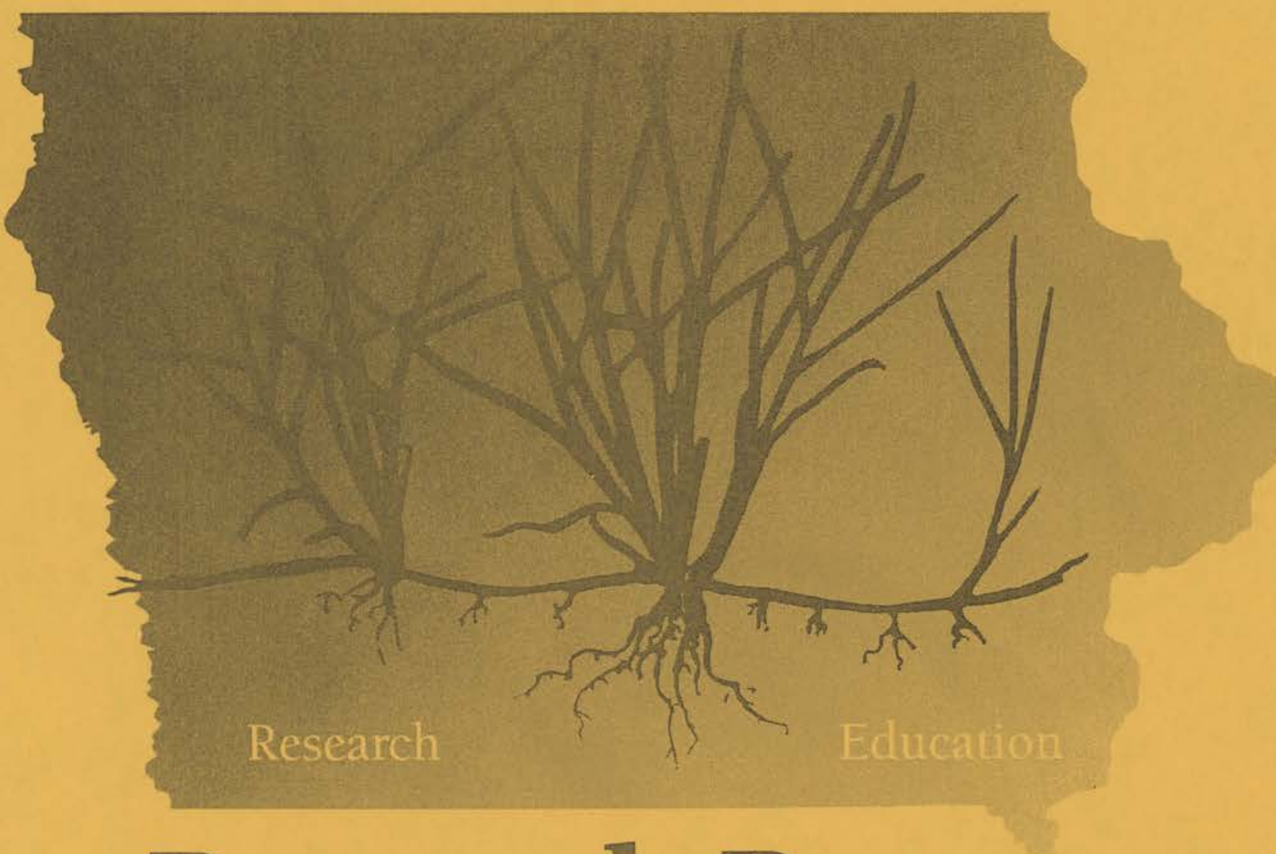
1995
Iowa Turfgrass



Research Report

Department of Horticulture
Department of Plant Pathology
Department of Entomology
Cooperative Extension
IOWA STATE UNIVERSITY

In Cooperation with the
Iowa Turfgrass Institute

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

University Extension

FG-463|July 1995

Introduction

N. E. Christians and D. D. Minner

The following research report is the 16th yearly publication of the results of turfgrass research projects performed at Iowa State University. Copies of information in earlier reports are available from most of the county extension offices in Iowa.

