7
LSD 0.05	NS	19	NS	0.08	NS	NS	NS	NS	NS
0.01	NS	29	NS	0.11	NS	NS	NS	NS	NS

Table 6. Response in seed yield and quality to time of swathing and combining of perennial ryegrass. 1989, Field 51.

Head Moisture Content (%)		Seed Yield (kg ha^{-1})	Thousand Seed Weight (g)	Shattered Seed Loss (kg ha^{-1})	Thousand Seed Weight Shattered Seed (g)	Germination (%)	
Swathing	Combining					14 days	7 days
51	7	880	1.70	246	1.38	95	88
45	9	1086	1.76	587	1.40	94	89
34	12	923	1.81	556	1.36	96	92
34	7	571	1.81	650	1.34	95	92
23	11	704	1.73	284	1.30	94	89
23	8	506	1.53	403	1.43	95	91
Mean		829	1.76	445	1.37	95	90
C.V.(%)		16.2	4.0	65	6.5	1.7	3.4
LSD 0.05		198	NS	NS	NS	NS	NS
0.01		269	NS	NS	NS	NS	NS

CONTROL OF PERENNIAL RYEGRASS SEEDLINGS IN RYEGRASS SEED FIELDS

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AT APPLICATION

Method Date and Crop Growth Stage:
July - July 22, 1988: Ryegrass stubble 3-5 cm tall.
September - September 21, 1988: established ryegrass 12.5 cm tall.
Equipment: Bicycle sprayer
Spray Volume: 225 l ha^{-1}

Tips: SS 8002 LP
Spraying Pressure: 157 kPa
Weed Growth Stage: July 22 - ryegrass volunteer seedlings 1 leaf stage, Sept. 21 - ryegrass seedlings 3-5 leaves.

Treatment	Rate (kg ha^{-1})	Application Time	Average Inter-row Width (cm) Aug. 23/89	Visual Seedling Control Rating Aug. 30/89	Ryegrass Seed Yield (kg ha^{-1}) Aug. 89
Simazine	1.0	July	6.2	47	1414
Simazine	1.0	September	5.5	47	1208
Simazine	2.0	July	4.9	40	1257
Simazine	2.0	September	6.4	45	870
Atrazine	1.0	July	4.2	30	1623
Atrazine	1.0	September	6.9	12	1331
Atrazine	2.0	July	5.9	47	1339
Check (no chemical)			5.2	3	1416
Atrazine	2.0	September	6.3	52	605
Metribuzin	0.5	July	5.0	22	1530
Metribuzin	0.5	September	6.8	35	1370
Metribuzin	1.0	July	5.9	45	1597
Metribuzin	1.0	September	4.2	2	1300
Paraquat	1.0	July	3.1	8	1482
Paraquat	1.0	September	5.0	50	1114
LSD 0.05			3.2	NS	207

September applications of triazine herbicide were more injurious to the ryegrass stand than July treatments. No treatments were particularly effective in controlling volunteer ryegrass seedlings.

VOLUNTEER WHEAT CONTROL IN ESTABLISHING PERENNIAL RYEGRASS GROWN FOR SEED PRODUCTION

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AT APPLICATION

Method Date and Crop Growth Stage: 3 leaf fall - Sept. 21, 88; Ryegrass 4-5 leaves, 6 leaf fall - Oct. 6, 88, Ryegrass 7-8 leaves, Spring - May 3, 89; Ryegrass 3 new leaves.
Equipment: Bicycle sprayer
Spray Volume: 225 l ha^{-1}
Tips: SS 8002 LP
Spraying Pressure: 175 kPa
Weed Growth Stage: Sept. 21, 88 - Volunteer wheat 3 leaves, October 6, 88 - Volunteer wheat 6 leaves plus tillers, May 3, 1989 - Volunteer wheat 4 leaves 7-10 cm tall.

Treatment	Rate (kg ha^{-1})	Application Time	Wheat Foliage Fresh Weight (g/.25 m^2) June 27/89	Visual Rating % Stand After Harvest	Ryegrass Seed Yield (kg ha^{-1}) Aug. 89
Sodium TCA	2.0	2 leaf fall	720	88	961
Sodium TCA	2.0	5 leaf fall	721	87	992
Sodium TCA	2.0	Spring	805	89	986
Sodium TCA	4.0	2 leaf fall	514	87	1055
Sodium TCA	4.0	5 leaf fall	603	82	750
Sodium TCA	4.0	Spring	573	86	1121
Sodium TCA	6.0	2 leaf fall	115	75	606
Sodium TCA	6.0	5 leaf fall	426	69	763
Sodium TCA	6.0	Spring	464	80	983
Ethofumesate	1.0	2 leaf fall	905	86	1010
Ethofumesate	1.0	5 leaf fall	848	84	827
Ethofumesate	1.0	Spring	756	86	1023
Ethofumesate	1.5	2 leaf fall	756	81	976
Ethofumesate	1.5	5 leaf fall	516	81	934
Ethofumesate	1.5	Spring	806	87	972
Ethofumesate	2.5	2 leaf fall	100	69	750
Ethofumesate	2.5	5 leaf fall	49	69	764
Ethofumesate	2.5	Spring	464	80	1167
Check (no chemical)			954	81	1036
Atrazine	0.5	2 leaf fall	1080	23	134
Atrazine	0.5	5 leaf fall	965	72	641
Atrazine	0.5	Spring	828	79	792
Atrazine	1.0	2 leaf fall	353	0	0
Atrazine	1.0	5 leaf fall	691	25	263
Atrazine	1.0	Spring	415	71	640
Simazine	0.5	2 leaf fall	1003	64	398
Simazine	0.5	5 leaf fall	869	79	793
Simazine	0.5	Spring	1001	79	711
Simazine	1.0	2 leaf fall	1109	31	125
Simazine	1.0	5 leaf fall	845	69	465
Simazine	1.0	Spring	873	77	866
LSD 0.05			281	14	265

BROADLEAF CONTROL IN ESTABLISHED RYEGRASS

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AT APPLICATION

Method Date and Crop Growth Stage: Fall - Sept. 28/88; Ryegrass 5-6 leaves (7 cm tall). Spring - May, Ryegrass 8-15 cm. tall.
Equipment: Bicycle sprayer
Spray Volume: 225 l ha^{-1}
Tips: SS 8W2 LP
Spraying Pressure: 17 kPa
Weed Growth Stage: Sept. 28/88 - lamb'squarters 3-5 pr., wild mustard rosettes to 30 cm across, wormseed mustard 2 pr. (some plants up to 12 cm tall), Spring- May 24/89 - wild buckwheat 1-3 leaves, ragweed 2 leaf pair, lady's thumb 2 leaves.

Treatment	Rate (kg ha^{-1})	Application Time	Weed Control Ratings July 17, 1989		Ryegrass Seed Yield (kg ha^{-1}) Aug. 89	Percent Stand After Harvest
			Lady's Thumb	Wild Buckwheat		
2,4-D Amine	0.5	Fall	71	71	1138	91
2,4-D Amine	0.5	Spring	85	95	1270	86
2,4-D Amine	1.0	Fall	81	41	985	84
2,4-D Amine	1.0	Spring	70	89	1088	88
2,4-D Amine	1.5	Fall	44	46	992	86
2,4-D Amine	1.5	Spring	88	100	1067	86
2,4-D LV Ester	1.0	Fall	54	49	1028	80
2,4-D LV Ester	1.0	Spring	66	68	962	89
Dicamba	0.15	Fall	53	25	855	81
Dicamba	0.15	Spring	100	98	946	83
Dicamba	0.30	Fall	36	63	777	77
Dicamba	0.30	Spring	89	96	1122	79
Dicamba	0.60	Fall	73	85	958	84
Dicamba	0.60	Spring	100	100	886	65
Check (no chemical)			55	25	989	59
Bromoxynil	0.30	Fall	45	35	1153	49
Bromoxynil	0.30	Spring	100	100	1071	63
Bromoxynil	0.60	Fall	35	30	1147	65
Bromoxynil	0.60	Spring	98	100	1169	58
Bromoxynil	0.90	Fall	38	53	927	63
Bromoxynil	0.90	Spring	100	100	1273	71
Linuron	0.50	Fall	29	25	705	71
Linuron	0.50	Spring	94	74	859	80
Linuron	1.0	Fall	4	0	277	33
Linuron	1.0	Spring	100	100	589	70
Paraquat	0.50	Fall	0	0	0	0
Paraquat	0.50	Spring	8	13	0	56
Paraquat	1.0	Fall	0	0	0	0
Paraquat	1.0	Spring	10	6	0	40
LSD 0.05					258	30

EVALUATION OF THIRTEEN PERENNIAL RYEGRASS CULTIVARS FOR SEED PRODUCTION

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Department of Crop Science

PURPOSE

To evaluate thirteen varieties of perennial ryegrass for seed production in southern Ontario.

PROCEDURE

Experimental design: Randomized complete block. Four replicates were used.
Plot size: 6.0 m. x 1.24 m.; 7 rows, 17.78 cm wide, harvested.
Previous crop: Soybean plowed under in fall of 1986. Fallow 1987 until seeding.
Date of Seeding: 21/08/87.
Rate of Seeding: 4.0 kg ha^{-1}
Fertilizer: 1987: 50 kg ha^{-1} nitrogen applied 28/09/87; 340 kg ha^{-1} 0-20-20 applied 14/10/87. 1988: 60 kg ha^{-1} nitrogen applied 04/05/88. 300 kg ha^{-1} 0-20-20 applied 28/09/88. 55 kg ha^{-1} nitrogen applied 28/09/88. 1989: 60 kg ha^{-1} nitrogen applied 28/04/89.
Herbicide: 1987: Basagran 1.75 L ha^{-1} + Assist 15/09/87; Simazine 50WP 0.84 kg a.i. ha^{-1} 15/10/87; 1988: Atrazine 80WP 1.5 kg ha^{-1} applied 12/08/88.
Varieties: Turf types: Barry, Derby, Fiesta, Fiesta II, Palmer, Pennant, WWE 207, Yorktown II.
Forage types: Bastion, Condesa, Johnstone*, Kenhy*, Norlea. (*P. ryegrass x fescue.)
Winter sunival: recorded as percent of plot with living plants; observed 4/05/88; 25/05/89.
Days to Head: recorded when 50% of heads extended above flag leaf collar.
Days to anthesis: recorded when 50% of heads showed 10% extruded anthers.
Yield: direct combine harvested; yield calculated at 10% moisture.

COMMENTS

This test suffered from ice encasement during the winter of 1988. Accordingly, the test is more indicative of varietal tolerance to ice encasement than yielding ability of the variety. There was no additional winter kill during the winter of 1989. The percent survival data are higher than the 1988 data because the survival was observed approximately 20 days later, following a more complete recovery of the plants.

Table 1. Evaluation of 13 perennial ryegrass cultivars for seed production over two years, Elora Research Station. 1988, 1989.					
Cultivars	Winter Survival (%)		Seed Yield (kg ha^{-1})		
	1987/88	1988/89	1988	1989	Mean
Fiesta II	38	56	820	1085	912
Fiesta	28	46	784	1025	905
Norlea	63	70	820	941	881
Yorktown II	43	53	683	1032	858
Palmer	17	33	501	1019	760
WWE207	25	50	477	980	729
Barry	36	48	630	787	709
Kenhy	43	56	337	797	567
Johnstone	7	38	149	731	440
Pennant	5	13	235	350	293
Derby	2	10	143	316	230
Condesa	4	8	128	174	151
Bastion	2	8	68	130	99
Mean	24	37	444	720	582
LSD 0.05	25	20	237	271	
C.V.	72	37	37	26	

Table 2. Evaluation of 13 perennial ryegrass cultivars for seed production over two years, Elora Research Station. 1988, 1989.									
Cultivars	Date of Heading[a]			Date of Anthesis[b]			Date of Harvest		
	1988	1989	Means	1988	1989	Means	1988	1989	Means
Fiesta II	June 10	June 14	June 12	June 19	June 22	June 20.5	July 13	July 31	July 22
Fiesta	June 10	June 16	June 13	June 17	June 22	June 19.5	July 13	July 31	July 22
Derby	June 10	June 16	June 13	June 18	June 22	June 20	July 27	July 31	July 29
Palmer	June 10	June 19	June 15	June 17	June 27	June 20.5	July 27	July 31	July 29
Johnstone	June 10	June 22	June 16	June 17	June 26	June 21.5	July 13	July 31	July 22
Kenhy	June 10	June 22	June 16	June 17	June 26	June 21.5	July 13	July 31	July 22
Pennant	June 10	June 23	June 17	June 17	June 26	June 21.5	July 27	July 31	July 29
Condensa	June 10	June 24	June 17	June 18	June 28	June 23	Aug 04	Aug 09	Aug 07
Yorktown II	June 13	June 24	June 19	June 19	June 28	June 23.5	July 27	July 31	July 29
Bastion	June 10	June 28	June 19	June 18	July 03	June 25.5	Aug 04	Aug 09	Aug 07
Norlea	June 15	June 26	June 21	June 22	June 30	June 26	July 27	July 31	Ju1y 29
WWE207	June 15	June 28	June 22	June 20	July 03	June 26.5	Aug 04	Aug 09	Aug 07
Barry	June 15	June 28	June 22	June 22	July 03	June 27.5	July 27	Aug 09	Aug 03
Mean	June 11	June 23	June 17	June 19	June 27	June 23	July 25	Aug 03	July 30

[a] - observed when 50% of heads extend above flag leaf collar.
[b] - observed when 50% of heads showed 10% extruded anthers.

EVALUATION OF TWENTY PERENNIAL RYEGRASS CULTIVARS FOR SEED PRODUCTION

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PURPOSE

To evaluate 20 cultivars of perennial ryegrass for seed production in Southern Ontario. These cultivars include turf and forage types.

PROCEDURE

Experimental design: Randomized complete block. Four replicates.
Plot size: 6.0 m x 1.24 m; 7 rows, 17.7g cm wide, harvested.
Previous crop: Red clover plowed under in fall of 1987. Fallow until seeding.
Date of Seeding: 12/08/88
Rate of Seeding: 4 kg ha^{-1}.
Fertilizer: 1988: 300 kg ha^{-1} 0-20-20 applied 28/09/88. 55 kg ha^{-1} nitrogen applied 28/09/88. 1989: 90 kg ha^{-1} nitrogen applied 28/04/89.
Cultivars: Turf types: Barry, Derby, Fiesta, Fiesta II, Gator, Omega II, Palmer, Pennant, Ronja, WWE202, WWE207, WWE217, Yorktown II. Forage types: Bastion, Condesa, Frances, Grimalda, Johnstone, Kenhy, Norlea.
Plant Height: recorded in cm as average of two observations per plot; observed 14/07/89.
Lodging Index: recorded using the Belgium system (0.2 = no lodging; 9.0 = completely lodged). Two ratings, 27/06/89 and 27/07/89.
Days to Head: recorded when 50% of heads extend above flag leaf collar.
Days to Anthesis: recorded when 50% of heads showed 10% extruded anthers.
Winter Survival: recorded as percent of plot with living plants; observed 10-15/05/89.
Stand Establishment: recorded as percent of plot with plants (dead and alive); observed 10- 15/05/89.
Leaf Rust: recorded as 1-5 rating as percent of tillers showing greater than 10% infestation where:
1 = <10% 2 = 10-25%
3 = 25-50% 4 = 50-75%
5 = >75%, observed 27/07/89.
Yield: direct combine harvested; yield calculated at 10.0% moisture.

COMMENTS

The winter kill that occurred in this test resulted from ice encasement. The European forage type varieties appear to be more sensitive to icing than the turf types. Kenhy and Johnstone also had reduced winter survival although their yields were probably reduced by late harvest for these early lines. The precipitation of late May and June favored the late maturing varieties for seed yield.

Table 1. Evaluation of 20 perennial ryegrass cultivars for seed production, Elora Research Station. 1989.

Cultivars	Seed Yield (kg ha^{-1})	Seed Weight[a] (g)	Plant Height (cm)	Lodging Index[b]	Lodging Index[c]	Days to 50% Head[d]	Days to Anthesis[d]	Winter Survival[e] (%)	Leaf Rust[f] (%)	Date of Harvest
Norlea	1453	1.88	85.0	3.6	9.0	26	30	86	2.5	10/08
WWE217	1434	1.92	82.5	3.9	9.0	26	28	91	2.0	10/08
WWE207	1258	1.84	78.1	2.7	8.6	26	30	71	1.0	10/08
Fiesta	1253	2.07	63.1	5.4	8.3	14	22	78	3.8	03/08
Omega II	1194	2.24	56.9	5.7	8.1	16	23	77	1.0	03/08
Fiesta II	1183	2.01	74.4	5.0	8.3	19	23	83	4.0	03/08
Gator	1156	1.94	65.0	4.0	8.1	22	26	73	3.3	03/08
Yorktown II	1136	1.73	72.5	4.7	9.0	26	30	84	5.0	03/08
Palmer	1132	2.20	63.1	5.8	8.1	22	26	89	2.6	03/08
Pennant	1077	2.29	66.3	6.7	8.8	14	22	82	3.5	03/08
Grimalda	894	3.45	69 4	3.9	6.6	19	28	46	4.8	03/08
Barry	870	1.91	78.8	3.4	8.3	26	30	70	3.0	10/08
Ronja	868	1.76	73.8	2.9	9.0	30	35	62	2.5	10/08
Frances	864	2.02	63.1	6.4	8.1	19	28	71	3.0	03/08
WWE202	796	1.70	80.0	2.2	7.9	32	37	82	2.3	10/08
Derby	739	1.96	70.6	3.4	7.2	22	28	34	4.8	03/08
Bastion	736	3.30	75.0	4.4	7.4	24	28	48	3.0	03/08
Kenhy	521	2.46	78.1	1.2	4.1	19	23	56	1.5	03/08
Condesa	502	2.49	78.8	1.7	7.2	37	41	56	2.0	10/08
Johnstone	404	2.59	68.8	1.0	4.7	19	30	43	1.0	03/08
Mean	973	2.19	72.2	3 9	7.8	22.9	28.4	70	2.8	-
LSD 0.05	214	0.14	7.1	1.8	1.7	-	-	19.7	0.63	-
C.V. (%)	15.5	4.5	6.9	33.2	11.6	-	-	19.9	16.01	-

[a] - weight of 1,000 seeds; [b] - observed 27/06/89; [c] - observed 27/07/89; [d] - day one is 01/06/89; [e] - observed 10-15/05/89; [f] - observed 10-15/05/89.

EVALUATION OF TWO CULTIVARS OF TURF-TYPE TALL FESCUE FOR SEED PRODUCTION

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PURPOSE

To evaluate potential seed production of turf-type tall fescue in Southern Ontario.

PROCEDURE

Experimental design: Randomized complete block design. Four replicates. Plot size: 6.0 m x 1.24 m; 7 rows, 17.78 cm wide.
Previous crop: Red clover plowed under in fall of 1987. Fallow until seeding.
Date of Seeding: 12/08/88.
Rate of Seeding: 5.0 kg ha^{-1}
Fertilizer: 1988: 300 kg ha^{-1} 0-20-20 applied 28/09/88. 55 kg ha^{-1} nitrogen applied 28/09/88. 1989: 90 kg ha^{-1} nitrogen applied 28/04/89.
Cultivars: Mustang. Rebel II.
Plant Height: recorded in cm as average of two observations per plot; observed 14/07/89.
Lodging Index: recorded using the Belgium system (0.2 = no lodging; 9-0 = completely lodged); observed 27/06/89.
Days to Head: recorded when 50% of heads extend above flag leaf collar.
Days to Anthesis: recorded when 50% of heads showed 10% extruded anthers.
Winter Survival: recorded as percent of plot with living plants; observed 10/05/89.
Stand Establishment: recorded as percent of plot with plants (dead and alive); observed 10/05/89.
Yield: swathed at approximately 35% m.c. (14/07/89) then combined (17/07/89); yield calculated at 10% moisture

Table 1. Evaluation of two turf-type tall fescue cultivars for seed production, Elora Research Station. 1989.

Attribute	Variety		CV (%)
	Rebel II	Mustang	
Seed yield (kg ha^{-1})	1355	1250	22.1
Seed weight (g)[a]	2.39	2.32	2.37
Plant height (cm)	107	98	8.7
Lodging index[b]	5.6	5.6	3.1
Winter Survival[c]	91	92	3.7
Stand Establishment[d]	91	94	3.0
Days to Head[e]	12	10	
Days to Anthesis[e]	26	24	

[a] - weight of 1,000 seeds; [b] - observed 27/06/89; [c] - observed 10/05/89; [d] - observed 10/05/89; [e] - day one is 01/06/89.

EVALUATION OF KENTUCKY BLUEGRASS FOR SEED PRODUCTION

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PURPOSE

To evaluate Kentucky bluegrass for potential seed production in Southern Ontario.

PROCEDURE

Experimental Design: Randomized complete block design. Four replicates.
Plot Size: 6.0 m x 1.24 m; 7 rows, 17.78 cm wide.
Previous Crop: Red clover plowed under in fall of 1987. Fallow until seeding.
Date of Seeding: 12/08/88.
Rate of Seeding: 2.5 kg ha^{-1}.
Fertilizer: 1988: 300 kg ha^{-1} 0-20-20 applied 28/09/88. 55 kg ha-l nitrogen applied 28/09/88. 1989: 90 kg ha^{-1} nitrogen applied 28/04/89.
Cultivars: Cheri, Gnome, Haga, Nassau, Regent, Sydsport.
Plant Height: recorded in cm. Average of two observations per plot; observed 14/07/89.
Lodging Index: Belgium system (0.2 = no lodging, 9.0 = completely lodged); observed 27/ 06/89.
Days to head: recorded when 50% of heads extend above flag leaf collar.
Days to anthesis: recorded when 50% of heads showed 10% extruded anthers.
Winter survival: recorded as percent of plot with living plants; observed 10/05/89.
Stand establishment: recorded as percent of plot with plants (dead and alive); observed 10/05/89.
Yield: swathed at 25-30% mc (14/07/89) then combined (17/07/89); yield calculated at 10% seed moisture content.

COMMENTS

There was a fairly uniform, heavy weed stand, primarily smartweed, which may have affected seed yield. However, the yield data represent the first seed harvest following establishment in August. Other areas of production have reported reduced seed yields in the first harvest year following a summer seeding of Kentucky bluegrass.

Table 1: Evaluation of six Kentucky bluegrass cultivars for seed production in first year of harvest, Elora Research Station. 1989.

Cultivar	Seed Yield (kg ha^{-1})	Seed Weight (g)[a]	Plant Height (cm)	Lodging Index[b]	Winter Survival[c]	Stand Establishment[d]	Days to Head[e]	Days to Anthesis[e]
Regent	303	0.38	63.5	1.4	86	89	16	19
Cheri	300	0.34	62.0	1.9	88	89	16	19
Gnome	293	0.35	57.0	0.9	91	92	16	19
Haga	285	0.33	59.3	4.9	90	91	12	19
Nassau	232	0.32	60.3	1.6	87	88	16	19
Sydsport	224	0.34	62.5	1.6	92	93	16	19
Mean	273	NS	60.8	2.1	89	90	15.3	19
LSD 0.05	NS	NS	NS	1.2	3.6	NS		
C.V.(%)	20.6	11.8	8.9	383	2.7	3.1		

[a] - weight of 1,000 seeds; [b] - observed 27/06/89; [c] - observed 10/05/89; [d] - stand establishment observed 10/05/89; [e] - day one is 01/06/89

THE EFFECT OF PLANT GROWTH REGULATORS ON FLORET DYNAMICS AND SEED PRODUCTION OF PERENNIAL RYEGRASS

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The difference between potential and actual yield in perennial ryegrass suggests that floret site utilization is determined by the dynamics of the floret population during the period from anthesis to seed harvest.

The floret dynamics during the first 10 days following anthesis, seed shattering at maturity, and seed yield of "Fiesta II" and "Norlea" perennial ryegrass were investigated in seven field experiments conducted near Elora, Ontario, in 1988 and 1989. Four plant growth regulators (PGRs: paclobutrazol, CCC+CC, XE-1019, and ethephon) were applied at three different rates and two developmental stages. Combinations of nitrogen (N) rates, paclobutrazol, and a systemic fungicide (propiconazole) were also investigated. Source-sink relationships were altered by selective defoliation.

Shedding of seed-bearing florets started 6-8 days after anthesis and paclobutrazol appeared to retard floret abscission whereas the effect of other PGRs was inconsistent. Seed set at Day 2 after anthesis averaged 84% and was not affected by treatments. After 10 days, 20 to 30% of the seed initially set had aborted. Paclobutrazol, XE-1019 and CCC+CC significantly reduced abortion in several instances, but the effect was inconsistent. Shattered seed at maturity amounted to 40% of overall mean yield. In experiments in which the four PGRs were examined, all PGRs, except paclobutrazol, increased seed shattering. In other experiments, the effect of paclobutrazol was inconsistent. Overall, paclobutrazol seems to increase seed retention up to a critical maturity point, suggesting a major role for timing and method of harvest. Seed yield was not affected by PGRs other than paclobutrazol. The effect of paclobutrazol on seed yield was variable. It appears that paclobutrazol is biologically very active and unpredictable interactions with climate and precise developmental stage at application, determine the direction of the response. The most consistent response to paclobutrazol, and to a lesser degree to XE-1019, was control of lodging and the fungicidal activity of those two triazoles. Also consistent was the increased proportion of green leaves and N content in leaves of paclobutrazol-treated plants. However, seed yield was not related to control of lodging nor increased N content in the leaves. The overall occurrence of early seed abortion under different source-sink relationships induced by the PGRs, N and defoliation treatments suggests that abortion is determined by factors other than nutritional. Chemical manipulation of seed crops can alter floret dynamics and crop morphology but the effects on yield are not predictable.

This report summarizes the results of research described in a PhD thesis completed by the first author in December 1990.

TURFGRASS MANAGEMENT AND RENOVATION

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.

Preliminary observations indicate that tall fescue (Figure 1) is more sensitive to reduced soil temperatures than perennial ryegrass (Figure 2). Seedings after the end of September show delayed or reduced germination, and seedings after the end of October have not germinated to date. Observations in the spring of 1991 will determine the long term effects of timing.

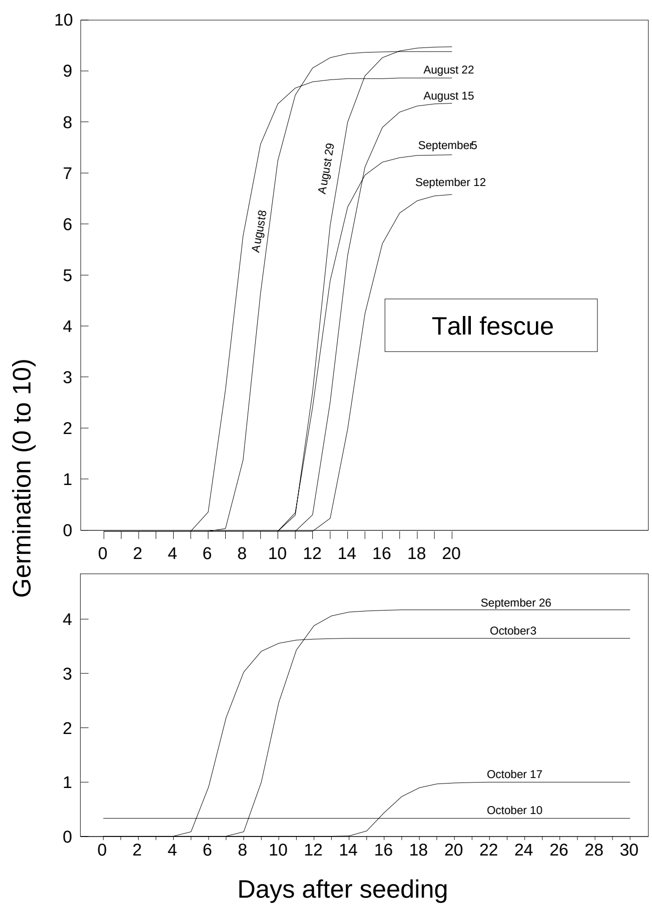

Figure 1. Germination of tall fescue seedings. Curves of the form:

$$\text{Germination} = \exp(-\beta \exp(-\text{Days}))$$

were fitted to the data points to estimate speed of germination.

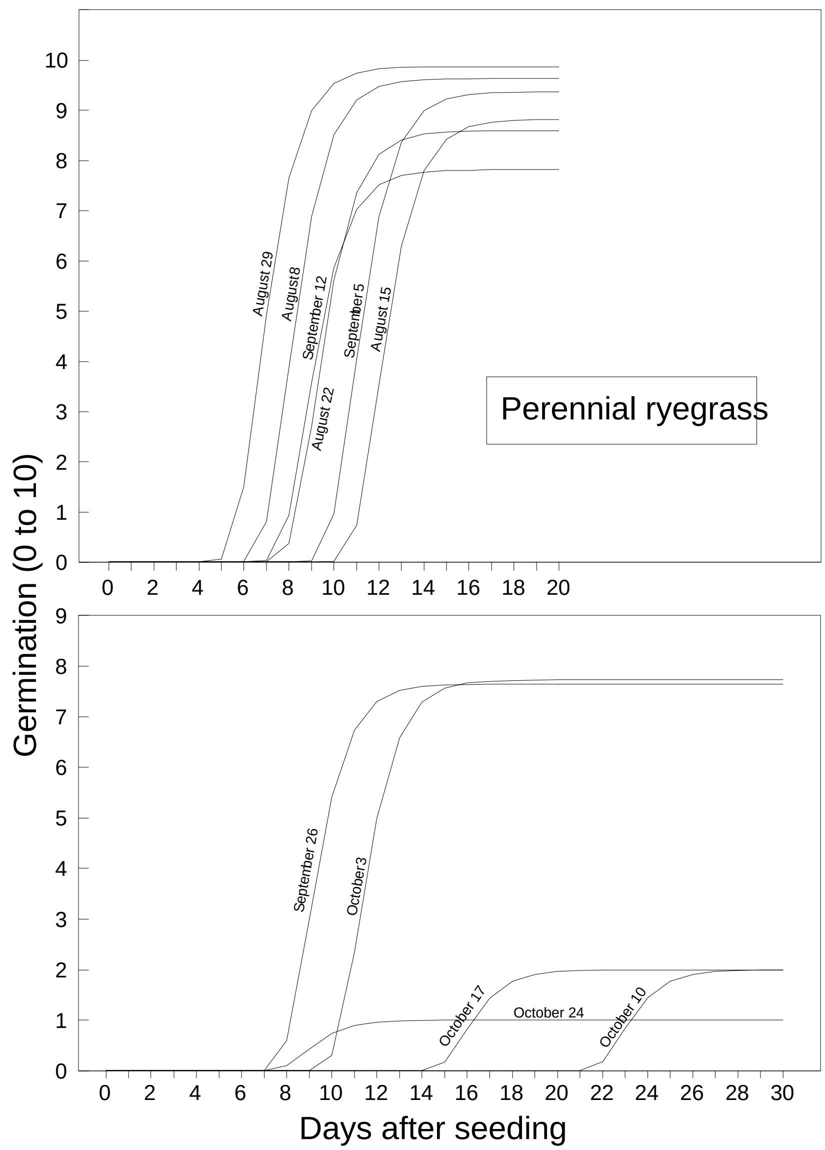

Figure 2. Germination of perennial ryegrass seedings. Curves of the form:

$$\text{Germination} = \exp(-ß \exp(-\text{Days}))$$

were fitted to the data points to estimate speed of germination.

TURF RENOVATION BY SODDING - THE EFFECTS OF SITE PREPARATION INTENSITY AND TIMING

J. L. Eggens and K. Carey
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Introduction

Sodding is a fast, reliable method for establishing a new lawn. It is also a valuable method for renovation of old, neglected or problem turf areas. Compared to seeding or overseeding, it may be rather more expensive, both in material costs and in required labor.

The ideal conditions for successful sodding of a new lawn include: a cultivated, leveled, and smoothed bed of good topsoil; sod laid when drought and heat stresses are at a minimum; adequate irrigation, applied "religiously"; and no traffic until the sod is knit. When new lawns are sodded, these conditions may be relatively easy to obtain without much extra effort, since the landscaping needs to be done anyway.

When sodding is used to renovate old turf areas, however, we have more opportunity (like it or not!) to decide just how much time and labor to invest in site preparation. Some preparation is absolutely necessary: old turf and weeds need to be killed and debris removed, and the area to be sodded needs to be reasonably smooth and level. Beyond that we have a number of options or alternatives. At the turf plots at the Cambridge Research Station, we have been experimenting with various alternatives for renovating turf areas with sod.

Experimental approach

Two important factors, which work together to determine the success of renovation by sodding, are the amount and type of site preparation, and the timing of the work (spring, summer, fall).

Research plots representing three sodding times (early summer, mid-summer, and fall) in high maintenance turf and two sodding times (mid-summer and fall) in low maintenance turf have been established at the Cambridge Research Station. We used a range of site preparations which we considered representative, from very intensive (time and labour) to almost no preparation. In all cases we first killed the old vegetation (in this case established Kentucky bluegrass/bentgrass/fescue turf) with Round-up7 (glyphosate). Ten to twenty days after Round-up treatment, the old turf was scalped with a rotary mower, and the debris removed. The site preparation treatments include 1. resodding over killed turf; 2. addition of 3 mm of topsoil and resodding; 3. vertical mowing (5 cm depth) and resodding; 4. rototilling to 13 cm and resodding and 5. stripping of killed turf and resodding over bare soil.

The experiments were repeated with spring, summer, and fall soddings in a high maintenance site (automatic irrigation), and with summer and fall soddings in a lower maintenance site (manual irrigation)

The effect of timing

Timing, both in terms of season of year and weather conditions, had a major effect on the short-term appearance of turf renovated by sodding. Sod laid in either late spring and midsummer required a period of recovery and showed stress symptoms for up to two months after sodding. In contrast, sod laid in the fall remained uniformly green, and all treatments were fully and equally recovered the following spring.

The effect of site preparation intensity

In late spring and midsummer sodding, when drought and temperature stress affects the appearance of the new sod, the lower intensity site preparation produces significantly poorer success in the first few days. This is evident primarily as an increase in the proportion of the new sod area which is brown. The rate of recovery or improvement (brown turning to green) is similar among the different treatments (Figure 1). By about 60 days after sodding, no differences remained among the sodding treatment. There was no difference among the treatments in winter survival, or any other medium term effects.

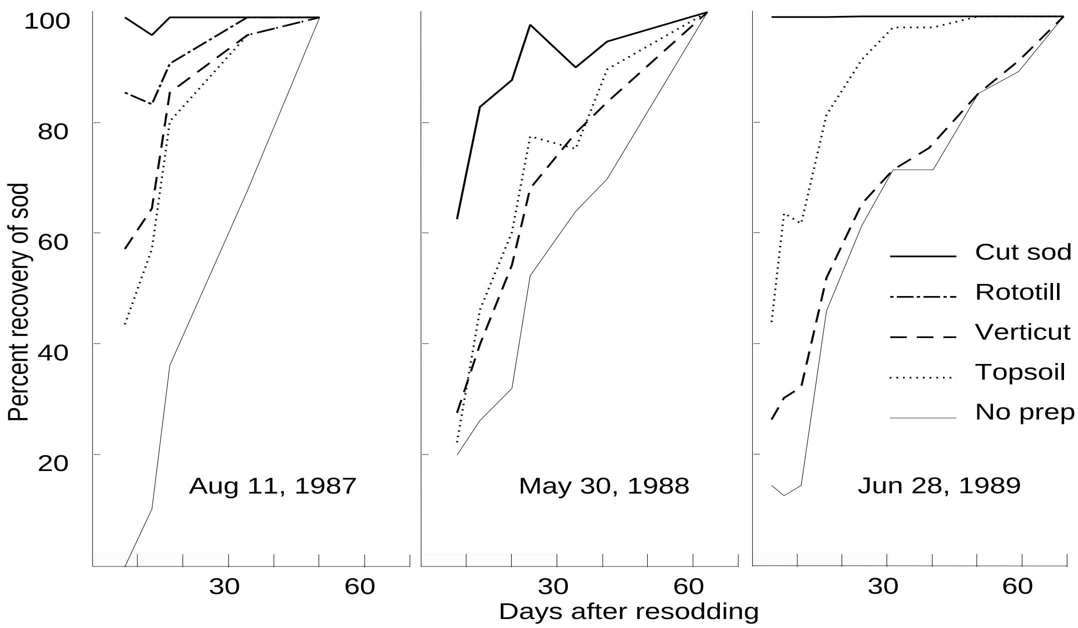

Figure 1. The effect of site preparation treatment on recovery of newly laid sod. The plots resodded August 11, 1987 and May 30, 1988 were in high maintenance turf; those resodded June 28, 1989 were in lower maintenance turf. Fall resodding treaments are not presented, because there was no stress damage, and uniform complete recovery.

Long term effects

One major difference between the treatments as we applied them is that the dead organic material under the new sod was a) removed by sod cutting, b) disrupted and mixed with mineral material to various extents (rototilling, verticutting, adding topsoil), or c) left intact (no preparation). We have not seen any difference in thatch development, layering, or root growth that might have been expected based on this. In all the treatments (so far), the old organic material has been incorporated without problems into the soil.

There has been some weed infestation in the older of the experiments (Figure 2). Annual bluegrass infestation is highest in treatments with the least site preparation, but generally there is no significant difference among the treatments in susceptibility to invasion by annual bluegrass, creeping bentgrass, or broadleaf weeds.

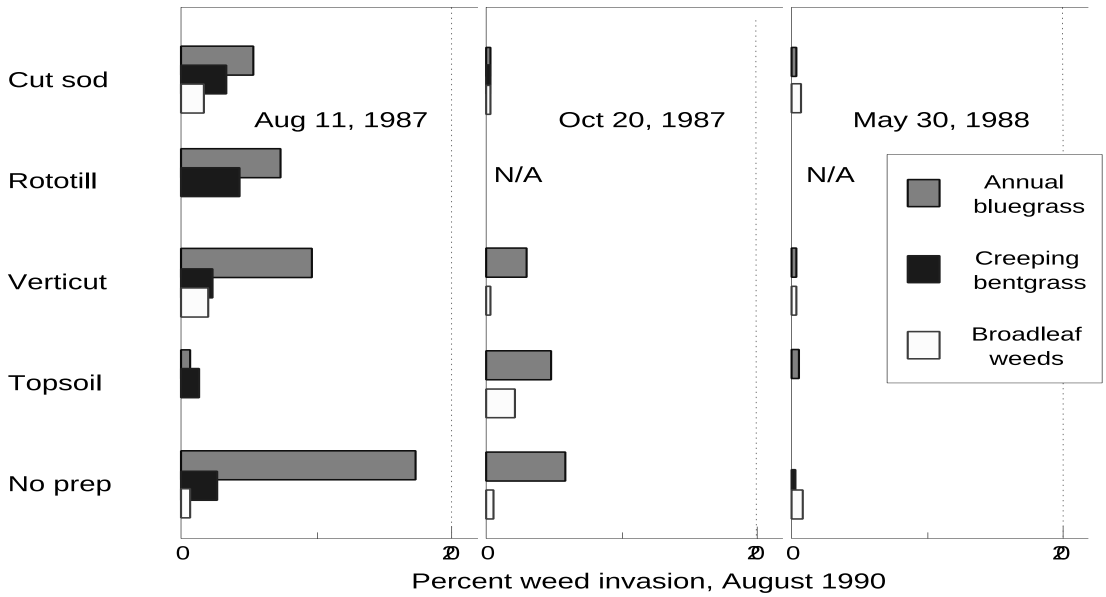

Figure 2. The effect of site preparation treatment on weed invasion into sodded turf.

Prescription and caveats

Anyone who has laid sod knows the pitfalls that may lead to failure. Some of these are present regardless of the type of preparation that you use for the site, and were not specifially addressed by this research.

Irrigation is the primary factor for success of sodding - no matter how you prepare the site, if the new sod is not properly irrigated, it will die. Depending on the season and weather, the first 20 to 30 days are the most important.

Protection of the new sod from physical disruption is also an important factor. Our research plots are protected from traffic, and the sites have at most a gentle slope, so the sod did not need to be pegged.

The third factor, which is perhaps the most difficult to deal with, is the willingness of the owner of the renovated turf to accept a period of recovery of the new sod. We have seen in our experiments that even the most minimal site preparation at the most stressful season of the year can result in full recovery and a successful renovation. However, there can be anywhere from 10 to 30 days delay in recovery to an acceptable level (75 to 80% green) with the less intensive preparation. If the renovation is done in early spring or late fall, the preparation intensity can be reduced without apparent effect.

With these factors in mind, we still may be able to reduce the intensity of site preparation in many renovation situations and still obtain successful results.

THE EFFECT OF DELAY AFTER ROUNDUP7 (GLYPHOSATE) APPLICATION ON THE SUCCESS OF RESODDING

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Department of Horticultural Science

Methods

This project was design to evaluate the effects of delay between Roundup7 application and resodding, if the minimal site preparation is used (that is, the turf killed and scalped, new sod laid over the dead turf). This experiment was set out in the late fall (November 14, 1989) in lower maintenance turf. Plots were sprayed with Roundup7 and then scalped (mowed to 1/2 inch and the debris removed) and resodded one, three or twenty days after herbicide application. A control treatment was resodded with no herbicide application.

Results

No stress damage was evident in the fall, but differences did appear the following spring. The results, as presented in Figure 1, indicate that at least 10 days should be left between spraying and scalping/resodding in order for damage to the new turf to be minimized. We are following the long-term progress of this experiment to see whether different periods of delay will affect weed invasion, etc.

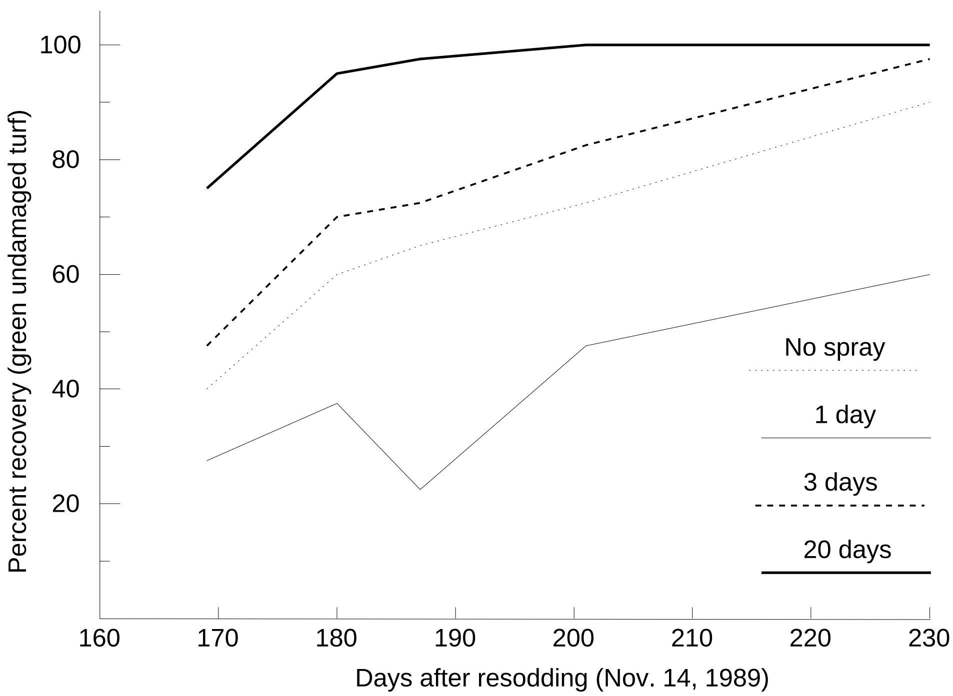

Figure 1. The effect of delay after Roundup7 treatment on the spring recovery of fall sodded turf. Treatments were a) no Roundup7 spray (sod laid over live turf), b) one day delay between spray and resodding, c) three days delay between spray and resodding, and d) 20 days delay between spray and resodding.

SODIUM FORMATE AS A DEICER: PHYTOTOXICITY TO TURFGRASS

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Department of Horticultural Science, Department of Land Resource Science,
Department of Environmental Biology

Sodium formate and sodium chloride were compared for their phytotoxic effects on turfgrass, as part of a larger study on sodium formate. Aqueous solutions of each salt (concentrations from 0.1% to 5%) were applied by backpack sprayer to Kentucky bluegrass turf at the Cambridge Research Station in the late winter 1989-1990. Tissue samples were collected for analysis for formate and chloride concentration.

Neither salt produced any significant phytotoxic effects on the turfgrass at the concentrations applied. There was some slight, barely significant yellowing of some plots at the higher concentrations of both sodium formate and sodium chloride, but the yellowing disappeared rapidly as the turf became active in the spring (Table 1).

Table 1. Yellowing[1] of Kentucky bluegrass turf sprayed with various concentrations of sodium formate and sodium chloride.

Treatment	Concentration (%)	April 9	April 23	April 30	May 4	May 14
Control		0.0	0	0	0	0.2
Sodium chloride	0.1	0.0	0	0	0	0.0
Sodium chloride	0.5	0.0	0	0	0	0.0
Sodium chloride	1.0	0.0	0	0	0	1.6
Sodium chloride	2.0	0.2	0	0	0	0.6
Sodium formate	0.1	0.0	0	0	0	0.0
Sodium formate	0.5	0.0	0	0	0	0.2
Sodium formate	1.0	0.0	0	0	0	0.2
Sodium formate	2.0	0.4	0	0	0	0.4
Sodium formate	5.0	1.6	0	0	0	0.4
	LSD (5%)	0.54	0	0	0	1.66

[1] Yellowing rated visually 0 to 10, 10 = completely yellow turf.

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. The software produces a hybrid of graphic and textual information, so that "pictures" of treated areas, scheduled treatments, management records, potential stress problems, soil/rootzone data and species/cultivar mixes can be presented in the form of a multicolored map of the turf area (golf course, city parks, sod farm, etc.) and combined with text windows of information about past and scheduled/predicted treatments. The software will be implemented and tested first at the new GTI research plots, and will allow us to track routine management and complex research programs, prevent missed or inappropriate treatments, optimize assignment of plots, and keep a detailed history of the research areas for future reference. When combined with weather data, this will allow us to include and test integrated pest management programs to predict and prevent pest outbreaks in timely, economical and ecologically sound fashion.