The 1994 season was nearly perfect for growth of cool-season grasses. It was a much better year than 1993 which was extremely wet.

For the fifth year, this research report contains a section titled "Environmental Research." This section is included to inform the public of our many research projects that are aimed at the many environmental issues that face our turf industry. Of particular interest in this section are a number of reports on the use of natural products as substitutes for synthetic herbicides.

In February 1995, Dr. Dave Minner filled the Extension and Research position that was open for one year following Dr. Mike Agnew's departure. Mike now works for Ciba as a Senior Technical Support Specialist and continues to support turf research at ISU through Ciba-Geigy Corporation. Dr. Minner received his B.S. from the University of Delaware, M.S. from the University of Maryland, and Ph.D. from Colorado State University. Before joining ISU, Dave was the Extension Turfgrass Specialist at the University of Missouri for 10 years. Some of the research projects that Dr. Minner is developing at Iowa State are:

1. Rubber topdressing to improve traffic tolerance,
2. Synthetic stabilizers for sand based athletic fields,
3. Calcined clay topdressing to reduce heat and dry spot on putting greens, and
4. Sub surface forced air systems for managing sand base putting greens.

Dave, and his wife Beth, also have an active interest in ornamental grasses and prairie restoration. They have 4 children, Meghan and David 10, Sarah 8, and Chandler 6. Dave enjoys most sports and looks forward to hunting and fishing in Iowa.

We would like to acknowledge Richard Moore, who became superintendent of the ISU Horticulture Research Station in 1994; Jim Dickson, manager of the turf research area; Bryan Unruh, Ph.D. graduate student; Dave Gardener, MS graduate research assistant; Dianna Liu, Post Doctoral researcher; Barbara Bingaman, Post Doctoral researcher; Doug Campbell, research associate, and all others employed at the field research area in the past year for their efforts in building the turf program.

Special thanks to Lori Westrum for her work in typing and helping to edit this publication.

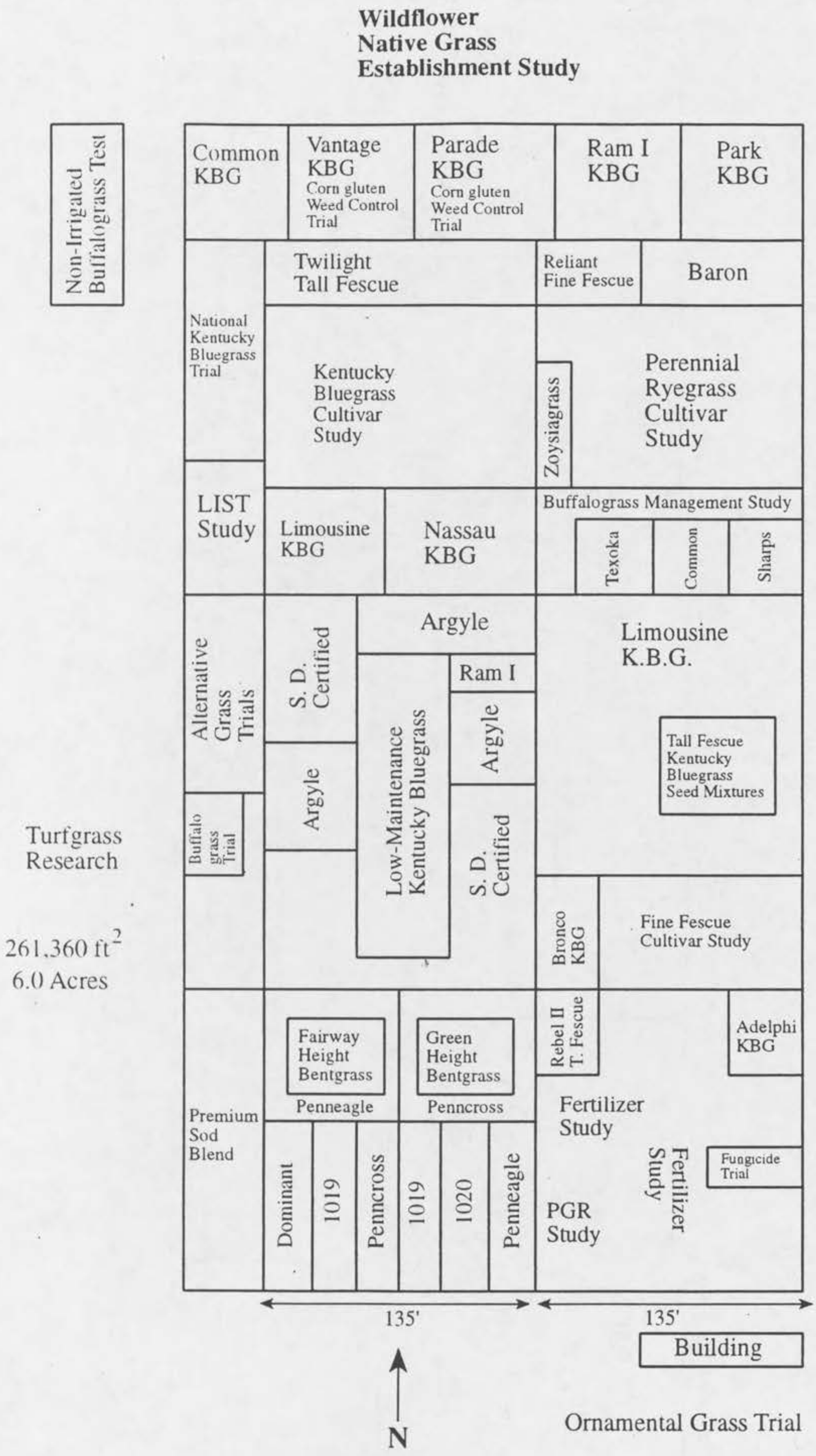
Edited by Nick Christians and David Minner, Iowa State University, Department of Horticulture.