We hope to develop the management software to be flexible enough to form a core for further applications. In this regard, this proposal would represent a seed project, with future developments (applications developed for city park systems, road side vegetation, nursery management) funded and supported by municipalities, government ministries, etc. The requirement for accurate and accessible records, combined with assistance in making management decisions, will be vital to vegetation managers of all sorts as society demands increased consciousness of water use, chemical input, labour costs, etc.

The software is implemented for an IBM "standard" (640 K RAM, EGA or VGA color graphics) microcomputer, with some mass storage (hard disk) capability.

WEED CONTROL AND GROWTH REGULATION

WEED CONTROL IN TURF, 1990

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Department of Environmental Biology
University of Guelph

SUMMARY

Preemergence control of weeds in turf. Chlorthal-dimethyl, bensulide, trifluralin, ethalfluralin and the emulsifiable concentrate formulations of Mon-15104 gave excellent season long preemergence control of crabgrass. Granular applications of Mon-15111 FG, Mon-15112 FG, Mon-15152 G and Mon-15175 G also gave excellent preemergence control of crabgrass. Fall application of Mon-15104 and Mon-15111 FG, Mon-15112 FG and Mon-15175 G gave excellent season long control of crabgrass.

Postemergence control of crabgrass. Postemergence control of crabgrass at the two to three leaf stage and early tiller stage of development was good this year. Mon-15104, Mon-18775 and all formulations of Hoe-046360 and Hoe-033171 provided good to excellent control of crabgrass. Mon-15151 combined with Hoe-046360 90 EC gave excellent crabgrass control; however, Mon-15151 alone or in combination with Bas-514 or MSMA gave poor to good crabgrass control. The granular formulations of the Mon-15100 series were not as effective applied postemergent but still gave very good crabgrass control. Mon-15100 hose end formulations provided excellent control of preemergent and postemergent crabgrass with very little injury to the turfgrass. Home and garden applications of Hoe-046360 alone and combined with a fertilizer gave excellent control of crabgrass. Excellent crabgrass suppression was achieved with the HC90 series applied early, mid and late post. In some cases the HC90 series caused moderate injury to the turfgrass. Applications of bensulide, chlorthal-dimethyl, Ici-0604 and Asc-893 resulted in poor postemergent crabgrass control.

Phytotoxicity of herbicides when applied to turfgrass species. HC9015, HC9016, HC9017, HC9018 and Mon-15104 prevented germination of four turf species when applied just before and just after seeding. Hoe-033171 and Hoe-046360 did not reduce the % of germination in any of the four turfgrass species. Ubi-2587 and Ici-0604 caused severe damage to bentgrass species but the turf recovered later in the season. Ici-0604 applications to Kentucky bluegrass resulted in moderate injury to the turf. Little or no damage occurred to Kentucky bluegrass and fine fescue when treated with various Hoe-046360 formulations. No injury ocurred with applications of trifluralin, Asc-893, imazethapyr, Asc-66952 or isoxaban on Kentucky bluegrass. Applications of Mon-18701 and Mon-18702 for turf renovation completely controlled Kentucky bluegrass when applied postemergent. Neither Asc-893 or Asc-66952 caused injury to fine fescue or perennial ryegrass.

Selective control of annual bluegrass. Formulations of the Mon-15100 series gave moderate to good control of annual bluegrass in bentgrass swards when applied in the fall.

Broadleaf weed control. Clopyralid/triclopyr, MCPA/MCPP/dicamba, chlorsulfuron and chlorsulfuron with thiameturon gave good to excellent season long control of broadleaf weeds. Applications of Mon-18744 and Mon-18729 through the Expedite application system provided excellent broadleaf weed control. Isoxaben alone did not control broadleaf weeds.

MON-15100 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 - 0515-PRE
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0814, 0904

Additional information - Crabgrass was very slow to germinate due to unfavourable growing conditions.

		Dose	% Reduction of crabgrass (WAT)	
			12	15
1	Control	0.00	0	0
2	Mon-15104 EC	0.28	95	93
3	Mon-15014 EC	0.35	95	93
4	Mon-15104 EC	0.42	95	88
5	Mon-15104 EC	0.56	93	88
6	Mon-15104+2,4-D/MCPP/dicamba[1]	0.42+1.85	75	95
7	Mon-15104+MCPP/MCPA/dicamba[2]	0.42+1.85	88	83
8	Control	0.00	0	0
9	Mon-15152 2.5G	0.28	90	98
10	Mon-15152 2.5G	0.42	78	98
11	Mon-15175 2.5G	0.28	85	80
12	Mon-15111 2.7FG	0.28	88	85
13	Mon-15111 2.7FG	0.35	85	80
14	Mon-15111 2.7FG	0.42	85	95
15	Control	0.00	0	0
16	Mon-15112 3.5FG	0.56	100	93
17	chlorthal-dimethyl[3]	11.60	90	98
18	bensulide[4]	11.60	88	90
19	chlorthal-dimethyl	15.00	93	80
20	bensulide	15.00	90	93
21	isoxaban DF	2.75	93	93
22	isoxaban DF	3.66	95	98
23	isoxaban DF	4.13	95	100
24	trifluralin[5]	1.70	90	74
25	trifluralin	1.95	85	95
26	trifluralin	2.20	85	83

WAT - weeks after treatment EC - emulsifiable concentrate G - granule
FG - fertilizer granule WP - wettable powder DF - dry flowable
[1] 2,4-D+MCPP+dicamba-385/75/19 [2] MCPP/MCPA/dicamba-100/200/18
[3] chlorthal-dimethyl-750g/kg WP Fermenta [4] bensulide-480 g/l EC Chipman
[5] trifluralin-500 g/l EC Hoechst

Crabgrass did not germinate until the first week in July and pre-emergent treatments were applied on May 15. Good crabgrass suppression was achieved with all compounds up to 15 weeks after application. No injury occurred to Kentucky bluegrass.

EFFECT OF APPLICATION DATE ON THE 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 - 0516-PRE; 0530-PRE; 0612-PRE
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kpa
Tips - SS8002LP
Date of assessment - 0814; 0904.

	Treatment	Dose kg ai/ha	% Reduction of crabgrass (WAT)					
			Treatment[1]		Treatment[2]		Treatment3	
			12	15	10	13	8	11
1	Control	0.00	0	0	0	0	0	0
2	bensulide*	7.50	95	90	80	83	85	73
3	bensulide	11.00	83	85	83	85	73	73
4	bensulide	14.00	100	98	93	90	98	87
5	bensulide	16.80	93	90	85	90	75	93
6	chlorthal-dimethyl**	10.00	93	93	78	80	90	97
7	chlorthal-dimethyl	15.00	95	90	83	80	95	83
8	trifluralin***	1.95	80	83	73	95	73	93
9	trifluralin	2.20	98	93	83	85	83	90

WAT-weeks after treatment; EC-emulsifiable concentrate; WP-wettable powder.
*bensulide-480 g/l EC Chipman
**chlorthal-dimethyl 750 g/kg WP Fermenta
***trifluralin 500 g/l EC Hoechst
[1] Experiment sprayed 0516-PRE
[2] Experiment sprayed 0530-PRE
[3] Experiment sprayed 0612-PRE

All preemergence herbicides gave good control of crabgrass at the different application dates. Regardless of the application date, excellent crabgrass suppression was achieved throught the summer. No injury occurred to the Kentucky bluegrass.

POST-EMERGENCE 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 - 0710-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0814; 0904

	Treatment	Dose kg ai/ha	% Reduction of crabgrass (WAT)	
			4	8
	Control	0.00	0	0
2	Mon-15104 EC	0.28	90	85
3	Mon-15104 EC	0.35	98	85
4	Mon-15104 EC	0.42	93	85
5	Mon-15104 EC	0.56	98	88
6	Mon-15104+Agrol 90	0.42+0.5%	98	98
7	Mon-15104+2,4-D/MCPP/dicamba*	0.42+1.85	98	95
8	Mon-15104+MCPP/MCPA/dicamba**	0.42+2.00	98	95
9	Mon-15175 2.5G	0.28	60	68
10	Control	0.00	0	0
11	Mon-15152 2.5G	0.28	68	70
12	Mon-15152 2.5G	0.42	90	93
13	Mon-15111 2.7FG	0.28	60	50
14	Mon-15111 2.7FG	0.35	68	53
15	Mon-15111 2.7FG	0.42	53	30
16	Mon-15112 3.5FG	0.56	58	60
17	Hoe-0463690 EC	0.20	93	78
18	Hoe-046360 90 EC+trifluralin***	0.20+2.2	98	98
19	Ici-0604+Agrol 90	0.125+0.1%	20	15
20	Ici-0604+Agrol 90	0.25+0.1%	55	38
21	linuron****	1.00	40	15
22	linuron	1.50	78	35

WAT - weeks after treatment EC - emulsifiable concentrate G - granule FG - fertilizer granule
*2,4-D/MCPP/dicamba-385/75/19 **MCPA/MCPP/dicamba-200/100/18
***trifluralin-500 g/l EC Hoechst ****linuron-450 g/l EC Hoechst

Mon-15104 gave good control of crabgrass when applied at the 1-3 leaf stage of crabgrass, with and without agrol 90 and with the addition of 2,4-D/MCPP/dicamba and MCPP/MCPA/dicamba. The low rate of Mon-15152, and Mon-15175, Mon-15111, Mon-15112, Ici-0604 and linuron were not as effective as Mon-15104. Regardless of treatment no injury occurred to Kentucky bluegrass.

POST-EMERGENCE 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 - 0801-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0814; 0904

	Treatment	Dose kg ai/ha	% Reduction of crabgrass (WAT)	
			2	5
1	Control	0.00	0	0
2	Mon-15104 EC	0.28	45	73
3	Mon-15151 EC	0.56	68	100
4	Mon-15151+msma*	0.28+1.12	58	93
5	Mon-15151+msma	0.56+2.24	53	93
6	Mon-18775 75EC	1.40	80	93
7	Mon-18775 75EC	2.80	65	93
8	Mon-15151+Hoe-046360**	0.28+0.10	65	98
9	Mon-15151+Hoe-046360	0.28+0.15	83	100
10	Control	0.00	0	0
11	Mon-15151+Hoe-046360	0.28+0.20	73	100
12	Mon-15151+Hoe-046360	0.35+0.10	85	100
13	Mon-15151+Hoe-046360	0.35+0.15	70	100
14	Mon-15151+Hoe-046360	0.35+0.20	78	100
15	Mon-15151+Bas-514 WP	0.28+0.28	58	68
16	Mon-15151+Bas-514 WP	0.28+0.56	83	65
17	msma	2.24	30	0
18	Hoe-046360 90 EC	0.20	75	98
19	Hoe-046360 75 EW	0.20	98	95
20	Hoe-046360 30 EW	0.10	50	48
21	Hoe-046360 5 EC	0.10	98	75
22	Hoe-033171 90 EC	0.20	98	95
23	Bas-514 WP	0.56	75	45
24	Ici-0604 EC	0.125	28	18
25	Ici-0604 EC	0.25	28	25

WAT - weeks after treatment EC - emulsifiable concentrate WP - wettable powder
EW - emulsifiable water
*msma - Crabgrass Killer 200 g/l EC Greencross **Hoe-046360-90 g/l EC Hoechst
Agrol 90 was added at 0.5% to treatments 3-18 & 23-26.

Five weeks after application, Mon-15104 gave excellent control of crabgrass (1-3 tiller stage) when applied alone or in combination with Hoe-046360 90EC or msma. Mon-18775 also gave excellent control of crabgrass. Suppression of crabgrass was not as good when Mon-15104 was combined with Bas-514. Bas-514 and msma alone did not give very good control of crabgrass. Hoe-046360 90 EC and 75 EW and Hoe-033171 90 EC provided excellent control of crabgrass (1-3 tiller stage). Hoe-046360 5 EC provided excellent control of crabgrass 2 weeks after application but control declined 5 weeks after application. The 30 EW formulation of Hoe-046360 did not suppress crabgrass as well as the 75 EW and 5 EC formulations. Ici-0604 did not give acceptable control of crabgrass at the 1-3 tiller stage.

EFFECT OF APPLICATION TIME ON THE EFFICACY OF FENOXAPROP-ETHYL WHEN APPLIED ALONE AND IN COMBINATION WITH TRIFLURALIN FOR THE 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 - 0810-POST (1-4 leaf stage) for treatments 2-5; 0801-POST (1-3 tiller stage) for treatments 6-10; 0814-POST (multi-tiller) for treatments 11-13
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0814; 0904.

	Treatment	Dose kg ai/ha	% Reduction of crabgrass		Injury (0-10)			
			0814	0904	0716	0724	0814	0904
1	Control	0.00	0	0	0	0	0	0
2	HC9015	5.00 l/ha	100	95	1	2	3	0
3	HC9016	5.00 "	100	95	1	2	1	0
4	HC9017	5.00 "	100	98	1	2	3	0
5	Mon-15104 EC	0.42	98	93	0	1	1	0
6	HC9015	5.00 "	60	98			2	0
7	HC9016	5.00 "	80	90			4	0
8	HC9017	5.00 "	83	98			2	0
9	Hoe-033171*	0.20	95	93			2	0
10	Hoe-046360**	0.10	75	83			1	0
11	HC9015	5.00 "		93				0
12	HC9016	5.00 "		100				0
13	HC9017	5.00 "		95				0

WAT-weeks after treatment EC-emulsifiable concentrate EW-emulsifiable water.
*Hoe-033171-90 g/l EC Hoechst **Hoe-046360 75 g/l EW Hoechst

At the 1-4 leaf stage of crabgrass, HC9015, HC9016, HC9017 and Mon-15104 gave excellent control of crabgrass 8 weeks after application. Slight injury to the turf was recorded 3 and 5 weeks after application but the turf recovered 8 weeks after treatment. At the 1-3 tiller stage HC9015, HC9016, HC9017, Hoe-033171 and Hoe-046360 gave good crabgrass control 2 and 5 weeks after application; only slight injury occurred 2 weeks after application and disappeared 5 weeks after treatment. At the multi-tiller stage, HC9015, HC9016, and HC9017 also gave good control of crabgrass 3 weeks after treatment; no injury occurred to the Kentucky bluegrass.

POST-EMERGENCE CONTROL OF CRABGRASS AT THE 1-3 TILLER STAGE IN A MIXED STAND WITH 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 - 0801-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0814; 0904.

	Treatment	Dose kg ai/ha	% Reduction of crabgrass WAT	
			2	5
1	Control	0.00	0	0
2	Hoe-033171 90 EC	0.20	98	95
3	Hoe-046360 75 EW	0.10	100	90
4	Hoe 046360 30 EW	0.10	50	48
5	Hoe-046360 5 EC	0.10	98	75
6	Mon-15104 EC	0.20	45	73
7	Ici-0604 EC+Agrol 90	0.125+0.1%	28	18
8	Ici-0604 EC+Agrol 90	0.25+0.1%	28	25

WAT - weeks after treatment EC - emulsifiable concentrate EW - emulsifiable water.

Hoe-033171 90 EC and Hoe-046360 75 EW provided excellent control of crabgrass at the 1-3 tiller stage 5 weeks after application. Hoe-046360 5 EC provided excellent control 2 weeks after application but control of crabgrass declined 5 weeks after application. The 30 EW formulation of Hoe-046360 did suppress crabgrass as well as the 75 EW and 5 EC formulations. Ici-0506 did not give acceptable control of crabgrass at the 1-3 tiller stage.

UBI-2587 AND ASC-893 FOR THE POST-EMERGENCE 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 - 0710-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0717; 0724; 0801; 0814; 0904.

	Treatment	Dose kg ai/ha	% Reduction of crabgrass (WAT)							
			1		2	3	5		8	
			I*	R	I	I	I	R	I	R
1	Control	0.00	0	0	0	0	0	0	0	0
2	Ubi-2587 EC	0.025	2	0	1	1	0	63	0	45
3	Ubi-2587 EC	0.035	1	0	1	1	0	88	0	45
4	Ubi-2587 EC	0.045	1	0	2	1	0	85	0	63
5	Ubi-2587 EC	0.065	2	0	2	1	0	68	0	55
6	Ubi-2587+Agrol 90	0.025+0.1 %	2	0	2	1	0	93	0	35
7	Ubi-2587+Agrol 90	0.035+0.1 %	2	0	2	1	0	68	0	43
8	Ubi-2587+Agrol 90	0.045+0.1 %	3	0	3	2	0	68	0	35
9	Asc-893 WP+Agrol 90	5.00+0.1%	2	0	1	1	0	45	0	35
10	Asc-893 WP+Agrol 90	10.00+0.1 %	2	0	1	1	0	70	0	53

WAT-weeks after treatment *I-injury to turf (0-10) EC-emulsifiable concentrate
WP-wettable powder

Five weeks after application, Ubi-2587 applied alone or with Agrol 90 gave poor to good control of crabgrass. However, 8 weeks after treatment control was no longer adequate. Some injury to the Kentucky bluegrass occurred at all doses 1 and 2 weeks after application but all plots recovered 5 weeks after treatment.

UBI-2587 AND ASC-893 FOR THE POST-EMERGENCE 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 - 0801-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0814; 0904.

	Treatment	Dose kg ai/ha	% Reduction of crabgrass (WAT)			
			2		5	
			I*	R	I	R
1	Control	0.00	0	0	0	0
2	Ubi-2587 EC	0.025	1	88	0	45
3	Ubi-2587 EC	0.035	1	70	0	45
4	Ubi-2587 EC	0.045	1	70	0	63
5	Ubi-2587 EC	0.065	0	63	0	55
6	Ubi-2587+Agrol 90	0.025+0.1%	1	48	0	35
7	Ubi-2587+Agrol 90	0.035+0.1%	1	63	0	43
8	Ubi-2587+Agrol 90	0.045+0.1%	1	75	0	35
9	Asc-893+Agrol 90	5.00+0.1%	0	30	0	35
10	Asc-893+Agrol 90	10.00+0.1%	0	68	0	53

WAT - weeks after treatment   EC - emulsifiable concentrate   *I = injury (0-10).

Asc-893 and Ubi-2587 applied alone or in combination with Agrol 90 gave poor control 5 weeks after application. Injury to the turf was minimal 2 weeks after treatment. The turfgrass fully recovered 5 weeks after application.

EFFECT OF UBI-2587 ON 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 - 0612-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0619; 0625; 0709; 0724; 0808.

	Treatment	Dose kg ai/ha	% Stand and Injury (0-10) (WAT)							
			1	2	3	4		6		8
			I*	I	I	I	S*	I	S	I
1	Control	0.00	0	0	0	0	100	0	100	0
2	Ubi-2587	0.025	1	1	6	1	96	0	100	0
3	Ubi-2587	0.035	1	4	4	1	91	1	95	0
4	Ubi-2587	0.045	2	4	6	3	76	1	93	1
5	Ubi-2587	0.065	3	8	8	8	20	3	73	2
6	Ubi-2587	0.075	2	4	6	4	63	1	91	1
7	Ubi-2587+Assist	0.025+1%	2	3	4	2	89	1	98	0
8	Ubi-2587+Assist	0.035+1%	3	7	8	4	60	2	86	1
9	Ubi-2587+Assist	0.045+1%	4	7	8	4	64	2	84	1
10	Ubi-2587+Assist	0.065+1%	4	7	7	4	63	3	75	2
11	Ubi-2587+Assist	0.075+1%	3	6	6	3	75	2	83	1

WAT - weeks after treatment *I = injury to turf (0-10) S = % turf stand.

Ubi-2587 caused severe damage to bentgrass at all doses 3 weeks after application but the turf recovered 8 weeks after application. Damage appeared to be slightly worse when Assist was used.

TOLERANCE OF KENTUCKY BLUEGRASS TO VARIOUS HERBICIDES.

Experiment Location - Cambridge Research Station
Crop - Kentucky Bluegrass
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 - 0614-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0626; 0704; 0724.

	Treatment	Dose kg ai/ha	Injury (0-10) (WAT)		
			2	3	6
1	Control	0.00	0	0	0
2	trifluralin**	1.70	1	0	0
3	trifluralin	1.95	2	0	0
4	trifluralin	2.20	1	1	0
5	Asc-893 WP+Asc-66901	5.00+1%	1	0	0
6	Asc-893 WP+Asc-66901	10.00+1%	1	0	0
7	Ici-0604 DF+Agrol 90	0.125+0.1%	3	3	0
8	Ici-0604 DF+Agrol 90	0.15+0.1%	3	3	1
9	Ici-0604 DF+Agrol 90	0.25+0.1%	4	3	0
10	Ici-0604 DF+Agrol 90	0.50+0.1%	4	4	0
11	Control	0.00	0	0	0
12	imazethapyr SC	0.025	2	0	0
13	imazethapyr SC	0.05	3	1	0
14	Asc-66952 WP	0.28	1	0	0
15	Asc-66952 WP	0.56	2	0	0
16	Asc-66952 WP	0.84	2	0	0
17	isoxaban DF	2.75	1	0	0
18	isoxaban DF	3.66	1	0	0
19	isoxaban DF	4.13	2	1	0

WAT - weeks after treatment *trifluralin - 500g/l EC Hoechst
EC - emulsifiable concentrate WP - wettable powder DF - dry flowable
SC - soluble concentrate

Injury to Kentucky bluegrass was moderate 3 weeks after application with Ici-0604 plus Agrol 90. Some minor injury occurred after application of imazethapyr and Asc-66952. Six weeks after application all treatments were fully recovered. Trifluralin, Asc-893 and isoxaban treatments showed little or no injury 2 weeks after application.

TOLERANCE OF BENTGRASS TO VARIOUS HERBICIDES.

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 - 0614-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0619; 0625; 0709; 0724.

	Treatment	Dose kg ai/ha	% Stand and Injury (0-10) (WAT)					
			1	2	4		6	
			I	I	I	S*	I	S
1	Control	0.00	0	0	0	100	0	100
2	trifluralin**	1.70	1	1	0	99	0	100
3	trifluralin	1.95	0	1	0	98	0	100
4	trifluralin	2.20	1	1	1	96	0	100
5	Asc-893 WP+Asc-66901	5.0+1%	2	1	0	100	0	100
6	Asc-893 WP+Asc-66901	10.00+1%	2	2	0	100	0	100
7	Ici-0604 DF+Agrol 90	0.125+0.1%	2	5	3	79	2	93
8	Ici-0604 DF+Agrol 90	0.15+0.1%	2	5	3	80	1	96
9	Ici-0604 DF+Agrol 90	0.25+0.1%	1	7	3	78	2	93
10	Ici-0604 DF+Agrol 90	0.50+0.1%	2	6	5	38	5	64
11	Control	0.00	0	0	0	100	0	100
12	imazethapyr SC	0.025	1	1	0	100	0	100
13	imazethapyr SC	0.05	1	0	0	100	0	100
14	Asc-66952 WP	0.28	1	2	0	100	0	100
15	Asc-66952 WP	0.56	2	2	0	100	0	100
16	Asc-66952	0.84	2	1	0	100	0	100
17	isoxaban DF	2.75	0	2	0	100	0	100
18	isoxaban DF	3.66	0	2	0	100	0	100
19	isoxaban DF	4.13	0	2	0	100	0	100

WAT - weeks after treatment *S = % turf stand **trifluralin - 500g/l EC Hoechst
EC - emulsifiable concentrate SC - soluble concentrate WP - wettable powder
DF - dry flowable

Injury to bentgrass was moderate six weeks after application of Ici-0604 plus Agrol 90. Little or no injury showed on plots treatment with trifluralin, imazethapyr, isoxaban, Asc-893 or Asc-66952 4 weeks after treatment.

TOLERANCE OF FINE FESCUE AND PERENNIAL RYEGRASS TO ASC-66952 AND ASC-893.

Experiment Location - Cambridge Research Station
Crop - perennial ryegrass; fine fescue
Soil type - sandy loam
Planting date - established turf
Plot size - 1 x 2 m
Experimental design - randomized complete block
Replicates - 3

AT APPLICATION - Date and method - 0622-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0628; 0706; 0717;0808.

	Treatment	Dose kg ai/ha	Injury (0-10) (WAT)							
			FF*				PR*			
			1	2	3	6	1	2	3	6
1	Control	0.00	0	0	0	0	0	0	0	0
2	Asc-66952 WP	0.28	0	0	0	0	2	2	0	1
3	Asc-66952 WP	0.56	0	1	2	0	3	2	2	2
4	Asc-66952 WP	0.84	0	1	2	0	3	2	2	2
5	Asc-893+Agrol 90	5.0+0.1%	0	0	1	0	1	1	1	2
6	Asc-893+Agrol 90	10.0+0.1%	0	0	1	0	1	1	1	0

WAT - weeks after treatment
*FF - fine fescue
WP - wettable powder
PR - perennial ryegrass

The 2 highest doses of Asc-66952 caused injury to fine fescue 3 weeks after application but the turf recovered 6 weeks after treatment. All 3 doses of Asc-66952 caused injury to perennial ryegrass 2 weeks after application. The turf did not fully recover 6 weeks after application. Asc-893 did not cause significant injury to either species.

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 - 0515-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0605; 0619; 0717; 0814.

	Treatment	Dose kg ai/ha	Weed Counts (no./4 m^2) (WAT)			
			0	3	5	9
1	Control	0.00	19	25	27	31
2	clo/tri EC*	2.00	18	5	2	4
3	clo/tri EC	2.30	21	7	3	3
4	MCPA/MCPP/dicamba**	5.50	20	4	1	2
5	chlorsulfuron***	0.023	19	8	1	2
6	chlorsulfuron+thiameturon	0.023+0.035	20	6	1	3
		LSD:		7.0	7.3	7.2

WAT - weeks after treatment EC-emulsifiable concentrate
DF-dry flowable
*clo-clopyralid; tri-triclopyr
**MCPA/MCPP/dicamba-200/100/18 EC
***chlorsulfuron-750g/kg DF Dupont

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

SEED GERMINATION AFTER APPLICATIONS OF VARIOUS FORMULATIONS OF FENOXAPROP-ETHYL.

Experiment Location - Cambridge Research Station
Crop - Kentucky bluegrass; perennial ryegrass; fine fescue; bentgrass
Soil type - sandy loam
Planting date - July 26 for preplant and July 27 for preemergent
Plot size - 1 x 2 m
Experimental design - randomized complete block
Replicates - 4

AT APPLICATION - Date and method - July 26 for preplant and July 27 for preemergent
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0808; 0814; 0905

	Treatment (seeded 4 h after spraying)	Dose kg ai/ha	Stand (WAT)											
			BG*			PR*			FF*			KB*		
			2	3	5	2	3	5	2	3	5	2	3	5
1	Control	0.00	0	10	83	100	100	100	45	40	95	40	53	98
2	Mon-15104	0.84	0	0	0	0	5	0	0	0	0	0	0	0
3	HC9015	5.00 l/ha	0	0	0	0	8	20	10	0	0	0	0	0
4	HC9016	5.00 "	0	0	0	0	5	10	0	0	0	0	0	0
5	HC9017	5.00 "	0	0	0	0	10	10	10	0	0	0	0	0
6	HC9018	5.00 "	0	0	0	0	8	0	0	0	0	0	0	0
7	Hoe-033171**	0.20	0	10	88	73	93	100	23	58	95	8	50	100
8	Hoe-046360***	0.10	0	10	98	75	100	100	40	60	98	30	58	100
9	Hoe-046360****	0.10	0	10	93	75	98	100	33	60	98	20	50	100
10	Hoe-046360+ fluazifop-butyl	0.05+ 0.0625	0	10	90	94	93	100	40	60	100	30	58	100

	Treatment (seeded 1 d before spraying)	Dose kg ai/ha	% Stand (WAT)											
			BG			PR			FF			KB		
			2	3	5	2	3	5	2	3	5	2	3	5
1	Control	0.00	0	18	88	100	100	100	40	83	100	50	80	100
2	Mon-15104 EC	0.84	0	0	0	0	5	0	0	0	0	0	0	0
3	HC9015	5.00 l/ha	0	0	0	0	0	0	0	0	0	0	0	0
4	HC9016	5.00 "	0	0	0	0	0	0	0	0	0	0	0	0
5	HC9017	5.00 "	0	0	0	0	0	0	0	0	0	0	0	0
6	HC9018	5.00 "	0	0	0	0	5	0	0	0	0	0	0	0
7	Hoe-033171**	0.20	0	10	85	85	100	100	40	83	100	35	78	100
8	Hoe-046360***	0.10	0	10	98	98	100	100	44	83	100	48	80	100
9	Hoe-046360****	0.10	0	13	85	95	98	100	38	75	100	40	78	100
10	Hoe-046360+ fluazifop-butyl	0.05+ 0.0625	0	15	85	98	100	100	45	80	100	48	80	100

WAT - weeks after treatment EC - emulsifiable concentrate EW - emulsifiable water
*BG - bentgrass PR - perennial ryegrass FF - fine fescue KB - Kentucky bluegrass
**Hoe-033171 90 EC ***Hoe-046360 75 EW ****Hoe-04636030 EW Hoechst

No germination of any of the four turf grass species occurred when treated with Mon-15104, HC9015, HC9016, HC9017, or HC9018 either preplant or preemergent. 100% germination occurred with Hoe-033171 90EC, Hoe-046360 75EW and 30EW and with fluazifop-butyl 5 weeks after application.

POST APPLICATION SAFETY INTERVAL FOR ESTABLISHMENT OF TURF FROM SEED.

Experiment location - Cambridge Research Station **Crop** - Kentucky bluegrass, perennial ryegrass
Soil type -sandy loam
Planting date - Sept. 12, 1990
Plot size - 1 x 2 m

AT APPLICATION - Date and method - May 25, June 22, July 24, roundup Aug.14
Equipment - bicycle sprayer
Volume - 700 L/ha
Pressure - 200 kPa
Tips - SS8002SP
Date of assessement - Oct. 11 (1'x1'area rated/plot) & Nov. 13 (1x2m area)

Additional information - Both species were seeded broadcast and slit; at time of ratings only perennial ryegrass species were germinated to any extent

	Treatment	Dose kg/ha	Oct. 11 % Germination PR					
			0525		0622		0724	
			*B	*S	B	S	B	S
1	Control	0.00	25	10	18	11	11	10
2	Mon 15104 EC	0.42	16	11	14	11	10	10
3	Mon 15104 EC	0.56	16	11	19	11	11	11
4	Mon 15104 EC	1.12	18	10	18	10	10	10
5	Mon 15152 G	0.28	13	10	15	10	13	10
6	Mon 15152 G	0.56	16	10	18	11	9	11
7	Dacthal	11.60	19	11	19	10	10	10

	Treatment	Dose kg/ha	Nov. 8 % Germination PR					
			0525		0622		0724	
			*B	*S	B	S	B	S
1	Control	0.00	54	43	46	41	35	24
2	Mon 15104 EC	0.42	55	38	44	40	26	22
3	Mon 15104 EC	0.56	54	40	45	40	26	29
4	Mon 15104 EC	1.12	53	39	46	38	28	21
5	Mon 15152 G	0.28	51	40	41	36	24	24
6	Mon 15152 G	0.56	50	39	45	41	31	24
7	Dacthal	11.60	48	39	41	38	33	26

*B = broadcast seeding S = slit seeding

NON-CHEMICAL ALTERNATIVES TO HERBICIDES FOR WEED CONTROL IN TURF.

Experiment Location - University of Guelph - Arboretum
Crop - Kentucky bluegrass
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 - mowed every 10-14 days; fertilized as per regime
Equipment - industrial Lawnboy mower, Scotts drop type fertilizer spreader
Date of assessment - 0523; 0618; 0726; 0814.

Treatment[1]			Weed Counts (no./4 m^2) (WAT)			
			0	4	8	12
1	Mowing height 1"; Fertility 1		45	35	31	36
2	Mowing height 2"; Fertility 1		35	27	22	48
3	Mowing height 3"; Fertility 1		32	31	24	26
4	Mowing height 1"; Fertility 2		47	28	43	52
5	Mowing height 2"; Fertility 2		32	16	22	39
6	Mowing height 3"; Fertility 2		20	12	19	21
7	Mowing height 1"; Fertility 3		40	28	25	34
8	Mowing height 2"; Fertility 3		34	22	23	43
9	Mowing height 3"; Fertility 3		18	13	13	15
		LSD:	18.2	13.8	12.1	22.3
Treatment[2]						
1	Mowing height 1"; Fertility 1		20	7	7	13
2	Mowing height 2"; Fertility 1		10	6	7	9
3	Mowing height 3"; Fertility 1		12	4	3	4
4	Mowing height 1"; Fertility 2		22	6	7	13
5	Mowing height 2"; Fertility 2		12	3	5	8
6	Mowing height 3"; Fertility 2		8	2	2	4
7	Mowing height 1"; Fertility 3		17	6	4	14
8	Mowing height 2"; Fertility 3		19	4	5	7
9	Mowing height 3"; Fertility 3		4	3	2	2
		LSD:	13.6	4.5	3.7	6.2

WAT - weeks after treatment
Fertility 1 - no fertilizer
Fertility 2 - 3.0 lbs total N/1000 ft^2 applied 0.5 lb in May 22, June 21, July 18, August 10, September 18, and October followed by 1.0 lb actual N/1000 ft^2 in November
Fertility 3 - total N/year=2.0 lbs actual N/1000 ft^2 applied 1.0 lb on May 22 and September 25.
[1]No chemical weed control prior to fertilization and mowing;
[2]Plot area was sprayed with 1.4 kg ai/ha of 2,4-D/MCPP/dicamba prior to commencement of experiment in May of 1989; no herbicide was applied in 1990 season.

Plots in treatment 1 (no chemical weed control prior to fertilization and mowing) experienced a trend towards decreased weed populations with increased mowing height and higher fertility. Plots in treatment 2 had no significant reduction in weeds between treatments.

PLANT GROWTH REGULATORS, 1990

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SUMMARY

Plant growth regulators in turf. Paclobutrazol and flurprimidol suppressed seed head development when applied to Kentucky bluegrass and bentgrass. Imazethapyr and flurprimidol suppressed seed head development when applied to annual bluegrass. Significant height differences were recorded in bentgrass swards treated with paclobutrazol and flurprimidol, however, no height differences were recorded in Kentucky bluegrass swards. Significant height differences were also recorded in annual bluegrass plots treated with flurprimidol. Injury symptoms occurred in Kentucky bluegrass, annual bluegrass and bentgrass plots treated with flurprimidol.

EFFECT OF THE PLANT GROWTH REGULATORS PACLOBUTRAZOL, ASC-66952, AND FLURPRIMIDOL ON KENTUCKY BLUEGRASS.

Experiment Location - Cambridge Research Station
Crop - Kentucky bluegrass
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 - 0614-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0619; 0626; 0709; 0724; 0808.

	Treatment	Dose kg ai/ha	Injury, height, dry weight and seed head suppression (WAT)								
			1	2		3		4	6		7
			I*	I	H*	S*	H	W*	I	S	W
1	Control	0.00	0	0	11.8	0	15.8	11.4	0	0	21.0
2	paclobutrazol G	1.20	1	0	10.7	85	12.2		0	68	
3	paclobutrazol G	2.40	1	0	11.3	96	9.6		1	61	
4	Asc-66952 WP	0.28	1	1	11.7	43	13.0	11.0	0	5	20.3
5	Asc-66952 WP	0.56	2	2	10.9	45	13.1	8.9	0	5	19.1
6	Asc-66952 WP	0.86	1	2	10.2	50	16.1	6.0	0	10	17.9
7	flurprimidol WP	1.50	2	2	10.5	90	10.2		2	8	
8	flurprimidol WP	2.00	2	3	11.1	100	10.8		2	23	
9	flurprimidol WP	2.50	2	4	11.3	100	9.8		2	83	
10	flurprimidol WP	3.00	3	7	10.0	100	12.6		3	80	
			LSD:		2.6		6.7	7.7			6.1

WAT - weeks after treatment G - granular WP - wettable powder
*I = injury (0-10) H = height (cm) S = seed head suppression W = dry weight (g)
All treatments were left unmowed.

Two weeks after treatment, injury was visible in plots treated with Asc-66952 and flurprimidol; thereafter these plots recovered. Injury was apparent as long as 6 weeks after treatment in plots treated with flurprimidol. Plots treated with flurprimidol and paclobutrazol showed good seed heed suppression. No significant height or weight differences were recorded after application of any PGR.

EFFECT OF THE PLANT GROWTH REGULATORS PACLOBUTRAZOL, ASC-66952 AND FLURPRIMIDOL ON 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 - 0614-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0619; 0626; 0709; 0724; 0808.

	Treatment	Dose kg ai/ha	Injury, height, dry weight and seed head suppression (WAT)								
			1	2		3		4	6		7
			I*	I	H*	S*	H	W*	I	S	W
1	Control	0.00	0	0	1.9	0	4.3	3.5	0	0	14.7
2	paclobutrazol G	1.20	0	1	1.8	76	3.7		0	88	
3	paclobutrazol G	2.40	2	1	1.7	85	3.1		1	55	
4	Asc-66952 WP	0.28	1	1	1.7	65	3.9	5.7	0	10	16.0
5	Asc-66952 WP	0.56	1	1	1.3	20	3.9	3.5	0	13	16.4
6	Asc-66952 WP	0.86	1	4	1.5	3	5.2	4.3	0	30	14.3
7	flurprimidol WP	1.50	1	4	1.3	65	3.6		1	33	
8	flurprimidol WP	2.00	1	5	1.3	83	2.9		0	13	
9	flurprimidol WP	2.50	2	5	1.4	88	2.8		0	84	
10	flurprimidol WP	3.00	2	6	1.3	84	2.8		0	74	
		LSD:			0.4		1.5	2.5			4.4

WAT - weeks after treatment G-granular WP-wettable powder
*I = injury (0-10); H = height (cm) S = seed head suppression W = dry weight (g).
All treatments were left unmowed.

Two weeks after treatment, injury was visible in plots treated with flurprimidol; thereafter these plots recovered. Three weeks after application, plots treated with flurprimidol recorded significant height differences. Six weeks after application, plots treated with paclobutrazol and the two highest doses of flurprimidol showed significant seed head suppression. No significant differences in weight were recorded after application of any PGR.

EFFECT OF THE PLANT GROWTH REGULATORS PACLOBUTRAZOL, IMAZETHAPYR, AND FLURPRIMIDOL ON ANNUAL BLUEGRASS.

Experiment Location - Cambridge Research Station
Crop - annual bluegrass
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 - 0612-POST
Equipment - bicycle sprayer
Volume - 700 l/ha
Pressure - 200 kPa
Tips - SS8002LP
Date of assessment - 0618; 0626; 0709;0724.

	Treatment	Dose kg ai/ha	Injury, height and seedhead suppression (WAT)							
			1	2		4		6	8	
			I*	I	H*	I	H	S*	S	H
1	Control	0.00	0	0	3.8	0	6.6	0	0	9.6
2	paclobutrazol G	1.20	0	0	4.6	0	8.8	28	24	6.6
3	paclobutrazol G	2.40	0	0	3.2	0	3.5	71	60	4.5
4	imazethapyr SC	0.025	1	1	2.5	0	6.8	30	59	8.8
5	imazethapyr SC	0.05	1	2	2.0	0	4.8	70	75	8.3
6	flurprimidol WP	1.50	0	1	3.8	0	5.5	54	74	7.1
7	flurprimidol WP	2.00	1	2	2.1	0	4.3	80	83	5.3
8	flurprimidol WP	2.50	1	2	1.6	0	2.7	90	96	4.9
9	flurprimidol WP	3.00	1	3	1.7	0	3.2	86	91	4.1
		LSD:			1.5		4.5			2.48

WAT - weeks after treatment G - granular SC - soluble concentrate
WP - wettable powder
*I = injury (0-10) H = height (cm) S = seed head suppression
All treatments left unmowed.

Two weeks after application, injury was visible in plots treated with flurprimidol; thereafter these plots recovered. Two weeks after application, plots treated with flurprimidol showed significant height decreases. Good seed head suppression was recorded on plots treated with imazethapyr and flurprimidol 6 weeks after application.

TURFGRASS PATHOLOGY

FUNGICIDE TRIALS FOR DOLLARSPOT CONTROL, 1990

T. Hsiang
Department of Environmental Biology

ABSTRACT

Twenty fungicide treatments were evaluated on a 13-year-old sward of creeping bentgrass in Southern Ontario during September and October, 1990. The fungicides tested included: Rovral Green, Thiram 80WP, Tersan 1991, Dyrene 50WP, Daconil Flowable, and Daconil 90DG, the first five of which are registered and recommended for use to control Dollarspot disease of turfgrass in Ontario. Three other chemicals (prefix ASC) provided by Fermenta ASC were also tested at various rates. Neither Thiram nor Daconil 90DG provided acceptable disease control (#10 spots). Daconil Flowable and Dyrene 50WP provided acceptable control, but only a month or more after initial application: these two chemicals may have greater preventive than curative activity. ASC66518-Xa provided barely acceptable control, but better than that of ASC66518-Xb and ASC66518-Xc. ASC6617 showed variable results at the different rates of application: at 18 mL and 12 mL curative, disease control was acceptable 2 weeks after first spray, but not at the other rates. ASC6608 for the most part provided acceptable levels of control 2 weeks after first application, as did Tersan 1991 and Rovral Green.

METHODS

Fungicide treatments were evaluated on a 13-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 dollarspot, 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 applied to each plot. Inoculations for curative plots were done 2 weeks prior to fungicide sprays; for preventive plots, inocula was applied 1 day after spraying. Fungicide treatments were first applied on 3 September 1990, with a wheelmounted compressed air boom sprayed at 140 kPa. Fungicides were re-applied on a 14-day or 21-day schedule according to their label over a 6 week period. Disease evaluations were performed weekly for 6 weeks, by counting number of spots. Spots that were very small or barely visible were not counted, while spots that were larger than normal or more noticeable were counted as multiple spots. Analysis of variance was performed with PROC ANOVA in SAS[7]. When a significant treatment effect was found, mean separation was done with the test of least significant difference (LSD).

RESULTS

Dollarspot was present in nearly all plots prior to spraying (Table 1). The mean number of spots was 35, with a small group above 50 and the majority below. One week after spraying, the mean number of spots had increased to 45, with indications of fungicide treatment activity: these treatments lead to significantly fewer spots compared to the inoculated controls (ASC66518-Xa, Tersan 1991, ASC66608 @ 152 gm & 305 gm, Daconil Flowable @ 95.5 mL, and ASC66617 preventive @ 12 mL).

Table 1. Dollarspot counts with preventive (pre-inoculation) and curative (post-inoculation) treatments over 6 weeks[a] beginning September 3, 1990.

Preventive	Rate[b] (/100 m^2)	Application interval	Week 0	1	2	3	4	5	6
inoculated			34	55	113	150	200	200	230
no inoculation			44	78	63	80	225	223	163
ASC66608	152 gm	14 d	24	25	23	9	10	0	0
ASC66608	305 gm	14 d	24	15	10	3	15	3	0
ASC66617	6 mL	21 d	34	36	8	9	6	28	5
ASC66617	12 mL	21 d	24	23	4	15	16	24	23
ASC66518 Xa	61 gm	14 d	19	28	25	9	9	13	5
ASC66518 Xb	61 gm	14 d	33	34	38	31	46	40	16
ASC66518 Xc	55 gm	14 d	30	45	34	34	30	33	6
DACONIL 90DG	23 gm	14 d	45	54	105	93	130	135	163
DACONIL 90DG	52 gm	14 d	19	40	55	48	40	28	6
DACONIL FLOW.	95.5 mL	14 d	23	25	31	28	26	18	4
DYRENE 50WP	125 gm	14 d	21	44	53	19	8	11	4
ROVRAL GREEN	60 mL	14 d	34	44	5	4	5	10	0
TERSAN 1991	30 gm	21 d	28	26	4	1	4	4	5
THIRAM 80WP	90 gm	14 d	23	50	95	78	98	113	135
Curative									
inoculated			46	63	158	200	198	188	230
no inoculation			41	70	135	143	160	130	140
ASC66608	450 gm	14 d	50	50	10	0	0	0	0
ASC66617	6 mL	21 d	50	49	15	14	11	6	1
ASC66617	12 mL	21 d	54	44	13	5	1	1	0
ASC66617	18 mL	21 d	41	53	6	0	2	0	0
DACONIL FLOW.	300 mL	14 d	63	65	30	23	9	8	1
ROVRAL GREEN	60 mL	14 d	49	58	20	4	1	3	0
LSD (protected, p=0.05)			23	27	34	32	40	38	42

[a] Curative plots were inoculated 2 weeks prior to spraying, while preventive plots were inoculated 1 day after spraying.

[b] The rate is in units of compound per 100 m2, not active ingredient.

After two weeks, there were more apparent differences with 7 treatments below the esthetic criterion of 10 spots (Tersan 1991, ASC66617 preventive @ 6 mL & 12 mL, Rovral Green preventive, ASC66617 curative @ 18 mL, ASC66608 @ 305 gm & 450 gm). At the other extreme, 4 treatments were above 50 spots (Daconil 90DG @ 23 gm & 52 gm, Thiram 80WP, Dyrene 50WP).

At week three, 4 more fungicides joined the list of under 10 spots (Rovral Green curative, ASC66617 curative @ 12 mL, ASC66608 @ 152 gm, ASC66518-Xa), while 1 fell out (ASC66617 preventive @ 12 mL). Two treatments stayed above 50 spots (Daconil 90DG @ 23 gm, Thiram 80WP).

Four weeks after initial spraying, 11 treatments averaged less than 10 spots, an increase of 2 over the previous week (Dyrene 50WP, Daconil Flowable @ 300 mL). At the high end, the same two treatments remained (Daconil 90DG @ 23 gm, Thiram 80WP) without significant differences from the unsprayed controls.

During week five, two more treatments entered the list of under 10 spots (ASC66608 @ 305 gm, ASC66617 curative @ 6 mL) while three left it (Dyrene 50WP, ASC66518-Xa, ASC66617 preventive @ 6 mL). Two treatments remained inefficacious (Thiram 80WP, Daconil 90DG @ 23 gm).