Table of Contents

Environmental Research - cont.

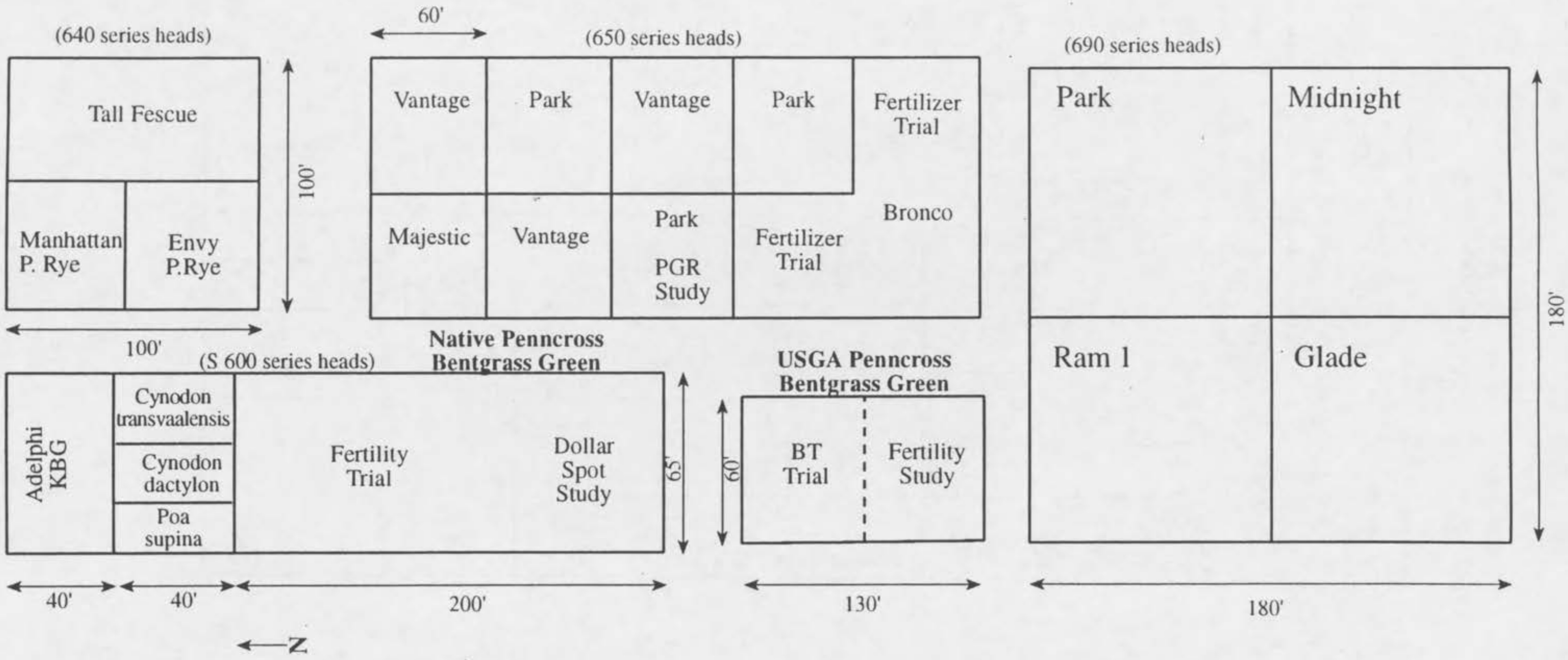
Ornamental Studies

Introducing

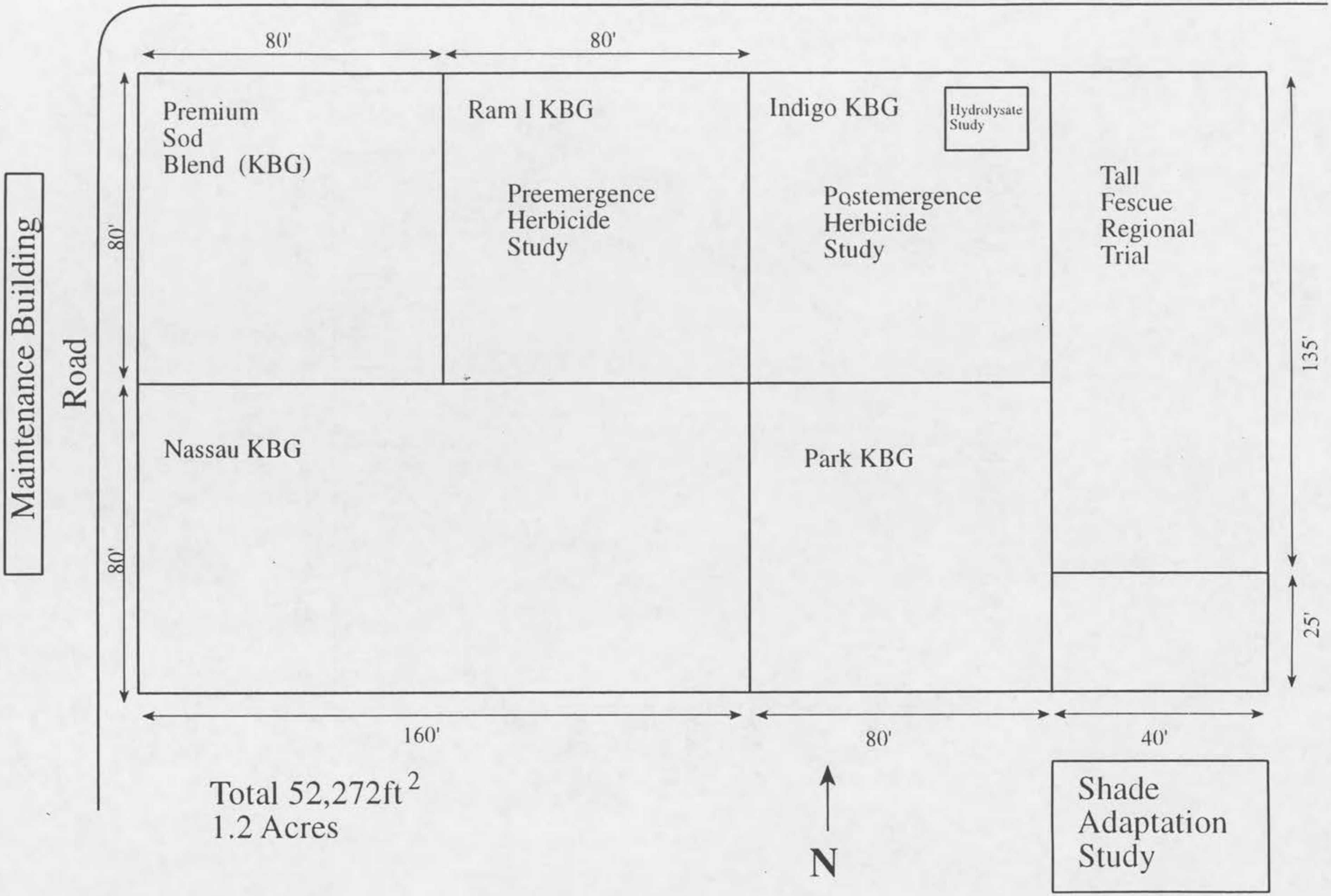


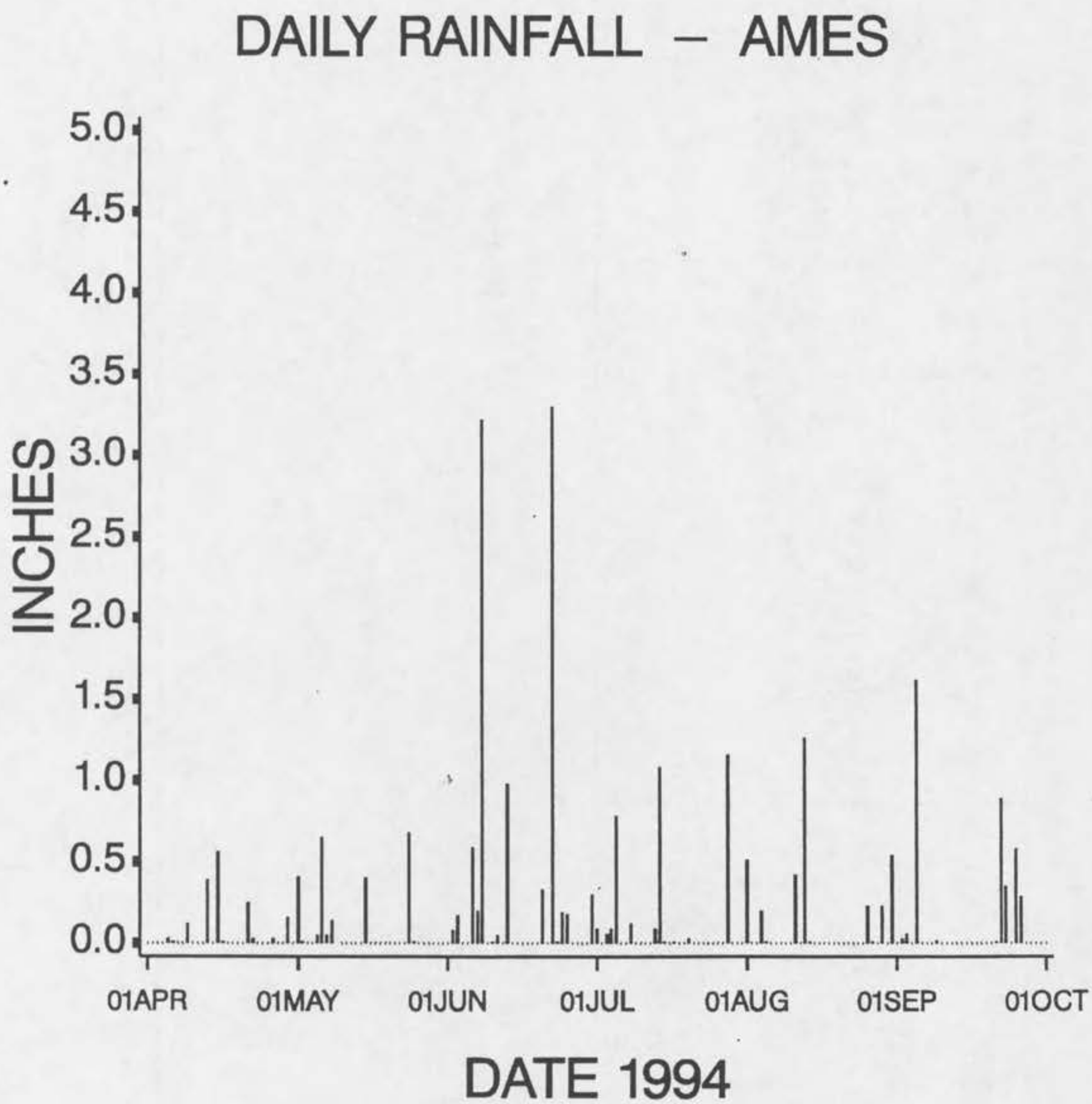
Wildflower
Native Grass
Establishment Study
Non-Irrigated Buffalograss Test
Common KBG
Vantage KBG Corn gluten Weed Control Trial
Parade KBG Corn gluten Weed Control Trial
Ram I KBG
Park KBG
Twilight Tall Fescue
Reliant Fine Fescue
Baron
National Kentucky Bluegrass Trial
Kentucky Bluegrass Cultivar Study
Zoysiagrass
Perennial Ryegrass Cultivar Study
170'
LIST Study
Limousine KBG
Nassau KBG
Buffalograss Management Study
Texoka
Common
Sharps
Alternative Grass Trials
S. D. Certified
Argyle
Ram I
Argyle
Low-Maintenance Kentucky Bluegrass
Argyle
S. D. Certified
Limousine K.B.G.
Tall Fescue Kentucky Bluegrass Seed Mixtures
170'
Buffalo grass Trial
Turfgrass Research
261,360 ft^2
6.0 Acres
Bronco KBG
Fine Fescue Cultivar Study
Fairway Height Bentgrass
Penneagle
Green Height Bentgrass
Penncross
Rebel II T. Fescue
Adelphi KBG
Premium Sod Blend
Fertilizer Study
Dominant
1019
Penncross
1019
1020
Penneagle
Fertilizer Study
Fungicide Trial
PGR Study
170'
135'
135'
Building
N
Ornamental Grass Trial