By the time of the sixth and last week, very distinct treatment groups were obvious. The two treatments (Daconil 90DG @ 23 gm, Thiram 80WP) showed no effect on dollarspot at this time nor throughout the experiment. Two medium level treatments (ASC66617 preventive @ 12 mL, ASC66518-Xb) were above the 10 spot esthetic point, with the remainder below. Seven treatments gave complete control of dollarspot (ASC66617 curative @ 12 mL & 18 mL, ASC66608 @ 152 gm & 305 gm & 405 gm, Rovral Green curative and preventive).

DISCUSSION

Curative treatments did not differ significantly from their counterparts in the preventive trials (Table 1). There was a dramatic increase in disease incidence during the two weeks between curative plot inoculations and initial fungicide applications. This altered the nature of the preventive trials since the disease severity on the plots for preventive trials was initially almost as high as those on the curative plots. In essence, all trials in this experiment could be regarded as curative.

All treatments except Daconil 90DG @ 23 gm and Thiram 80WP showed statistically significant levels of disease control compared to the unsprayed control plots. The treatments ASC66608 @ 450 gm, ASC66617 @ 18 mL, Rovral Green preventive, and Tersan 1991 gave excellent control from the second week onward, scoring consistently under the 10-spot esthetic criterion.

By the sixth week, seven treatments gave complete control of dollarspot: ASC66617 curative @ 12 mL & 18 mL, ASC66608 @ 152 gm & 305 gm & 405 gm, Rovral Green curative and preventive. However, by the sixth week (17 October 1990), the weather had changed considerably from the start of the experiment. Conditions at the end, particularly lower temperatures, were not as favorable for dollarspot disease expression, which influences the interpretation of week 6 results. The esthetic cut-off of 10 spots is an arbitrary selection, and a higher value would allow more treatments to be considered highly effective.

CONCLUSIONS

Neither Thiram nor Daconil 90DG provided acceptable disease control (#10 spots). Daconil Flowable and Dyrene 50WP provided acceptable control, but only a month or more after initial application. These two chemicals may have greater preventive than curative activity. ASC66518-Xa provided barely acceptable control but better than that of ASC66518-Xb and ASC66518-Xc. ASC6617 showed variable results at the different rates of application: at 18 mL and 12 mL curative, disease control was acceptable 2 weeks after first spray, but not at the other rates. ASC6608 for the most part provided acceptable levels of control 2 weeks after first application, as did Tersan 1991 and Rovral Green.

EVALUATION OF SPRING APPLICATION OF INSECTICIDES FOR CONTROL OF EUROPEAN CHAFER

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This experiment was designed to evaluate the efficacy of a spring application of various insecticides for the control of European Chafer. There is concern that some populations of chafer are becoming resistant to pesticides registered for control of this pest. This research study was conducted on turfgrass fairways at Kilbride, Ontario.

RESEARCH PROCEDURE

Treatments (Table 1) applied to the fairways at Kilbride were replicated four times on plots (2 x 5 m) arranged in a randomized complete block design. Liquid formulations were applied with a hand-held, CO_2-pressurized spray boom with four TJ8004 nozzles. The volume delivered was 500 L/ha (500 ml per plot) at 200 kPa. Granular products were weighed, placed in a 2-L bottle and evenly distributed over the plot through a fan-shaped funnel attached to the bottle.

Applications were made on 28 April. All treatments were irrigated with 1 cm of water immediately after application. Thatch thickness was <1 cm. One sample (0.3 m^2) was taken in each plot by lifting the sod and inspecting the roots and underlying soil for live and dead grubs. Evaluation of efficacy was made on 22 May by counting the live grubs in one sample (0.3 m^2) per replicate.

RESULTS

Table 1. Insecticides, formulations and rates of application for evaluation of control of European chafer.

Treatment	Formulation		Rate (kg ai/ha)		Amount per 40 m^2		No. live grubs[1] per 0.3 sq. m. 28 days post-treatment	
Check	-		-		-		17.0	a
Triumph	1	G	2.3		19.2	ml	4.3	d
Triumph	480	L	2.3		92	gm	6.0	bcd
GXA 8731CI	-		5.0	bill.	-		9.0	bcd
Basudin II	500	EC	7.5		60	ml	11.0	abcd
Dylox	420	EC	9.0		85.7	ml	5.3	cd
Trumpet	80	WP	3.0		15.0	gm	8.8	bcd
Trumpet	80	WP	6.0		30.0	gm	12.5	abc
S. carpocapsae	-		2.5	bill.	-		12.3	abc
S. carpocapsae	-		5.0	bill.	-		13.0	ab
Dursban	5	G	2.0		800.0	gm	4.5	d
					LSD (5%)		6.6	
					C.V. (%)		48.8	

[1]Values followed by the same letter are not significantly different (P > 0.05, protected LSD).

CONCLUSIONS

Triumph 1 G, Dylox and Dursban provided better control than other products in this test and produced acceptable reduction in numbers of grubs 4 weeks after treatment.

EVALUATION OF FALL APPLICATION OF INSECTICIDES FOR CONTROL OF EUROPEAN CHAFER - I

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This experiment was designed to evaluate the efficacy of a fall application of various insecticides for the control of European Chafer. There is concern that some populations of chafer are becoming resistant to pesticides registered for control of this pest. This research study was conducted to assess possible resistance at two sites in Kilbride, Ontario and to determine the effectiveness of experimental pesticides.

RESEARCH PROCEDURE

Treatments (Table 1) were applied to turfgrass fairways in two locations at Kilbride, Ontario. Treatments were replicated four times on plots (2 x 5 m) arranged in a randomized complete block design. Liquid formulations were applied with a hand-held, CO_2-pressurized spray boom with four TJ8004 nozzles. The volume delivered was 500 L/ha (200 ml per plot) at 200 kPa. Granular products were weighed, placed in a 2-L bottle and evenly distributed over the plot through a fan-shaped funnel attached to the bottle.

Applications were made on 2 October to Site 1 and 5 October to Site 2. All treatments were irrigated with 1 cm of water immediately after application. Thatch thickness was <1 cm. One sample (0.3 m^2) was taken in each plot by lifting the sod and inspecting the roots and underlying soil for live and dead grubs. Pre-treatment densities of grubs were 13 per 0.1 m^2 at Site 1 and 7 per 0.1 m^2 at Site 2.

RESULTS

Table 1. Insecticides, formulations and rates of application for evaluation of control of European chafer.

Treatment	Formulation	Rate (kg ai/ha)	Amount per 40 m^2	No. live grubs[1] per 0.3 sq. m. Site 1 Oct 27/89	Site 1 May 14/90	Site 2 Oct 27/89	Site 2 Jun 26/90
Check	-	-	-	52.0 a	6.3 a	25.7 a	13.0 a
Diazinon	300 CS	7.5	100 ml	18.0 c	2.3 ab	13.5 abc	3.5 cd
Triumph	480 L	2.3	19.2 ml	17.5 c	1.5 ab	11.5 bc	1.3 d
Triumph	1 G	2.3	92 gm	15.3 c	0.8 b	12.8 abc	1.3 d
GXS 8743	-	15.0 L	60 ml	38.5 abc	3.5 ab	25.0 a	5.0 cd
GXS 8743	-	20.0 L	80 ml	47.3 ab	5.0 ab	24.3 ab	11.3 ab
Basudin I	500 EC	7.5	60 ml	17.7 c	4.0 ab	17.7 abc	0.3 d
Basudin II	500 EC	7.5	60 ml	19.7 c	4.5 ab	12.3 abc	1.3 d
Banisect	100 EC	2.0	80 ml	35.5 abc	4.8 ab	17.0 abc	7.8 bc
Dylox	420 EC	9.0	85.7 ml	15.7 c	6.3 a	13.8 abc	1.8 d
Diazinon	5 G	7.5	600 gm	18.0 c	1.8 ab	6.0 c	1.0 d
GXA 8731CI	-	5.0 bill.	-	26.0 bc	4.3 ab	18.0 abc	9.8 ab
	LSD (5%)			21.7	4.1	11.0	4.2
	C.V. (%)			54.7	76.1	47.4	61.4

[1]Values followed by the same letter are not significantly different (P > 0.05, protected LSD).

CONCLUSIONS

Diazinon 5 G and Triumph 480 L effectively reduced the number of grubs at each site. After >3 weeks, treatments of other products containing diazinon, Triumph 1 G, GXA 8731CI, and Dylox 420 EC resulted in significant reductions of grubs at Site 1 but only diazinon 5 G performed adequately at Site 2. The following spring, all products except the parasitic nematodes produced a significant reduction in grubs at Site 2. Only Triumph 1 G provided adequate control at Site 1. However, soil below the sod was only examined to a depth of 2.5 cm while at Site 2 soil was examined to a depth of 10 cm.

EVALUATION OF FALL APPLICATION OF INSECTICIDES FOR CONTROL OF EUROPEAN CHAFER - II

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This experiment was designed to evaluate the efficacy of a fall application of various insecticides for the control of European Chafer. There is concern that some populations of chafer are becoming resistant to pesticides registered for control of this pest. This research study was conducted to assess possible resistance at two sites at the Cambridge Research Station and to turfgrass fairways in Kilbride, Ontario and to determine the effectiveness of experimental pesticides.

RESEARCH PROCEDURE

Treatments (Table 1) were applied to plots 2 m x 5 m replicated four times arranged in a randomized complete block design. Liquid formulations were applied with a hand-held, CO_2-pressurized spray boom with four TJ8004 nozzles (screens were removed to facilitate spraying nematode solutions). The volume delivered was 500 L/ha (500 ml per plot) at 200 kPa. Granular products were weighed, placed in a 2-L bottle and evenly distributed over the plot through a fan-shaped funnel attached to the bottle.

Table 1. Insecticides, formulations and rates of application for evaluation of control of European chafer.

Treatment	Formulation	Rate (kg ai/ha)	Amount per 40 m^2	No. live grubs[1] per 0.6 m^2 25 days post-treatment CRS Site 1	CRS Site 2	per 0.3 m^2 28 days post-treatment Kilbride
Check	-	-	-	35.0 a	30.3 a	30.3 a
Triumph	1 G	2.3	19.2 ml	6.3 d	6.8 b	6.8 b
Triumph	480 L	2.3	92 gm	2.3 d	3.0 b	3.0 b
GXA 8731CI	-	5.0 bill.	-	14.8 bcd	16.3 ab	16.3 ab
Basudin II	500 EC	7.5	60 ml	2.8 d	1.3 b	1.3 b
Dylox	420 EC	9.0	85.7 ml	12.8 cd	4.5 b	4.5 b
Trumpet	80 WP	3.0	15.0 gm	15.3 bcd	3.5 b	3.5 b
Trumpet	80 WP	6.0	30.0 gm	3.8 d	1.0 b	1.0 b
S. carpocapsae	-	2.5 bill.	-	32.5 ab	31.3 a	31.3 a
S. carpocapsae	-	5.0 bill.	-	27.8 abc	22.5 a	22.5 a
Dursban	1 G	2.0	800.0 gm	31.5 abc	30.0 a	30.0 a
			LSD (5%)	17.6	14.2	
			C.V. (%)	72.6	71.8	

[1]Values followed by the same letter are not significantly different (P > 0.05, protected LSD).

Applications were made on 25 September at the two Cambridge sites and on 2 October to the Kilbride site. All treatments were irrigated with 1 cm of water immediately after application. Thatch thickness was <1 cm at Cambridge and <0.5 cm at Kilbride. One sample (0.6 m^2) at Cambridge and (0.3 m^2) at Kilbride was taken in each plot by lifting the sod and inspecting the roots and underlying soil for live and dead grubs. Evaluation of efficacy was taken on 20 October at Cambridge and 30 October at Kilbride. These sites will be reassessed in the spring of 1991.

RESULTS

Results are presented in Table 1.

CONCLUSIONS

At the Cambridge sites all products except the parasitic nematodes and Dursban 1 G effectively reduced the populations of grubs at both sites. At Site 1 the number of grubs was reduced significantly by the nematode preparation GXA 8731CI, but not at Site 2. Triumph, Basudin and Trumpet at 6 kg were the most effective compounds. At Kilbride, Basudin and both formulations of Triumph effectively reduced the number of grubs. Dursban, Trumpet (at 6 kg) and GXA 8731CI did not provide significant reductions of grubs as expected from results of previous experiments.

INTEGRATED PEST MANAGEMENT (IPM) FOR TURF: I. SITE MONITORING

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The current trend towards the reduction of pesticide use for turfgrass management indicates there is an increasing need for research and extension efforts related to Integrated Pest Management (IPM). In 1989 monitoring of 7 sites in the Guelph area was undertaken to experiment with various IPM techniques. In 1990 this extension program was continued and expanded to include site monitoring, environmental monitoring and analyses systems, disease detection kits and grub sampling.

OBJECTIVES

1) To conduct regular site monitoring and utilize various IPM methods to document the occurrence of insect, disease and weed problems on low to moderately maintained turf areas.

2) Use this information to aid in more informed pest management decisions

METHODS

Monitoring was conducted on ten sites once a week from the end of May to the middle of August. These sites were located in Guelph (U of G Arboretum, Riverside Park, McRae House, Woodlawn Cemetery), Kitchener (Victoria Park, Woodland Cemetery), Burlington (Holy Sepulchre Cemetery) and Cambridge (Cambridge Research Station).

An initial survey was conducted on all sites. Consultations with personnel in charge of turf maintenance of the sites were done to obtain information on history of pest problems on the site and information on current maintenance programs.

Various methods were used to monitor the sites for insects. One pitfall trap was installed at each site to monitor surface insects These traps consisted of a set of 3 plastic cups inside one another. A cup changer was used to remove a plug of turf and then the pitfall trap was set into the ground, below the grass/thatch level. The traps were checked weekly. A cloth sweep net was utilized to trap surface insects. Sampling consisted of 3-5 brisk sweeps across the turf. The flotation method was used for the detection of chinch bugs. A metal juice can with both ends cut out, was inserted several centimetres in the ground and then filled with water. Any chinch bugs present would float to the surface within 1-3 minutes. Sod webworm larvae were monitored on site by spraying a soapy water solution on the turf surface. Grubs were monitored using a golf course cup changer and sampling was done to a depth of 10 - 15 cm. Grubs were also monitored by cutting .1m^2 of turf and rolling back turf to look for grubs.

Visual observations for the appearance of disease symptoms, weeds eg. crabgrass germination and general conditions of the turf were also recorded.

DISCUSSION

Information from these sites aided in tracking insect/disease/weed problems throughout the season. This information was reported to turf managers at each site to assist with pest management decisions. Due to the favourable growing conditions during the 1990 season, there were relatively few insect or disease problems at any of the sites that warranted control measures. Therefore the problems that were identified could be rectified either through modified cultural practices or by spot treatment.

Time in monitoring each site involved approximately 30-45 minutes (not including transportation) per site depending on the time of the season. Each site was visited 15 times throughout the season. Labour costs for a pest management scout were approximately $115.00 per site for the entire season. On a commercial scale the frequency could probably be reduced to 5 - 7 visits which would reduce the labour costs. Although IPM involves higher labour costs this would be potentially offset by the reduction in the amount of pesticide applications that would have to be made.

Further efforts at utilizing monitoring and sampling techniques and interpretation of this information for pest imanagement recommendations will be continued in 1991.

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INTEGRATED PEST MANAGEMENT (IPM) FOR TURF: II. ENVIRONMENTAL MONITORING AND ANALYSIS SYSTEMS

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OBJECTIVES

1) To collect weather data to monitor environmental conditions such as degree days, leaf wetness, relative humidity, rainfall and soil temperature that influence disease, insect and weed problems in turf.

2) To evaluate prediction models for several diseases.

3) To provide regional weather data to enable turf managers to make more informed pest management decisions.

METHODS

Data from seven weather stations (Harrow, London, Guelph, Hamilton, Alliston, Bowmanville, Smithfield and Kemptville) were used to collect regional degree day, air temperature and rainfall information that could was used to provide regional recommendations for forecasting the occurrence and peak populations of turfgrass pests.

An environmental monitoring and analysis system (EnviroCaster[J]) was installed in close proximity to the pathology green at the Cambridge Research Station. The green is surrounded by trees on 3 sides and therefore would simulate a 'hot spot', an area on a golf course where an outbreak would most likely occur. The EnviroCaster[J] was also located within regular irrigation patterns to insure similar leaf wetness conditions as the green. Information on degree days, air temperature, leaf wetness, dewpoint, relative humidity, rainfall and soil temperature was collected weekly from June - September.
The Envirocaster was also equipped with predictive models that utilized the environmental data to make predictions based on the following conditions:

Model	Conditions
Pythium blight (*Pythium aphanidermatum*)	air temperature, relative humidity
anthracnose (*Colletotrichum graminicola*)	air temperature, leaf wetness
[models under development]	
summer patch (*Magnoporthe poae*)	soil temperature
brown patch (*Rhizoctonia solani*)	relative humidity, air temperature
dollar spot (*Lanzia* sp. or *Mollerdiscus* sp.)	air temperature, relative humidity, leaf wetness
annual bluegrass seedhead formation	50 degree days (above 50°F)

The prediction models were consulted regularly during the summer for latest forecasts, historical advisories and historical data and compared to visual observations on the pathology green.

DISCUSSION

Degree day information collected from the regional weather stations was used for monitoring the peak of 3rd instar chinch bug nymph (750 Degree Days (air) at 7°C Base Temperature) and black turfgrass ataenius egg laying (150 Degree Days (air) at 13°C Base Temperature). This information was reported on the Turf Hot Line which is a weekly phone recording that is available to the commercial turf industry.

With the exception of dollarspot, there was very low incidence of disease on the pathology green in 1990. Therefore, it was difficult to fully evaluate the EnviroCaster prediction models. Seven light infections and one moderate infection for anthracnose were recorded. No visual symptoms of anthracnose were observed on the green. No spray was advised for pythium blight, no visual symptoms of pythium were observed. With regards to the developmental models both brown patch and dollar spot appeared to be underpredicted by the Envirocaster.

Further evaluation and application of environmental monitoring and analytical systems will be conducted in 1991.

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INTEGRATED PEST MANAGEMENT (IPM) FOR TURF: III. DISEASE IDENTIFICATION AND MANAGEMENT WITH IMMUNOASSAY DIAGNOSTIC KITS

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OBJECTIVES

1) To evaluate the detection and management of pythium blight, dollar spot and brown patch on putting greens using Reveal[J] Turf Disease Detection Kit, commercially available immunoassay diagnostic kits.

2) To compare the effect of random versus biased sampling on the level of disease detected on putting greens by the Reveal Dollar Spot Detection Kit.

METHODS

One putting green at each of two sites was sampled weekly from late June - early September. Sampling was done either by random hand sampling of 10 - 15 subsamples or collection of fresh clippings from a greensmower. For dollar spot testing, both a random and biased sample was taken for six weeks. The biased sample was collected from areas showing visual symptoms or areas where dollar spot had previously occurred on the green. After collection of the grass clippings, the samples were ground between abrasive strips and placed in an extract solution. Drops of the extract solution followed by detection solution, rinse solution, colour solution and finishing solution were applied to a Reveal[J] disease detector. The disease detector was than examined visually. Colour developed if the specific pathogen was detected in the sample. The Agrimeter II[J] was used to read quantitative results.

Incidence of disease in 1990 was very low. There were no prolonged periods of high relative and high temperature that would favour pythium blight and brown patch development. The level of disease detected for pythium blight and brown patch with the disease detection kits seemed to confirm this as levels never exceeded the low range (pathogen present at a low level or not detected) on any of the weekly readings. For dollar spot, the caution range (the pathogen is present and damage could occur under conditions that favour disease) coincided with visual dollar spot symptoms. Differences in random versus biased sampling were inconsistent and require further evaluation.

Based on the use of the disease detection kits, monitoring of environmental conditions and visual observations fungicide treatments would not have been necessary for brown patch and pythium blight at these two sites in 1990. With modified cultural practices, in particular, fertility, very few fungicide applications for dollar spot would have been required.

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INTEGRATED PEST MANAGEMENT (IPM) FOR TURF: IV. GRUB SAMPLING AND MAPPING

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During July and August 1990, grub sampling was conducted on five golf courses to determine the intensity and distribution of several grub species. A cup changer with a 4.25 in. diameter was used to conduct the sampling as this method causes minimal damage to the turfgrass area. Fairways and edge of rough areas were sampled every 30 yards the length and width of the fairway. A plug was taken and the grass, thatch and soil was examined for presence of grub eggs, larvae, pupae and adults. Using a factor of 10.15 the number of insects found per sample was converted to the number per square foot. One grub per cup changer was equivalent to approximately 10 grubs per 0.1 m^2 (1 sq. ft). A map indicating areas sampled and populations found was made for each site.

This method of monitoring helps because 1) make the correct diagnosis is made , 2) stage of grub development is monitored for proper timing of controls, 3) some information is provided to help establish a threshold that could be used in deciding whether or no control is necessary, and 4) the areas where the level of grubs are determined to require control can be spot treated, which reduces the total area that requires treatment and potentially reduces the amount of pesticide that has to be used.

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PESTICIDE RESIDUES

HOMEOWNER, PROFESSIONAL APPLICATOR AND BYSTANDER EXPOSURE TO 2,4-DICHLOROPHENOXYACETIC ACID (2,4-D)

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INTRODUCTION

The herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) is widely used for broadleaf weed control in agriculture, forestry, rights-of-way for power lines and for aquatic weed control. Studies concerning occupational exposure to 2,4-D under these use conditions are available (Draper and Street, 1982; Lavy et al., 1982; Nigg and Stamper, 1983; Libich et al., 1984; Prank et al., 1985; Lavy et al., 1987). The herbicide 2,4-D is also one of the most widely used chemicals by domestic and professional applicators for the home lawn and for public areas such as parks, playgrounds and playing fields. During use, exposure of the domestic or professional applicator may occur during mixing, application cleaning of equipment and disposal of unused spray solutions. Exposure of professional pest control applicators or lawn care technicians has been measured for the organophosphate insecticides (Hayes et al., 1980; Weisskopf et al., 1988) and for the herbicide 2,4-D (Yeary, 1986). Yeary (1986) investigated the occupational exposure of 45 lawn care applicators to 2,4-D. The quantity of 2,4-D excreted in the urine on a body weight basis ranged from 0.0003 to 0.066 mg/kg. Most applicators in the study were spraying 6 days a week for at least 3 weeks, so it was assumed that they were in a steady state for 2,4-D body burdens and a 24 hour urine sample was analysed to estimate daily absorbed dose. Results in this study were affected because spraying was cancelled at one location due to rain. Professional applicators rarely apply the exact amount of active ingredient each day and applications are often delayed due to poor weather. These conditions are not favourable in obtaining steady state body burdens. The daily exposure of professional applicators has not been measured over an extended period of time or under conditions of use in Ontario.

Homeowners may apply pesticides without regard to label directions and often application rates and precautions may be ignored or misinterpreted. The type of equipment used for homeowner application of pesticides is unlike that of large scale farm, forestry or professional turf spraying application operations and therefore, it is impossible to extrapolate to the potential exposure levels of this user group. Exposure of urban applicators or professionals using equipment typical of residential home owner use has been measured for carbamate and organophosphate insecticides (Gold et al., 1982; Davis et al., 1983) but has not been measured for homeowners applying 2,4-D.

Bystanders may be exposed to 2,4-D by entering treated areas during or immediately after application. Although recent studies (Thompson et al., 1984) have suggested that dislodgeability of 2,4-D after application on turf is less than 6% of the original amount, there is a chance of human exposure to 2,4-D by contact with treated turfgrass surfaces. The relevance of these results to bystander exposure has not yet been determined. Recent reports (CCT, 1987; Harvard School of Public Health, 1990) have pointed to the lack of adequate information on bystander and household exposure to 2,4-D.

The objectives of this study were (1) to determine the effect of 2,4-D formulation and the use of protective clothing on exposure rates of home applicators, (2) to determine the effect of 2,4-D formulation on exposure rates of bystanders and levels detected in the air, (3) to measure the daily exposure of professional applicators under conditions of use in Ontario, and (4) to evaluate the exposure of bystanders who have had a professional application of 2,4-D.

MATERIALS AND METHODS

Homeowners

Volunteers Forty-four volunteers composed of 22 applicators and 22 bystanders were selected to participate in the exposure study. Bystanders were considered to be persons living within the household but not applying the pesticide. The applicators were randomly split into two groups (protective and non-protective) before applications commenced. Two applicators and 3 bystanders withdrew from the study for personal reasons, leaving 39 participants. Each applicator agreed to apply a weed and feed fertilizer with 2,4-D in the spring and a liquid formulation of 2,4-D in the fall.

Air sampling Air sampling pumps (Gilian Model HFS 113A) connected to absorption tubes via 1.5 metres of TYGON tubing were calibrated using a bubble flow meter and set to draw air at a rate of 1 l/minute. Absorption tubes were made by filling capillary pipettes with approximately 2 g of fluorisil (60 mesh) and stopped at both ends with glass wool (Frank et al. 1985). Absorption tubes were stored in capped KIMAX test tubes until needed.

Prior to each application, 2 air sampling pumps connected to absorption tubes were set up 1.5 metres off the ground, one in the front hall way of the house and one downwind of the application site within 3 metres of the property line. Sampling pumps were run from approximately 10 minutes before and up to 30 minutes after each application. All sampling times were recorded.

At the end of each application, one absorption tube was spiked at the field site with 0.22 µg 2,4-D acid dissolved in methanol to serve as a field recovery check. All absorption tubes were returned to their original containers and stored in the freezer until extraction the following day.

Applications Eleven applicators (and 11 bystanders) were selected to participate in the protective group. This group was given verbal instruction regarding measuring, mixing, application, disposal of containers and cleaning of equipment prior to and during the application. Clean overalls, gloves and rubber boots were supplied to the applicator before any equipment or pesticide was handled. The applicator was instructed to keep the additional apparel on until the end of the application.

The nine applicators (and 8 bystanders) in the non-protective or control group wore their normal clothing for pesticide application and were allowed to apply the pesticide as they normally would. Only minimal verbal instructions were given if requested. Apparel and footwear worn during the application was noted.

A granular formulation of fertilizer (10:6:4:) with 1% 2,4-D was used for the spring application. If necessary, a professional 36 inch drop spreader was supplied for the larger properties and a 24 inch drop spreader was used on smaller properties. A liquid formulation of 2,4-D (250 g/L 2,4-D amine) was used for the fall application. All applicators were supplied with a clean hose-end sprayer. One hundred and fifty feet of hose which was rinsed after each use was available to the applicators to reach the far ends of their properties if necessary.

All measuring, mixing and portions of spreading or spraying were videotaped for later visual review. Information regarding product used, rates, area treated, weather, applicator and bystander sex, age and weight was recorded after application.

Biological monitoring To check for previous exposure to 2,4-D, a morning urine sample was obtained from both the applicator and the bystander on the day of application and was stored in a refrigerator in 500 ml NALGENE bottles until picked up that afternoon or evening. Shortly after the application, sub-samples of approximately 100 ml were taken from the morning pre-exposure samples supplied and were spiked with 11 µg 2,4-D acid dissolved in methanol to serve as field recovery checks. Spikes were stored in 125 ml or 500 ml NALGENE bottles and were returned to the volunteers after application. Volunteers were instructed to store the spiked samples with their day 1 samples either in the refrigerator, in supplied styrofoam coolers or soft sided cooler bags with frozen ice packs.

Professional Applicator Exposure

Subjects A professional lawn care company representative of the industry in Ontario was asked to participate in the study. Agreement from managers/owners from two locations was obtained. Five lawn care technicians from one area and 7 technicians (including 1 mixer/loader) from another location agreed to participate in the study.

Products used Records of the amount of 2,4-D (grams A.I.) sprayed were kept for each technician throughout the 14 day period. Technicians from location 1 sprayed a mixture of 2,4-D amine (118 g/l) and mecoprop (125 g/l). Volunteers from location 2 applied a mixture of 2,4-D amine (200 g/l), mecoprop (100 g/l) and dicamba (18 g/l). All technicians were asked to supply information regarding application procedures, and personal information such as age and weight.

Biological monitoring Prior to the commencement of spraying in the spring (location 1), and in the fall (location 2), a pre-exposure morning urine sample was collected from each participant on the first day of the study. Full, daily samples were collected from 11 technicians for a period of 14 days including week-ends or days off. One technician supplied samples for a period of 7 days. The technicians were instructed to store their urine samples in the supplied cooler bags with frozen ice packs while at work and in the refrigerator while at home overnight. Frozen ice packs were supplied each day of the study.

Bystander Exposure - Professional Application

Subjects Ten volunteers were selected in the Guelph area to participate in the bystander exposure portion of the study. Three volunteers withdrew from the study for personal reasons. All professional applications were set up to be completed in one day by one applicator.

Air sampling Air sampling methods were conducted as for homeowners. Samplers were set up immediately prior to each application and left running for a period of up to 15 minutes following completion of the professional application.

Applications Once air samplers were running, the technician was free to apply the pesticide in the manner in which he had been trained. A mixture of 2,4-D amine (110 g/l) and mecoprop (115 g/l) was applied. Portions of the spraying were videotaped for later visual review. After each application, the property was measured and a sign was posted indicating pesticide application. Tank dip measurements recorded by the technician were used to estimate the amount of pesticide sprayed on each property.

Biological Monitoring The urine sampling procedures were those of the home-owner exposure procedures addressed above.

RESULTS AND DISCUSSION

Homeowner applications

Compliance with collection protocols Creatinine values were calculated in mmoles from daily volume measurements for four 24 hour periods for each bystander and homeowner applicator. A mean for the four days is reported in Tables 1-4. All creatinine values were above or fell within the normal range for adult males (7.0-18.0 mmole/24 hours) and adult females (5.0-16.0 mmole/24 hours), indicating complete sample collection, except for 2 bystanders (#3 - 4.9 mmole/24 hr and #8h - 4.6 mmole/24 hr). Creatinine correction was not necessary because no detectable 2,4-D was found in the urine samples.

Protective apparel group Tables 1 and 2 present a summary of applicator and bystander exposure in relation to grams (A.I.) 2,4-D applied in a protective application situation. Quantifiable results were corrected for spiked recovery. Trace values were calculated assuming a worst case concentration at the level of detection (5 µg/L) and corrected for spiked field recovery for use in regression analysis.

No significant correlation between amount of liquid or granular 2,4-D applied and applicator exposure was found (R^2 = 0.05 and 0.14 respectively). The three exposures detected in applicators may be explained by isolated incidents. Volunteer #5 (Table 1) removed his gloves three or more times during application and may have come in contact with the concentrated liquid on the outside of his gloves. Volunteer #4 (Table 2), despite instructions, removed his gloves to cut open and pour the bags of fertilizer

Table 1. Applicator and bystander exposure in relation to grams of liquid 2,4-D (A.I.) applied under conditions of protective application.

		2,4-D Urine (total µg/person in 4 days)				2,4-D Air (µg/m^3)	
Vol.#	Grams A.I. applied	Applicator	Creatinine[1]	Bystander	Creatinine[1]	Inside	Outside
1	52.5	ND	18.3	ND	10.9	ND	ND
2	62.5	ND	18.2	ND	6.5	ND	ND
3	125.0	ND	10.1	ND	4.9	6.0	ND
4	437.5	ND	9.7	ND	8.7	ND	ND
5	62.5	63	7.2	ND	11.5	ND	ND
6	37.5	ND	11.3	--	--	ND	ND
7	125.0	ND	10.2	ND	7.2	ND	ND
8	37.5	38	12.3	ND	11.2	ND	ND
9	62.5	ND	12.9	ND	7.9	ND	ND
10	125.0	ND	20.6	ND	5.1	ND	ND
11	50.0	ND	18.3	ND	10.9	ND	ND
Mean	107.0						

Table 2. Applicator and bystander exposure in relation to grams of weed and feed 2,4-D (A.I.) applied under conditions of protective application.

		2,4-D Urine (total µg/person in 4 days)				2,4-D air (µg/m^3)	
Vol.#	Grams A.I. applied	Applicator	Creatinine	Bystander	Creatinine	Inside	Outside
1	300	ND	17.7	ND	11.8	ND	ND
2	300	ND	15.0	ND	7.4	ND	ND
3	900	ND	12.5	ND	8.8	ND	10.0
4	700	108	10.1	ND	8.7	ND	20.0
5	300	ND	12.2	ND	14.5	ND	ND
6	800	ND	11.5	ND	7.5	ND	ND
7	200	ND	11.4	ND	8.5	ND	ND
8	200	ND	9.7	ND	9.5	ND	ND
9	200	ND	12.9	ND	7.9	ND	ND
10	200	ND	13.0	ND	7.4	ND	ND
11	250	ND	10.8	ND	6.5	ND	2.2
Mean	395						

into the spreader and then replaced them to apply the material in the spreader. There were no obvious spills or contact with the pesticides in the case of the liquid application of 2,4-D by volunteer #8 (Table 1). Exposure may have resulted due to activities that involve contact with 2,4-D granular such as mowing the lawn. Assuming that all exposures in the protective group occurred on the day of application, exposures of volunteers #4, 5 and 8 resulted in doses of 0.0015, 0.00079 and 0.0005 mg/kg/day respectively. These values represent 1/190, 1/380 and 1/579 of the World Health Organization acceptable daily intake (ADI) of 0.3 mg/kg/day (WHO, 1984).

No detectable traces of 2,4-D were found in supplied four day urine samples of bystanders for either liquid or granular protective applications. Residues of 2,4-D were detected in four of the forty-four air samples taken during applications (Tables 1 and 2). Although 2,4-D was detected in an inside house air sample of volunteer #3 (0.006 mg/m^3) for the liquid application, and again in the outside air sample for the granular application (0.01 mg/m^3), it did not result in exposure of the applicator or bystander. Detectable 2,4-D was observed in an outdoor air sample of volunteer #4's granular application (0.02 mg/m^3). It is highly unlikely that the main route of exposure of the applicator was through the air. As explained earlier, instructions were not followed during the application. In addition, the bystander participating in the study received no exposure and was present outdoors during the entire application.

The original hypothesis that the use of a weed and feed formulation of 2,4-D results in lower exposure to the applicator and bystander than a liquid formulation cannot be substantiated when protective apparel is worn. Exposure, when it occurred, appeared to be related to spills and/or improper use of gloves.

Non-protected group Tables 3 and 4 summarize applicator and bystander exposure for a non protective application. A low correlation (R^2 = 0.34) was found between amount of granular 2,4-D applied and applicator exposure. However, the only measurable exposure was in the applicator who had applied a large amount of weed and feed fertilizer (1200 g A.I.).

Table 3. Applicator and bystander exposure in relation to grams liquid 2,4-D (A.I.) applied under conditions of non-protective application.

		2,4-D Urine (total for 4 days µg/person)				2,4-D air (µg/m^3)	
Vol.#	Grams A.I. applied	Applicator	Creatinine[1]	Bystander	Creatinine[1]	Inside	Outside
la	250.0	418	17.2	ND	10.2	10.0	ND
2b	250.0	159	12.3	ND	6.1	ND	ND
3c	250.0	TR	8.2	ND	8.0	--	--
4d	1450.0	135	16.8	ND	10.2	ND	ND
5e	81.3	744	15.0	ND	11.0	ND	ND
6f	87.5	86	15.0	ND	11.9	ND	ND
7g	31.5	87	10.3	--	--	ND	ND
8h	--	--	--	--	--	--	--
9i	62.5	ND	18.9	ND	10.4	ND	ND
Mean	307.9						

Table 4. Applicator and bystander exposure in relation to grams of weed and feed 2,4-D (A.I.) applied under conditions of non-protective application.

Vol.#	Grams A.I. applied	2,4-D Urine (total for 4 days µg/person) Applicator	Creatinine[1]	Bystander	Creatinine[1]	2,4-D air (µg/m^3) Inside	Outside
1a	1200	169	19.8	ND	11.1	ND	ND
2b	800	ND	15.9	ND	7.3	ND	ND
3c	500	ND	9.9	ND	7.5	ND	ND
4d	1200	ND	12.9	ND	8.6	ND	ND
5e	300	ND	17.2	ND	11.3	ND	ND
6f	200	ND	14.5	ND	8.2	ND	ND
7g	200	ND	9.9	--	--	ND	ND
8h	400	ND	12.4	ND	4.6	ND	ND
9i	150	ND	17.4	ND	8.1	ND	ND
Mean	550						

ND - not detectable < 4 µg/L
TR - trace 5-20 µg/L
[1] Average four day creatinine value (mmole/24 hr)

No significant correlation (R^2 = 0.002) was found between amount of liquid 2,4-D applied and applicator exposure in the non protective group. All six cases of quantifiable exposure (#'s 1a, 2b, 4d, 5e, 6f and 7g) were directly related to spills of liquid concentrate on the bare hands or forearms. When direct spills did not occur during the pouring or mixing, trace values were detected or no exposure resulted. In addition to a small spill during pouring, volunteer #1a twice sprayed dilute 2,4-D directly on his hands to determine if the sprayer was operating properly. Volunteer #5e (744.4 µg) spilled approximately 20 ml of concentrate directly on his hands when pouring the liquid concentrate into the hose-end sprayer and closing the sprayer. Assuming the worst case that this exposure occurred in the first day and that this person weighed 105 kg, this would be equivalent to about 1/42 of the ADI suggested by the World Health Organization (300 µg/kg/day or 2,100 µg/day in a 70 kg person).

Because a hose-end sprayer was used for the application, the hose was rolled up for storage after the application. Although most volunteers tried to avoid directly spraying the hose while spraying the lawn, the hose inevitably came into contact with 2,4-D spray on the grass. Most applicators rolled the hose in by hand which may explain the trace amount detected.

No bystanders in this group showed exposure to 2,4-D. One positive indoor air sample was found in all non protective applications (Volunteer #1a, 0.65 ug or 0.01 mg/m^3). Once again, this did not result in exposure of the bystander and it is unlikely that it is a major route of exposure to the applicator.

Lack of protection of the hands and forearm obviously resulted in a greater incidence of exposure in the unprotected group, however, highest exposure was consistently associated with spills or accidental contamination of the skin. Spills from the original container could have been avoided through the use of a better design to allow for easy pouring and the use of a firmer plastic for construction. Leaks of concentrate from the hose-end sprayer could be reduced through better design of seals between the sprayer and the pesticide container and through the use of a freely rotating coupling to the end of the hose.

In both groups of bystanders (liquid and granular, Tables 1-4) no detectable exposures occurred. It cannot be concluded that the use of a weed and feed formulation results in lower exposure to the bystander or lower air concentrations than a liquid formulation.

It appears that the use of protective apparel for application of a granular formulation of 2,4-D does not reduce exposure in the applicator (Tables 2 and 4). However, an obvious difference occurs when applying 2,4-D liquid. The use of rubber gloves and possibly overalls and rubber boots, when pouring, applying and cleaning the equipment reduced potential exposure.

PROFESSIONAL APPLICATORS

Bystander exposure No exposures were detected in volunteers who had a professional application of 2,4-D and creatinine values fell within the normal range for adult males and females (Table 5). Air samples taken both inside and outside the home downwind of the application showed no detectable residues of 2,4-D. The lack of detection of any 2,4-D in the bystanders urine samples or air samplers suggests that exposure to 2,4-D via this use-pattern is very low and that it presents a minimal risk.

Table 5. Bystander exposure under conditions of professional application of 2,4-D.

Volunteer #	2,4-D applied g a.i.	Total 2,4-D in urine (µg)[1]	2,4-D µg air inside	2,4-D µg air outside
1	9.43	ND[2] (7.8)[3]	ND	ND
2	37.63	ND (10.1)	ND	ND
3	8.17	ND (11.7)	ND	ND
4	147.18	ND (6.3)	ND	ND
5	48.15	ND (16.7)	ND	ND
6	41.63	ND (13.0)	ND	ND
7	15.83	ND (16.0)	ND	ND

[1] 2,4-D µg in combined 4 day sample corrected for field recovery
[2] ND - not detectable < 4 µg/L
[3] average four day creatinine value (mmo1e/24 hr)

Applicator exposure Mean exposure in group 1 was analyzed in relation to actual amount of 2,4-D excreted in the urine and the amount of 2,4-D excreted in relation to the amount of creatinine excreted on each day. Use of creatinine excretion as a correction factor did not greatly change the pattern of exposure and, in both analyses, 2,4-D excretion showed two peaks. These peaks of excretion lagged behind the amounts of A.I. used on each day by an apparent period of 2-4 days. Due to high variability between individuals in this group, linear regression analysis failed to show high correlations between the total amount of 2,4-D sprayed and the total excreted, either on a daily basis or over the entire period of the study.

Group 2 showed essentially the same trend as group 1 both in total 2,4-D excreted or 2,4-D excreted per mmole of creatinine but the highest mean exposure in the group was lower than in group 1, despite the fact that more 2,4-D (in total) was applied by group 2.

In addition to the applicators in groups 1 and 2, exposure was measured in a manager who had the daily responsibility for mixing and loading of the spray trucks. Although this person was not involved in actual spraying, he did handle the largest amount of pesticide of any person in the study. The exposure of the mixer/loader was lower than the mean of the spray crews from the same group, despite the considerably higher amount of 2,4-D concentrate handled.

Exposure of individual sprayers to 2,4-D showed great variability, both in terms of amount of A.I. applied and in exposure to 2,4-D. Comparison of total 2,4-D excreted to the amount excreted per mmole of creatinine suggested some incomplete samples, but, on the whole, compliance with collection protocols was good. Total exposure was poorly correlated with total amount of A.I. used (Table 6) suggesting that individual differences between sprayers was the major source of variability. Exposure data corrected for creatinine values failed to show correlation with A.I. used. It was not possible to observe each sprayer during their regular operations but it is likely that 2,4-D dose is correlated with personal work practices and precautions taken to decrease exposure. In other words, poor technique leads to higher exposures.

Table 6. Total 2,4-D use and excretion in applicators

		2,4-D excreted				
Applicator	Total 2,4-D applied	Total µg[1]	Total µg/mmole creatinine	Total µg/g A.I.	Average dose (µg/kg/day)	Fraction of A.D.I.
1	5128	4127	419.2	0.80	4.4	1/68
2	8300	2812	161.6	0.34	2.8	1/107
3	8101	1574	170.1	0.19	1.7	1/176
4	9399	2782	214.1	0.30	3.3	1/90
5	6577	2800	249.9	0.43	4.9	1/61
6	7400	3128	226.0	0.42	2.8	1/107
7	13960	2011	145.1	0.14	2.1	1/143
8	20480	6345	344.9	0.31	5.5	1/55
9	14500	4421	231.4	0.30	3.1	1/97
10	18880	3125	267.9	0.17	3.7	1/81
11	15480	2289	121.4	0.15	2.0	1/150

[1] R^2 for the regression of total µg excreted vs total g applied = 0.172

The highest single day exposure to 2,4-D in any of the sprayers was 1,108 µg. This is about 1/19 of the ADI suggested by the World Health Organization (300 µg/kg/day or 2,100 µg/day in a 70 kg person). In all other cases, exposure was lower and, if averaged over the two week period of the study, gave higher safety factors. All average exposures fell within the range previously reported by Yeary (1986). These results suggest that exposure of spray applicators to 2,4-D under these circumstances does not present an unacceptable risk.

GENERAL CONCLUSIONS

1 Under all conditions of homeowner use, exposure to 2,4-D was below the acceptable daily intake suggested by the World Health Organization.
2 The use of protective apparel such as rubber gloves, long-sleeve tightly woven polyester-cotton overall and rubber boots reduced the incidence of exposure during the application of liquid formulations of 2,4-D.
3 Exposure to 2,4-D from granular "weed-and-feed" formulations was less frequent than the liquid formulations, particularly when no protective apparel was worn.
4 Exposure from liquid formulations of 2,4-D was commonly associated with spills during opening of the container, filling the hose-end sprayer and attaching the sprayer to the hose. Another source of exposure to dilute spray is through handling the hose.
5 Bystanders to home applicators were not exposed to detectable levels of 2,4-D.
6 Bystanders to professional applicators were not exposed to levels greater than the detection threshold. Levels of 2,4-D in air samples taken both inside and outside houses where applications were made were below the detection threshold.

7 Professional applicators were exposed to 2,4-D but the degree of exposure was not well correlated with amount of herbicide applied. Factors such as personal work habits and hygiene may be more important than amount of material used.

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TOXICOLOGY UPDATE ON 2,4-D

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The herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) has been used widely in agriculture, forestry, home and garden applications and to control weeds in parks and rights-of- way for over 40 years. Because of its wide use and recent concerns over its safety, it is also one of the most studied herbicides in use today.

The safety evaluation of 2,4-D, or for that matter any chemical, must take into consideration all of the available scientific data and not just focus on selected studies. In the case of 2,4-D, there are data relating to its chemical purity and manufacture, its metabolism in animals and humans, as well as important studies relating to its genotoxicity and to its carcinogenic potential in both animals and humans.

CHEMISTRY

The available data indicate that commercial 2,4-D is relatively uncontaminated. The major impurities consist of other phenoxyacetic acids and chlorinated phenols. Concern has existed because of possible contamination with low levels of dioxins. However, analytical studies have demonstrated the absence of the highly toxic dioxin, 2,3,7,8-TCDD in commercial formulations of 2,4-D sold in North America. Trace amounts of other much less toxic dioxins have been detected in certain formulations and tolerances for these dioxins in 2,4-D formulations have been established. It may be concluded that any health concerns associated with 2,4-D exposure would most likely be attributable to 2,4-D itself rather than any contaminants it contains, particularly in view of the low exposure that applicators and bystanders receive.

EXPOSURE

Exposure to 2,4-D in the occupational setting has been well studied. In general, persons who apply the herbicide to rights-of-way receive the highest exposures, up to 0.08 mg/kg body weight per day, while farmers, commercial lawn applicators and home owners receive less than 0.008 mg/kg/day. The pattern and frequency of exposure are also important determinants of 2,4-D risk and this must be kept in mind in evaluating its safety. In general, people who apply 2,4-D daily for several weeks or months, even on a seasonal basis, will receive higher exposures than those who use it infrequently. Thus, rights-of-way sprayers and commercial lawn applicators may receive higher cumulative exposures than individual farmers or home gardeners who may use 2,4-D for only a few days a year. Since the major route of exposure to 2,4-D is via dermal (skin) penetration, protective clothing plays an important role in reducing possible exposure.