1984 Expansion of the Turfgrass Research Area
108,900 ft. - 2.5 Acres²



East Research Area




DAILY RAINFALL - AMES
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
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INCHES
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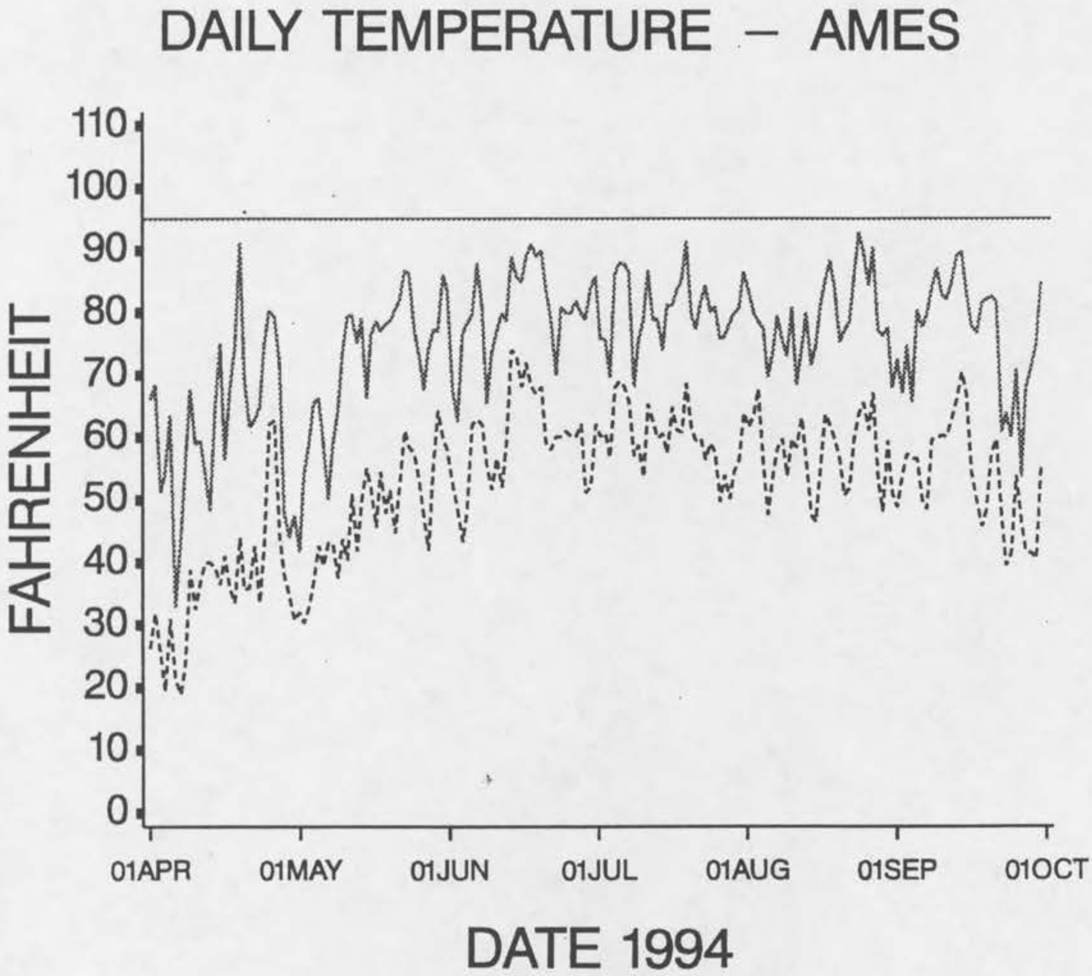
01SEP
01OCT
DATE 1994



Solid Line = Max Dashed Line = Min

Species and Cultivar Trials

Results of Kentucky Bluegrass Regional Cultivar Trials - 1994

N. E. Christians and J. D. Dickson

The United States Department of Agriculture (USDA) has sponsored several regional Kentucky bluegrass cultivar trials conducted at most of the northern agricultural experiment stations. The current test consists of 62, 80, or 128 cultivars; the number depending on the year of establishment and the type of trial. Each cultivar was replicated three times.

Three trials were underway at Iowa State University during the 1994 season. A high-maintenance study was established in 1990 that receives 4 lb N/1000 ft^2/yr and is irrigated as needed. The second trial was established in 1985 and receives 4 lb N/1000 ft^2/yr, but is non-irrigated. The third trial was established in the fall of 1991 and is a low-maintenance study that receives 1 lb of N/1000 ft^2/yr in September and is non-irrigated. The objective of the high-maintenance study is to investigate cultivar performance under a cultural regime similar to that used on irrigated home lawns in Iowa. The objective of the second study is to observe the cultivar response under conditions similar to those found in non-irrigated lawns that receive a standard lawn care program. The objective of the third study is to evaluate cultivars under conditions similar to those maintained in a park or school ground.

The values listed under each month in Tables 1, 2 and 3 are the averages of visual quality ratings made on three replicated plots for the three studies. Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Yearly means of data from each month were taken and are listed in the last column. The first cultivar received the highest average rating for the entire 1994 season. The cultivars are listed in descending order of average quality.

The 1994 season provided near perfect growing conditions for Kentucky bluegrass. It was neither too wet or too dry. This meant that there was a minimum amount of moisture stress on the non-irrigated areas. Some irrigation was needed during the summer months, but the non-irrigated turf did not go completely dormant at any time during the summer. Midnight was the highest ranked cultivar in the high-maintenance trial. This variety generally does very well in high-maintenance conditions in seasons when environmental conditions favor growth of Kentucky bluegrass. Low maintenance cultivars like Kenblue and South Dakota Certified ranked near the bottom in the high-maintenance trial. In the high-maintenance, non-irrigated study, Midnight dropped to 28th place. This variety is not well adapted to non-irrigated conditions and drops off in quality under moisture stress conditions. The best varieties in 1994 in this trial were Aquila, Wabash and A-34. Blacksburg, Sydsport, and Mystic also did well.