METABOLISM AND GENOTOXICITY

The safety evaluation of 2,4-D must include an assessment of its chemical properties and metabolism in the body. It is a relatively polar material which is absorbed into the body as such. Its amine, ester, and sodium forms are rapidly converted back to the free acid (2,4-D) in the body. Thus, for all practical purposes, exposed individuals receive the compound systemically, primarily in its acid form. This fact, coupled with knowledge of its metabolism, has important implications for its safety assessment. Unlike known carcinogens, 2,4-D is either not metabolized at all or is converted in small amounts to an even more polar glucuronide form. Both the glucuronide and the parent 2,4-D are rapidly excreted in the urine. Most carcinogens undergo metabolic activation to an ultimate carcinogenic form which attacks critical cellular targets such as DNA and 2,4-D has none of these properties. This fact has an important bearing on the interpretation of studies on its carcinogenic potential. Its failure to attack DNA or other critical cellular targets associated with carcinogenesis is supported by its relative lack of activity in short-term in vitro and in vivo tests of genotoxicity. Again, unlike the classical chemical carcinogens, 2,4-D has shown, at best, equivocal evidence of genotoxicity in certain in vitro tests involving cell systems and is consistently negative in short-term tests for carcinogenicity such as the Ames test. There is no convincing evidence that 2,4-D is genotoxic when tested in animals. This result is consistent with its known metabolic fate as described above.

LIFE-TIME TOXICITY TESTS

A critical component of the safety evaluation of 2,4-D relates to studies that have been conducted in animals to assess its carcinogenic potential. While several such studies have been conducted, two recent studies, one in mice, and one in rats, are of adequate quality to permit a rigorous evaluation for carcinogenesis. In brief, these studies involved giving groups of animals large daily doses of 2,4-D over a significant portion of their lifetime, followed by careful evaluation of the tissues for evidence of cancer induction. The results showed no evidence of carcinogenicity in mice. In rats, there was an apparent increase in the incidence of astrocytomas - a form of brain cancer in the highest dose group of 2,4-D-treated male rats compared to untreated controls. These tumors are known to occur spontaneously in groups of untreated rats with a variable incidence. Moreover, the tumors observed in the high dose 2,4-D treated group were identical in their cellular characteristics to the tumors observed in control rats and did not possess more advanced evidence of malignancy. While the increased incidence of tumors in 2,4-D-treated rats cannot be attributed exclusively to chance, it is unlikely that they were due to 2,4-D treatment. This conclusion is supported by the failure of 2,4-D to induce genotoxicity or to demonstrate the other hallmarks of well-studied carcinogens. These studies are being repeated to test this hypothesis. Importantly, there was no evidence in either the rat or mouse studies of tumor induction in the lymphoreticular system, the site alleged to be associated with tumors in workers exposed to phenoxy herbicides.

EPIDEMIOLOGY

A further important component of the safety evaluation of 2,4-D relates to epidemiological studies that have been conducted on persons exposed to phenoxy herbicides. Several such studies have been conducted in various parts of the world and include cohort, case- control and ecological studies. Much of the initial controversy over the alleged potential of 2,4-D to induce cancer arose as a result of studies conducted by Dr. Hardell and colleagues in Sweden. Hardell reported the results of a series of case-control studies that were said to demonstrate that phenoxy herbicides increased the incidence of three forms of related cancer, Hodgkin's disease, non-Hodgkin's lymphoma and soft tissue sarcoma.

These studies have been criticized due to methodological problems including potential bias in the selection of cases and controls, recall bias regarding the nature and extent of phenoxy herbicide exposure and bias that may have been introduced due to media publicity surrounding the studies. No doubt the most severe deficiency in these studies was the failure to report any quantitative data regarding 2,4-D exposure and the fact that workers mainly were exposed to 2,4,5-T not 2,4-D. Nonetheless, these series of studies have formed the basis for further testing of the hypothesis that 2,4-D exposure may increase the risk of certain cancers in humans.

Following the publication of the reports by Hardell and co-workers, several investigators have attempted to replicate the findings. Large scale ecological studies in Sweden and case- control studies in Australia, New Zealand, Italy and Washington State in the United States of exposed agricultural and forestry workers have failed to demonstrate any consistent relationship between exposure to phenoxy herbicide and the induction of cancers of the type reported to occur in the earlier Swedish studies.

A case-control study of Kansas farm workers, conducted by Dr. Hoar, of the U.S. National Cancer Institute (NCI) was said to demonstrate a relationship between exposure to phenoxy herbicides and an increased incidence of non-Hodgkin's lymphoma but not Hodgkin's disease or soft-tissue sarcoma. No data specifically regarding 2,4-D use were reported. At most, this study may be said to show a possible relationship with herbicide use and increased risk for non-Hodgkin's lymphoma, but it demonstrates no specific relationships between 2,4-D and increased cancer risk.

Recognizing the methodological deficiencies in the Kansas study, the NCI workers essentially repeated the study with a group of Nebraska farmers where they attempted to get more specific data on 2,4-D use. The results of this study are reassuring in that they showed no excess of non-Hodgkin's lymphoma in the farming population, however, there was a suggestion of a relationship between mixing and applying 2,4-D and increased risk of non- Hodgkin's lymphoma. The risk was found to increase with the number of days per year that 2,4-D was use, but there was no association between the number of years of 2,4-D use and risk of non-Hodgkin's lymphoma. According to the study, farmers who changed their clothes immediately after handling 2,4-D had a lower cancer risk, than those who did not change clothes until the following day.

A recent study of 70,000 Saskatchewan farmers by Dr. Wigle of the Canadian Health Protection Branch, demonstrated no increased incidence of Non-Hodgkin's lymphoma amongst farmers compared to the non-farm population of that province. However, the authors reponed that, within the farming population, there was a dose-response relationship between risk of non- Hodgkin's lymphoma and acres sprayed in 1970 with herbicides, as well as with dollars spent on fuel and oil for farm use. On farms in excess of 1000 acres, there was no increased risk of non-Hodgkin's lymphoma.

A similar study of Saskatchewan farmers with lung cancer by Dr. McDuffie also failed to establish a link between incidence of lung cancer and exposure to various chemicals including pesticides. The incidence of lung cancer in the farming population was lower than in the general population, an observation that has been made in previous studies.

Although several recent epidemiology studies have suggested that a relationship exists between 2,4-D exposure and increased risk of non-Hodgkin's lymphoma, this requires careful scrutiny. A principal concern relates to the lack of any direct link between 2,4-D use and increased cancer risk. It must be recognized that farmers would be exposed to herbicides at most, for a few days a year and their resulting lifetime exposure is relatively low. On the other hand, studies in chemical workers exposed continuously for many years to higher levels of 2,4-D in its manufacture have not shown any increased risk for non-Hodgkin's lymphoma or cancer at any other site. So the most heavily exposed individuals do not appear to be at increased risk.

Furthermore, the toxicology of 2,4-D provides little reason to suspect that it would be carcinogenic to humans. In animals exposed to heavy doses of 2,4-D, over 5000 times the daily dose received by farmers, there was no concrete evidence of tumor induction. If 2,4-D were carcinogenic in humans, it would have to be a potent carcinogen given the degree of human exposure, especially in farmers. If this was true, it most certainly would have shown clear evidence for carcinogenicity in the animal studies. Moreover, there is little reason to suspect that 2,4-D would be carcinogenic, based on its chemical properties, metabolism and lack of genotoxicity. Based on an evaluation of all the evidence, it may be concluded that any increased risk of cancer in farmers exposed to herbicides is unlikely attributable to 2,4-D.

It also should be noted that reducing exposure to any chemical lowers its potential risk. A recently completed study of 2,4-D exposure in home owners using this herbicide has shown that the absorbed dose was reduced to undetectable levels by the use of protective clothing such as rubber gloves, overalls, and rubber boots. Prudent use of such protective gear will significantly reduce any risks from herbicide exposure.

MONITORING PESTICIDE LEACHING FROM BENTGRASS MICRO-GREENS

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PRELIMINARY REPORT

OBJECTIVES

1) **To measure the amount of leaching of several pesticides from established creeping bentgrass micro-greens**

2) **To compare differences in leaching losses of several pesticides from calcareous and siliceous micro-green rootzones.**

METHODS

Treatments were applied in early August to established creeping bentgrass micro-greens at the Cambridge Research Station. The micro-greens were constructed in 1982 and consist of twelve 0.65 m^2 micro-greens of a calcareous sand and 12 of a siliceous sand. Each micro-green is contained within a fibreglass tank, which is equipped with drain lines to permit the collection of drainage water. The established turf is predominantly creeping bentgrass with some annual bluegrass contamination. Two insecticides, four fungicides and three herbicides were used in the study and were applied as tank-mixes according to analytical compatibility. Applications consisted of 2 treatments x 4 replications x 2 rootzones and 1 treatment x 2 replications x 2 rates x 2 rootzones. All pesticides with the exception of chlorpyrifos were applied with a backpack sprayer calibrated to apply 1.1 L spray solution /30 seconds with tank pressure maintained by continual pumping. The chlorpyrifos was applied as a dust and then irrigated in. All micro-greens were irrigated the day following application. Leachate was collected before application and at intervals of 2, 4, 9, 15, 21, 50 days after application[1]. Grass clippings were also collected at each sampling period. Rinsate from the sprayer was also sampled. During the growing season 2 spring fertilizer applications were made to the micro-greens.

Analyses from leachate and clipping samples were not available at time of printing of this report.

[1] The sampling interval was dependent on rainfall and/or irrigation in order to collect adequate leachate for analysis. Total volume of leachate was measured. Sub-samples of the leachate from each of the 24 micro-green were then taken back to the lab for analysis. Leachate samples were also analyzed for nitrate levels.

EVALUATION OF SPECIES AND CULTIVARS

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 1990 season include germination/density and color ratings. Rankings based on 1990 data are given below (Tables 1 to 4).

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

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

Since mowing height and other management was similar during the establishment period, the ratings presented are for six replicates of the 17 cultivars common to the two trial, and for three replicates of the 4 cultivars unique to one or other trial.

Table 1. Rankings for germination[1] of bentgrass cultivars.

Cultivar	Germination	
Emerald	4.03	a
National	4.00	a
Forbes 89-12	3.81	ab
Putter	3.75	abc
Normarc 101	3.69	abcd
Providence	3.53	abcde
Pennlinks	3.50	abcde
WVPB 89-D-15	3.08	abcde
Penncross	3.03	abcde
Egmont	2.92	bcdef
88.CBL	2.78	bcdef
BR 1518	2.78	bcdef
88.CBE	2.72	cdef
SR 1020	2.64	defg
Bardot	2.56	efgh
Cobra	2.50	efgh
TAMU 88-1	2.44	efgh
Penneagle	1.94	fgh
Tracenta	1.92	fgh
Allure	1.67	gh
Carmen	1.58	h

[1] Germination rated visually 0 to 10, 10=complete germination; mean of five evaluation dates: 90-08-27, 90-08-28, 90-08-29, 90-08-31, 90-09-04 .

Table 2. Rankings for density[1] of bentgrass cultivars.

Cultivar	Density	
National	9.42	a
Emerald	9.42	a
Forbes 89-12	9.42	a
Normarc 101	9.38	a
88.CBE	9.25	a
Putter	9.08	a
Penncross	9.04	ab
Pennlinks	9.00	ab
88.CBL	8.83	abc
Providence	8.79	abcd
Cobra	8.63	abcd
WVPB 89-D-15	8.63	abcd
TAMU 88-1	8.33	abcde
BR 1518	8.25	abcde
SR 1020	8.21	abcde
Egmont	8.08	abcdef
Bardot	7.67	bcdef
Tracenta	7.46	cdef
Penneagle	7.42	def
Carmen	7.04	ef
Allure	6.79	f

[1] Density rated visually 0 to 10, 10=complete cover; mean of five evaluation dates: 90-09-11, 90-09-17, 90-09-26, 90-10-05, 90-10-15.

Table 3. Rankings for summer color[1] of bentgrass cultivars.

Cultivar	Summer color	
BR 1518	8.94	a
Tracenta	8.72	ab
Egmont	8.67	ab
Bardot	8.56	ab
Allure	8.17	bc
Providence	7.83	cd
88.CBL	7.61	cde
88.CBE	7.56	cde
WVPB 89-D-15	7.56	cde
Cobra	7.39	def
Forbes 89-12	7.39	def
TAMU 88-1	7.33	def
Penneagle	7.33	def
Penncross	7.28	def
Pennlinks	7.22	def
Normarc 101	7.17	def
SR 1020	7.17	def
Carmen	7.06	ef
Putter	6.89	ef
Emerald	6.67	fg
National	6.22	g

[1] Color rated visually 0 to 9, 9=darkest green; mean of three evaluation dates: 90-09-11, 90-09-17, 90-09-26.

Table 4. Rankings for fall color[1] of bentgrass cultivars.

Cultivar	Fall color	
Tracenta	8.50	a
Bardot	8.00	ba
88.CBL	7.61	bc
BR 1518	7.56	bc
WVPB 89-D-15	7.17	bcd
Forbes 89-12	7.11	bcd
88.CBE	7.11	bcd
Egmont	7.06	cd
Providence	7.06	cd
Allure	6.94	cd
SR 1020	6.72	cd
Normarc 101	6.56	d
Cobra	6.56	d
Penneagle	6.44	d
Pennlinks	6.44	d
Putter	6.33	de
Penncross	6.28	de
Carmen	6.28	de
TAMU 88-1	6.22	de
National	5.50	ef
Emerald	5.17	f

[1] Color rated visually 0 to 9, 9=darkest green; mean of three evaluation dates: 90-10-05, 90-10-15, 90-10-30.

FINE FESCUE CULTIVAR EVALUATION

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Fine fescue cultivars (seeded in 1986) are being assessed for general appearance (uniformity and density), color, resistance to weed infestation, disease, and drought stress, and performance at different mowing heights. Rankings based on 1990 data are given below.

Table 1. Rankings for spring color[1] of fine fescue cultivars.

Cultivar	Spring color	
Scarlet	8.0	a
Fortress	8.0	a
Common creeping	7.3	ab
Luster	7.0	abc
Banner	6.5	bcd
Wilma	6.3	bcd
Victory	6.3	bcd
Azay	6.0	cde
Epsom	6.0	cde
Center	6.0	cde
Jamestown	6.0	cde
Atlanta	6.0	cde
Spartan	5.3	de
Biljart	5.3	de
Scaldis	5.0	e

[1] Color rated visually 0 to 9, 9 = darkest green; evaluation date 90-04-09.

Table 2. Rankings for summer color[1] of fine fescue cultivars.

Cultivar	Summer color	
Spartan	9.0	a
Fortress	8.7	ab
Scarlet	8.5	abc
Scaldis	8.5	abc
Biljart	8.3	abc
Common creeping	8.0	abcd
Banner	7.8	bcd
Wilma	7.7	bcde
Jamestown	7.3	cde
Azay	7.0	def
Victory	7.0	def
Luster	7.0	def
Atlanta	6.5	ef
Center	6.5	ef
Epsom	6.0	f

[1] Color rated visually 0 to 9, 9 = darkest green; evaluation date 90-06-12.

Table 3. Rankings for height[1] of fine fescue cultivars.

Cultivar	Height	
Victory	45.0	a
Scaldis	45.0	a
Azay	45.0	a
Luster	43.3	ab
Banner	42.5	abc
Spartan	40.0	abcd
Jamestown	40.0	abcd
Biljart	38.3	abcd
Fortress	36.7	abcd
Wilma	35.0	abcd
Scarlet	32.5	bcde
Common creeping	31.7	cde
Center	30.0	de
Atlanta	22.5	ef
Epsom	16.7	f

[1] Height (cm) rated visually in unmowed portion of plots; evaluation date 90-06-12.

PERENNIAL RYEGRASS CULTIVAR EVALUATION

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Perennial ryegrass cultivars (seeded 89/7/19) have been assessed for general appearance (uniformity and density), spring greenup, and summer color. Rankings based on 1990 data are given below.

Table 1. Rankings for spring, summer and fall color[1] of perennial ryegrass cultivars.

Cultivar	Spring	Cultivar	Summer	Cultivar	Fall
Saturn	6.83	Competitor	8.40	Aquarius	8.33
Caliente	6.83	Dimension	8.20	Competitor	8.00
Pennant	6.83	Aquarius	8.00	Dimension	7.67
Omega II	6.50	Barry	7.93	Pennant	7.00
Dimension	6.33	Omega II	7.67	Omega II	7.00
Nova	6.33	Saturn	7.67	Saturn	7.00
Barry	6.33	Nova	7.60	Nova	6.67
Aquarius	6.17	Caliente	7.07	Caliente	6.67
Sheriff	6.17	Sheriff	7.07	Barry	6.00
Competitor	5.67	Pennant	7.00	Sheriff	5.67
LSD 5%	0.85		0.51		1.16

[1] Color rated visually 0 to 9, 9 = darkest green; spring - mean of two evaluations: 90-04-09, 90-04-23; summer - mean of five evaluations: 90-05-07, 90-05-28, 90-06-12, 90-08-22, 90-09-04; fall - evaluated 90-10-15

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

Cultivar	General appearance
Caliente	9.22
Saturn	9.11
Sheriff	9.00
Barry	8.89
Omega II	8.78
Pennant	8.78
Nova	8.67
Competitor	8.67
Dimension	8.56
Aquarius	8.55
LSD 5%	0.66

[1] General appearance rated visually 0 to 10, 9 = best texture, uniformity; mean of three evaluations: 90-04-23, 90-08-22, 90-09-04

KENTUCKY BLUEGRASS CULTIVAR EVALUATION

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Kentucky bluegrass cultivars (seeded in 1987 and 1988) are being assessed for general appearance (uniformity and density), color, resistance to weed infestation, disease, and drought stress. Rankings based on 1990 data are given below.

The research plots of both the 1987 and 1988 Kentucky bluegrass trials have become heavily infested with annual bluegrass, as evident in general appearance and annual bluegrass infestation ratings. Because of this, the 1990 ratings are probably the last for these trials.

Cultivars seeded 1987.

Table 1. Rankings for spring color[1] of Kentucky bluegrass cultivars, seeded 1987.

Cultivar	Spring color	
Touchdown	8.00	a
Midnight	6.84	ab
Barblue	6.84	ab
Banff	6.34	bc
Haga	6.17	bc
Majestic	6.17	bc
Cheri	5.84	bcd
America	5.84	bcd
Sydsport	5.83	bcd
Nallo	5.67	bcd
Alpine	5.67	bcd
Ram I	5.67	bcd
Fylking	5.67	bcd
A-34	5.50	bcd
Nassau	5.34	bcd
Gnome	5.34	bcd
Nugget	5.00	cd
Julia	5.00	cd
Baron	4.84	cd
Bronco	4.50	d

[1] Color rated visually 0 to 9, 9 = darkest green; mean of three evaluation dates: 90-04-09, 90-04-16, 90-04-23.

Table 2. Rankings for summer color[1] of Kentucky bluegrass cultivars, seeded 1987.

Cultivar	Summer color	
Nugget	8.25	a
Midnight	8.00	ab
America	7.75	abc
Alpine	7.50	abcd
Gnome	7.50	abcd
Barblue	7.25	abcde
Baron	7.25	abcde
Cheri	7.25	abcde
Nallo	7.00	bcdef
Banff	7.00	bcdef
Haga	6.75	cdef
Bronco	6.75	cdef
Sydsport	6.75	cdef
A-34	6.50	def
Nassau	6.50	def
Majestic	6.50	def
Fylking	6.25	ef
Ram I	6.00	f
Julia	6.00	f
Touchdown	6.00	f

[1] Color rated visually 0 to 9, 9 = darkest green; mean of two evaluation dates: 90-05-07, 90-06-20.

Table 3. Rankings for general appearance[1] of Kentucky bluegrass cultivars, seeded 1987.

Cultivar	General appearance	
Touchdown	7.50	a
Haga	7.00	ab
Julia	6.50	abc
Banff	6.50	abc
A-34	6.50	abc
Midnight	6.50	abc
America	6.50	abc
Barblue	6.50	abc
Gnome	6.00	abc
Cheri	6.00	abc
Nugget	6.00	abc
Nassau	5.50	bc
Nallo	5.50	bc
Fylking	5.50	bc
Majestic	5.50	bc
Baron	5.00	c
Ram I	5.00	c
Alpine	5.00	c
Bronco	5.00	c
Sydsport	5.00	c

[1] Appearance rated visually 0 to 10, 10 = best uniformity/density/texture; evaluation date 90-04-23.

Cultivars seeded 1988.

Table 4. Rankings for spring color[1] of Kentucky bluegrass cultivars, seeded 1988.

Cultivar	Spring color
Touchdown	8.67
Nassau	7.67
Barblue	7.33
Freedom	6.83
Haga	6.50
Eclipse	6.50
America	6.34
Majestic	6.33
Cheri	6.17
Baron	6.00
Liberty	6.00
Gnome	6.00
Regent	5.83
Banff	5.67
Sydsport	5.67
A-34	5.50
Midnight	5.17
Nugget	4.83
Julia	4.34
Alpine	4.33
Fylking	3.67
LSD (5%)	1.45

[1] Color rated visually 0 to 9, 9 = darkest green; mean of three evaluation dates: 90-04-09, 90-04-16, 90-04-23.

Table 5. Rankings for summer color[1] of Kentucky bluegrass cultivars, seeded 1988.

Cultivar	Summer color
Alpine	8.50
Nugget	8.00
America	7.50
Midnight	7.50
Freedom	7.25
Gnome	7.25
Eclipse	7.25
Regent	7.00
Nassau	6.75
Liberty	6.50
Barblue	6.50
Banff	6.25
Cheri	6.25
Baron	6.25
Majestic	6.25
Sydsport	6.25
Fylking	6.00
Haga	5.75
Julia	5.50
A-34	5.50
Touchdown	5.50
LSD (5%)	1.13

[1] Color rated visually 0 to 9, 9 = darkest green; mean of two evaluation dates: 90-05-07, 90-06-20

Table 6. Rankings for general appearance[1] of Kentucky bluegrass cultivars, seeded 1988.

Cultivar	General appearance
Touchdown	8.50
Sydsport	8.00
Barblue	8.00
Haga	8.00
Gnome	7.50
Cheri	7.50
Freedom	7.50
Baron	7.00
Liberty	7.00
Eclipse	7.00
America	7.00
Midnight	7.00
A-34	7.00
Banff	7.00
Majestic	7.00
Nugget	6.50
Nassau	6.50
Julia	6.50
Fylking	6.00
Alpine	6.00
Regent	6.00
LSD (5%)	1.54

[1] Appearance rated visually 0 to 10, 10 = best uniformity/density/texture; evaluation date 90-04-23.

Table 7. Rankings for annual bluegrass infestation[1] of Kentucky bluegrass cultivars, seeded 1988.

Cultivar	Annual bluegrass
Gnome	3.50
Baron	3.00
Nassau	3.00
Majestic	3.00
Midnight	2.50
Fylking	2.00
Regent	2.00
Eclipse	2.00
Julia	1.50
Sydsport	1.50
America	1.50
Nugget	1.00
Freedom	1.00
Liberty	1.00
Barblue	1.00
Haga	0.50
A-34	0.50
Banff	0.50
Touchdow	0.50
Alpine	0.00
Cheri	0.00
LSD (5%)	1.84

[1] Area of infestation rated visually 0 to 5, 5 = most bluegrass; evaluation date 90-06-20.

TALL FESCUE CULTIVAR EVALUATION

J. L. Eggens, N. McCollum and K. Carey
Department of Horticultural Science

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 1990 data are given below.

Cultivars seeded 1988

Table 1. Rankings for spring color[1] of tall fescue cultivars, seeded 1988.

Cultivar	Spring color
Cochise	6.67
Tribute	6.67
Rebel II	6.50
Thoroughbred	6.33
Rebel	6.17
Houndog	6.17
Jaguar	6.00
Maverick	6.00
Mustang	6.00
Arid	5.83
Pacer	5.50
Chesapeake	5.00
LSD (5%)	0.73

[1] Color rated visually 0 to 9, 9 = darkest green; mean of two evaluation dates: 90-04-16, 90-04-30.

Table 2. Rankings for summer color[1] of tall fescue cultivars, seeded 1988.

Cultivar	Summer color
Cochise	8.67
Maverick	7.83
Arid	7.83
Tribute	7.67
Mustang	7.67
Rebel II	7.67
Thoroughbred	7.67
Pacer	7.33
Jaguar	7.17
Houndog	7.17
Rebel	7.17
Chesapeake	6.33
LSD (5%)	0.60

[1] Color rated visually 0 to 9, 9 = darkest green; mean of two evaluation dates: 90-06-20, 90-08-22

Table 3. Rankings for height[1] of tall fescue cultivars, seeded 1988.

Cultivar	Height
Mustang	2.00
Chesapeake	2.00
Arid	1.67
Pacer	1.67
Jaguar	1.33
Rebel II	1.33
Cochise	1.33
Thoroughbred	1.33
Houndog	1.00
Maverick	1.00
Tribute	1.00
Rebel	0.67
LSD (5%)	1.12

[1] Height rated visually 0 = short, 1 = medium, 2 = tall; evaluation date 90-06-20.

Table 4. Rankings for general appearance[1] of tall fescue cultivars, seeded 1988.

Cultivar	General appearance
Arid	6.67
Rebel II	6.33
Thoroughbred	6.33
Tribute	6.33
Jaguar	6.33
Rebel	6.33
Maverick	6.00
Pacer	6.00
Mustang	6.00
Houndog	6.00
Cochise	6.00
Chesapeake	5.67
LSD (5%)	0.74

[1] General appearance rated visually 0 to 10, 9 = best uniformity, density, texture; evaluation date 90-08-22.

Table 5. Rankings for seedhead density[1] of tall fescue cultivars, seeded 1988.

Cultivar	Seedhead density
Mustang	96.67
Chesapeake	90.00
Pacer	90.00
Arid	83.33
Cochise	73.33
Tribute	70.00
Thoroughbred	63.33
Houndog	60.00
Maverick	50.00
Rebel II	50.00
Jaguar	43.33
Rebel	36.67
LSD (5%)	30.76

[1] Seedhead density rated visually 0 to 100, 100 = 100% of unmowed plot area in seedhead; evaluation date 90-06-20.

Cultivars seeded August 3, 1990

Table 6. Rankings for summer color[1] of tall fescue cultivars, seeded 1990.

Cultivar	Summer color
Shortstop	9.00
MiniMustang	9.00
Emperor	9.00
Rebel Jr.	9.00
Crossfire	8.92
Bonsai	8.92
Sapphire	8.08
Thoroughbred	8.00
Jaguar II	7.92
Mustang	7.83
Thunderbird	7.83
Winchester	7.75
Falcon	7.58
Rebel II	7.58
Finelawn I	7.50
Tribute	7.50
Willamette	7.25
Jaguar	7.17
LSD (5%)	0.40

[1] Color rated visually 0 to 9, 9 = darkest green; mean of four evaluation dates: 90-08-16, 90-08-22, 90-09-04, 90-09-26.

Table 7. Rankings for fall color[1] of tall fescue cultivars, seeded 1990.

Cultivar	Fall color
Bonsai	8.89
MiniMustang	8.89
Emperor	8.89
Shortstop	8.89
Rebel Jr.	8.89
Crossfire	8.66
Thunderbird	7.89
Winchester	7.77
Tribute	7.77
Rebel II	7.66
Mustang	7.55
Sapphire	7.44
Jaguar II	7.44
Thoroughbred	7.11
Willamette	6.89
Falcon	6.77
Finelawn I	6.77
Jaguar	6.55
LSD (5%)	0.48

[1] Color rated visually 0 to 9, 9 = darkest green; mean of three evaluation dates: 90-10-05, 90-10-15, 90-10-30.

Table 8. Rankings for germination/cover[1] of tall fescue cultivars, seeded 1990.

Cultivar	Germination/cover
Thunderbird	8.06
Tribute	7.09
Rebel II	7.04
Winchester	6.54
Jaguar II	6.21
Willamette	6.07
Jaguar	6.01
MiniMustang	5.97
Crossfire	5.80
Finelawn I	5.68
Mustang	5.65
Shortstop	5.63
Falcon	5.18
Sapphire	4.98
Thoroughbred	4.89
Bonsai	4.44
Rebel Jr.	4.10
Emperor	3.79
LSD (5%)	1.00

[1] Germination/cover rated visually 0 to 10, 10 = best; mean of 11 evaluation dates: 90-08-07, 08-08, 08-09, 08-10, 08-13, 08-14, 08-16, 08-20, 08-22, 08-27, 09-04.

Table 9. Rankings for height[1] of tall fescue cultivars, seeded 1990.

Cultivar	Height
Mustang	3.00
Jaguar	3.00
Finelawn I	3.00
Falcon	3.00
Thoroughbred	3.00
Willamette	2.67
Rebel II	2.67
Tribute	2.33
Sapphire	2.33
Winchester	2.33
Jaguar II	2.00
Thunderbird	2.00
Crossfire	2.00
Rebel Jr.	1.33
Shortstop	1.33
Emperor	1.00
Bonsai	1.00
MiniMustang	1.00
LSD (5%)	0.60

[1] Height rated visually in unmown plots, 1 = short, 2 = medium, 3 = tall; evaluation date 90-10-05.

Table 10. Rankings for texture[1] of tall fescue cultivars, seeded 1990.

Cultivar	Texture
Thunderbird	2.67
Winchester	2.67
MiniMustang	2.33
Rebel II	2.33
Crossfire	2.33
Bonsai	2.00
Shortstop	2.00
Jaguar II	2.00
Willamette	2.00
Falcon	2.00
Tribute	2.00
Thoroughbred	2.00
Emperor	1.67
Jaguar	1.67
Mustang	1.33
Rebel Jr.	1.33
Sapphire	1.33
Finelawn I	1.00
LSD (5%)	0.90

[1] Texture rated visually 1 to 3, 3 = finest; evaluation date 90-09-04.

SPORTS TURF MIXTURE EVALUATION

J. L. Eggens, N. McCollum and K. Carey
Department of Horticultural Science

Mixes of various ratios of seed of different turfgrass species were seeded at the Cambridge Research Station on August 18, 1988 (Table 4). These mixes are being evaluated for functional features (germination, cover, color, general appearance, winter hardiness, and recuperative potential). Changes in botanical composition of the plots will also be evaluated. Rankings based on 1990 data are given below.

Table 1. Rankings for spring color[1] for sports turf mixtures.

Mixture	Spring color
22	7.83
10	7.00
23	6.83
3	6.83
21	6.67
13	6.67
15	6.67
9	6.67
26	6.33
2	6.17
6	6.17
14	6.17
5	6.17
8	6.00
1	6.00
7	5.83
11	5.83
12	5.83
27	5.83
16	5.83
4	5.50
20	4.83
25	4.83
24	4.83
LSD (5%)	1.75

[1] Color rated visually 0 to 9, 9 = darkest green; mean of two evaluation dates: 90-04-16, 90-04-30.

Table 2. Rankings for summer color[1] for sports turf mixtures.

Mixture	Summer color
11	8.67
10	8.67
2	8.33
12	8.33
8	8.33
3	8.33
9	8.33
4	8.17
5	8.17
6	8.00
1	8.00
7	8.00
21	8.00
16	8.00
27	7.83
24	7.83
14	7.83
22	7.83
15	7.67
23	7.50
25	7.33
26	7.00
13	6.83
20	6.83
LSD (5%)	0.62

[1] Color rated visually 0 to 9, 9 = darkest green; mean of two evaluation dates: 90-06-20, 90-08-22.

Table 3. Rankings for general appearance[1] for sports turf mixtures.

Mixture	General appearance
9	9.17
1	8.67
15	8.67
10	8.67
16	8.67
2	8.50
11	8.50
22	8.50
4	8.50
7	8.33
23	8.33
5	8.33
8	8.17
12	8.00
21	8.00
6	7.83
3	7.67
14	7.67
13	7.00
26	7.00
25	7.00
24	6.67
27	6.67
20	6.17
LSD (5%)	1.25

[1] General appearance rated visually 0 to 10, 10 = best uniformity, density, texture; mean of two evaluation dates: 90-06-20, 90-08-22.

Table 4. Sports turf mixtures

Mixture	Perennial ryegrass	Kentucky bluegrass	Tall fescue	Fine-leaved fescue
#1	50% Yorktown	25% Baron 25% Gnome		
#2	50% Barry 25% Yorktown		25% Rebel II	
#3	20% Barry	20% Baron	20% Rebel II	20% Wilma
		20% Gnome		
#4	50% Palmer 25% Yorktown II			25% Fortress
#5	30% Palmer	35% Gnome	10% Rebel II	25% Fortress
#6	25% Palmer 25% Yorktown II	25% Gnome		25% Wilma
#7	50% Palmer 25% Yorktown II	25% Baron		
#8	25% Palmer	25% Gnome	25% Rebel II	25% Fortress
#9	25% Gator 25% Yorktown II			25% Fortress 25% Wilma
#10	25% Barry	25% Baron 25% Midnight		25% Fortress
#11	50% Gator			50% Fortress
#12	60% Palmer	20% Baron		20% Fortress
#13		10% Baron	90% Rebel II	
#14	25% Barry	25% Baron	50% Rebel II	
#15	10% Fiesta	30% Touchdown 20% Fylking 15% Banff		25% Victory
#16	80% Fiesta II	20% Touchdown		
#20			100% Willamette	
#21	15% Omega II 15% Pennant	25% Liberty 10% Regent		45% Koket
#22	10% Fiesta II	30% Banff 20% common		40% Boreal
#23	15% Fiesta II	25% Touchdown 15% A-34 15% Fylking		30% Victory
#24	20% Omega		80% Jaguar	
#25			100% Jaguar II	
#26			80% Jaguar	20% Koket
#27		10% Touchdown	90% Mustang	

TURFGRASS EXTENSION

1990 SEASONAL SUMMARY

Annette Anderson, Turf Extension Specialist
Ontario Ministry of Agriculture and Food
Department of Horticultural Science

The weather, the economy and posting regulations figured prominently in the 1990 season for the turf industry.

SOD PRODUCTION

In terms of growing conditions the cool wet spring caused some disease problems, in particular, helminthosporium leaf spot. Due to the frequent rainfall very few sod growers had to irrigate for growing or harvest operations.

By late summer, demand for sod dropped off considerably. This decrease in demand was a reflection of the slow housing/construction industry. With the downturn in the economy it is probably not a good time for a new grower to get into sod production as there will most likely be a surplus supply of sod in 1991.

Total acreage seeded this fall is down approximately 30 - 40% from the past two years. Some early seedings had a few weed problems, but in general fall conditions have been good for getting the new crop established.

It is most likely that the slowing demand will have an impact on the 1991 price of sod, perhaps as much as a 10 - 20% decrease as the industry has enjoyed unusually high prices for the last few years.

Annual bluegrass and creeping bentgrass were significant problems in sod fields this year due to the high soil moisture conditions. There are no adequate controls registered for these grassy weed problems.

The 1990 American Sod Producers Association Summer Convention was hosted by Manderly Sod, Ottawa. Over 500 participants from the U.S., Europe, and Australia attended.

GOLF COURSES

Most golf courses found 1990 to be a relatively easy year to maintain turf, as there were not prolonged periods of stress. Slow green-up, poor response to fertilizers and poor conditions for seed germination and establishment were problems caused by cool temperatures in the spring. Occurrence of black layer on golf course greens was more prevalent on a number of courses this year. Black layer is a more of a problem when rootzones are saturated and anaerobic conditions persist.

There were relatively few reports of disease problems that resulted in significant turf damage. Incidence of dollar spot, brown patch and pythium was significantly lower in 1990. Fairy ring which in most years has only been observed on fairways was a problem on greens, especially on sand rootzones with low fertility and moisture.

Annual bluegrass weevil and grubs were the two main insect problems. Gypsy moth damage was severe on a number of golf courses with reports of as much as 30% defoliation of certain tree species.

LAWN CARE

In general most lawns fared pretty well over the course of the season due to the abundance of natural rainfall and good growing conditions. However, more disease problems than usual were experienced on home lawns. Incidence of Leaf Spot was high in the spring and the fall. Necrotic Ring Spot continues to be a serious disease problem on kentucky bluegrass. There is no chemical control available for this problem.

Other diseases such as red thread and rust were widespread problems this year. Mushrooms were quite noticeable on many home lawns.

Chinch bug damage was reported in as high a frequency as most years. Grub problems were widely reported in the spring. This continues to be the main insect problem. There were many complaints about poor grub control and with the products that are currently available.

Crabgrass germination was late again this year. The biggest problem with pre-emergent crabgrass control appears to be that people are applying it too early. Some problems were experienced with postemergent crabgrass control primarily due to poor timing. Broadleaf weeds thrived this year. Control was difficult in the spring and fall due to windy conditions or rainfall. Creeping bentgrass and rough bluegrass were widely reported grassy weed problems.

Despite slow downs in other sectors there does not appear to be a significant decline in the demand for lawn care services. More lawn care companies are offering services such as overseeding and core cultivation. Many companies are trying to address customer preference for organic lawn care.

REGULATION 751

Implementation of posting regulations took effect in early June. A survey was conducted by industry associations to obtain feedback from the commercial applicators regarding the public reaction to the signs, the logistics of posting and other implications.

PEST DIAGNOSTIC CLINIC

Turn around time of commercial turf samples sent to the Pest Diagnostic Clinic continues to be a concern. Staffing and budget cuts experienced by PDAC in 1990 is of concern to client groups that rely on this diagnostic service.

TURF HOT LINE

The Turf Hot Line was in operation until the end of October. This has proven to be a useful service to the turf industry with approximately 1000 calls received over the course of the season.

PUBLICATION 384

Publication 384 *Recommendations for Turfgrass Management* is a new publication that contains commercial recommendations for turfgrass fertility, and management of insect, disease and weed. This publication is available from any county office of The Ontario Ministry of Agriculture and Food or the Consumer Information Centre, 801 Bay St., Toronto, Ontario.

1991 GTI/OTRF RESEARCH FIELD DAY

The 1991 GTI/OTRF Research Field Day will be held August 22 at the Cambridge Research Station.

1990 TURF INDUSTRY SURVEY

A. Anderson and S. Dean
Ontario Ministry of Agriculture and Food
Department of Horticultural Science

OBJECTIVES

1) To determine the area of turfgrass and expenditures on turfgrass maintenance in Ontario.

2) To identify trends in fertility and pest management practices

3) To identify current problems or concerns with regards to turfgrass pests.

METHODS

Questionnaires were mailed or handed out to approximately 2000 clients . The survey format was based on the questionnaire used in the 1983 survey conducted by Sears and Gimplej.

Completed questionnaires will be tabulated according to category (golf course, lawn care, parks, sod production, other) and by geographic location (county)

RESULTS

Results from returned questionnaires will be presented in the 1991 GTI Annual Report. A copy of the questionnaire follows in the Annual Research Report. If you are a professional turfgrass manager in Ontario and have not received and submitted the questionnaire via another route, please feel free to remove it and complete it.

ACKNOWLEDGEMENTS

Canadian Golf Superintendents Association
Green Care
Landscape Ontario
Nursery Sod Growers Association
Sports Turf Association

The purpose of this questionnaire is to determine the area of turfgrass and expenditures on turfgrass maintenance in Ontario. please fill out this questionnaire as completely as possible. Questions 1 - 10 should be filled out by all participants. Questions 11 - 14 apply to golf courses, 15 - 18 apply to lawn care, 19 - 25 apply to sod farms , and 26 - 28 apply to municipalities/parks/government agencies.

Please complete and return to: **Annette Anderson, OMAF Turf Extension Specialist,**
Dept. of Horticultural Science,
University of Guelph,
Guelph, Ontario NIG 2W1.

Thank you for your co-operation.

1. Category: golf course _________ lawn care ________ parks ________ sod ________

   Other (please specify)____

2. County:______________________________

3.How many people, including yourself, are employed for the purposes of turf maintenance?

   a) permanent staff ...._______

      Average hourly wage _______

   b) seasonal ...._______

      Average hourly wage _______

4. Please indicate the total annual expenditure made for your operation in 1990 for each of the following items:

   a) Total annual expenditures on salaries for employees indicated in question #3. $___________

   b) Total annual expenditures on fringe benefits for above. $___________

   c) Total annual expenditures on fertilizers:

      1) Liquid $___________

      2) Granular $___________

   d) Total annual expenditures on herbicides. $___________

   e) Total annual expenditures on insecticides. $___________

   f) Total annual expenditures on fungicides. $___________

   g) Total annual expenditures on grass seed. $___________

   h) Total annual expenditures on sod. $___________

   i) Total annual expenditures on supplies (i.e., gas, oil, etc.). $___________

   j) Total annual expenditures on water. $___________

   k) Total annual expenditures on equipment repair. $___________

   l) Total annual expenditures on irrigation and drainage equipment and supplies. $___________

m) Total annual expenditures on trees and flowers $___________

n) Total annual expenditures on signs/notices required for posting/prenotification for pesticide applications $___________

5. What was the total amount (gallons/litres) of water used for irrigation? ___________

6. a) What was the value of all turf maintenance equipment, including irrigation, bought in 1990? $___________

b) What is the approximate replacement value of all turf maintenance equipment, including irrigation, tractors, cutters, spreaders, pipes, sprinklers, etc., owned in 1990? $___________

7. a) Which of the following sources of information have you contacted regarding turf maintenance problems?

Provincial government extension specialist ....______

University personnel ....______

Pest Diagnostic Clinic ....______

Private consultant..........______

Magazine/trade journal ....______

Books..........______

Association member ....______

Other (please specify) ___________________________

b) Which one(s) has been the most useful? ___________________________

____

8. What is the most serious lawn problem you encounter? (eg. weeds, insects, disease, poor soil, shade, diagnosis of pest problems, etc.) ___________________________

____

____

9. a) Which insect problems are of the most concern to you? ___________________________

____

____

b) Which disease problems are of the most concern to you? ___________________________

____

____

c) Which weed problems are of the most concern to you? ___________________________

____

____

10. Other comments/concerns ______________________________

____
____
____
____
____

FOR GOLF COURSES:

Course Description (private, semi-private, public) ______________________________

11. a. The course you maintain has:
9 holes .... ______
18 holes .... ______
27 holes .... ______
36 holes .... ______
Other (please specify)
____

b. Does your course have a driving range?
Yes .... ______
No .... ______

c. Approximate number of golf rounds per year .... __________

12. For each of the following categories please indicate the number of acres applicable to your course:

a) greens .... ______ acres

b) fairways .... ______ acres

c) tees .... ______ acres

d) rough .... ______ acres

e) sod nursery .... ______ acres

f) driving range .... ______ acres

g) other maintained turf .... ______ acres

h) total golf course acreage .... ______ acres

13. How many fertilizer applications per season do you make to the following areas? Where possible list total amount N applied per area.

	Total N/100m^2 per season	Total # Applications Granular	Total # Applications Liquid
Greens	______	______	______
Tees	______	______	______
Fairways	______	______	______
Rough	______	______	______
Other	______	______	______

14. How many pesticide applications per season do you make to the following areas? Where possible list total applications per area.

	Fungicides	Insecticides	Herbicides
Greens	______	______	______
Tees	______	______	______
Fairways	______	______	______
Rough	______	______	______
Other	______	______	______

What diseases do you treat preventatively (prior to symptoms)?

______

______

What diseases do you treat curatively (after symptoms)?

______

______

FOR LAWN CARE COMPANIES:

15. Please indicate the total number of locations for which you provided lawn care service during 1990.

______ locations

16. For the following segments, please indicate the total sales value earned in 1990

		Number of locations	Total Sales
a)	Residential	______	$ ______
b)	Commercial	______	$ ______
c)	Other	______	$ ______

17. For each of the following segments, please indicate the average number of treatments with pesticide and/or fertilizer during 1990.

	Average number of applications of			
	Fertilizer	Herbicide	Insecticide	Fungicide
a) Residential	______	______	______	______
b) Commercial	______	______	______	______
c) Other	______	______	______	______

18. For each of the following segments, please indicate the number of locations and total sales value earned during 1990 for other services (lawn maintenance, rolling, aerating, thatch removal, mowing, seeding, sodding, etc.)

	Number of locations	Average number of treatments	Total sales value
a) Residential	______	______	$ ______
b) Commercial	______	______	$ ______
c) Other	______	______	$ ______

FOR SOD PRODUCERS:

19. Total acres of nursery sod grown in 1990:
    - Kentucky bluegrass ______ acres
    - Kentucky bluegrass/fescue ______ acres
    - bentgrass ______ acres
    - other (please specify) ______ ______ acres

20. a) Total acreage of nursery sod harvested in 1990:
    - Kentucky bluegrass ______ acres
    - Kentucky bluegrass/fescue ______ acres
    - bentgrass ______ acres
    - other (please specify) ______ ______ acres

    b) Total acreage of nursery sod seeded in 1990:
    - Kentucky bluegrass ______ acres
    - Kentucky bluegrass/fescue ______ acres
    - bentgrass ______ acres
    - other (please specify) ______ ______ acres

21. Average number of rolls harvested/acre .... ______

22. Average price per roll
    - wholesale
      - f.o.b. .... ______
      - delivered .... ______
      - installed .... ______
    - retail .... ______

23. Breakdown of Total Sales

		Total Sales	
		Wholesale	Retail
a)	Residential	$ ______	$ ______
b)	Commercial	$ ______	$ ______
c)	Other	$ ______	$ ______

25. List average number of applications of the following per crop (from establishment to harvest).

Fertilizer ____________ Herbicides ____________

Insecticides ____________ Fungicides ____________

FOR MUNICIPALITIES/PARKS AND GOVERNMENT AGENCIES:

Name of municipality/agency: ____

Department involved: ____

26. a) Does your department have sole responsibility for maintenance of turfgrass areas within your municipality or within the jurisdiction of your agency?

Yes _____

No _____

b) If not, please list those individuals or departments that should be contacted

____

____

27. How many acres of turfgrass does your department maintain?

a) General turf areas:

_______ acres irrigated

_______ acres non-irrigated

b) Sports turf facilities (soccer fields, football, ball diamonds, lawn bowling, etc.):

_______ acres irrigated

_______ acres non-irrigated

28. List approximate number of applications of the following products in 1990:

	Herbicides	Insecticides	Fungicides	Fertilizers	
				Total applic.	Total N /acre/year
General turf areas	________	________	________	________	________
Sports turf areas	________	________	________	________	________