Table 1. The 1994 quality ratings for the high-maintenance, irrigated Kentucky bluegrass trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Midnight	7.3	7.7	8.0	9.0	8.7	8.3	8.2
2	Ascot (BA 77-279)	7.0	7.7	8.0	7.7	8.3	8.0	7.8
3	Belmont (798)	7.0	7.3	7.7	8.0	8.7	7.7	7.7
4	Eagleton	7.0	7.3	7.7	8.8	8.3	7.7	7.7
5	Estate	7.0	7.3	7.3	9.0	7.7	7.7	7.7
6	PST-A7-1877	7.0	7.7	7.3	8.7	8.0	7.3	7.7
7	SR 2000	6.7	7.7	8.0	7.3	8.3	8.0	7.7
8	Apex (Summit)	6.3	8.0	8.0	8.3	7.7	7.3	7.6
9	Julia	7.0	7.3	8.0	8.0	7.7	7.7	7.6
10	Opti-green (PST-B8-106)	7.0	8.0	7.3	9.0	7.0	7.3	7.6
11	Preakness (602)	7.0	7.0	7.7	8.7	7.7	7.7	7.6
12	PST-C-224	7.0	7.7	7.3	8.7	7.7	7.3	7.6
13	Blacksburg	7.3	7.7	7.7	8.7	6.7	7.0	7.5

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
14	PST-A84-405	7.0	7.0	7.7	8.0	7.7	7.7	7.5
15	Allure (BA 73-540)	7.0	7.0	7.0	8.7	7.7	7.3	7.4
16	Aspen	7.0	7.3	7.0	8.0	7.7	7.3	7.4
17	BA 70-131	7.0	7.0	7.3	8.0	7.7	7.3	7.4
18	Cardiff	6.7	7.3	7.7	8.0	7.7	7.0	7.4
19	Fairfax (BA 69-82)	7.3	7.3	7.3	8.3	7.7	6.7	7.4
20	PST-A84-803	6.7	7.0	7.3	8.0	8.0	7.7	7.4
21	BA 77-292	7.0	7.7	7.7	7.7	7.0	6.7	7.3
22	BAR VB 1169	7.0	7.0	7.3	8.0	7.3	7.0	7.3
23	Coventry	7.3	7.0	7.0	8.0	7.3	7.0	7.3
24	Miracle	6.3	7.0	7.7	8.0	7.7	7.3	7.3
25	Pennpro (PR-1)	7.0	7.7	7.3	8.0	7.0	6.7	7.3
26	Platini	7.0	7.0	7.7	8.0	7.0	7.0	7.3
27	PST-UD-10	7.0	7.0	7.0	7.3	8.0	7.3	7.3
28	PST-UD-12	7.0	7.0	7.3	7.7	7.3	7.3	7.3
29	Raven (BA 78-258)	7.0	7.3	7.0	7.7	7.0	7.7	7.3
30	Unique (PST-C-76)	7.0	7.0	7.3	7.7	7.7	7.3	7.3
31	WW AG 505	7.0	7.3	7.0	8.7	7.3	6.7	7.3
32	A-34	7.7	7.0	7.3	8.0	7.0	6.3	7.2
33	Able I	7.0	7.3	7.0	7.7	7.3	7.0	7.2
34	Alpine	7.0	7.0	7.3	8.0	7.0	6.7	7.2
35	Barcelona (BAR VB 1184)	7.0	7.0	7.0	8.0	7.3	7.0	7.2
36	Barsweet	6.7	7.0	7.3	8.7	6.7	6.7	7.2
37	Bartitia	7.0	7.0	7.0	8.0	7.0	7.0	7.2
38	EVB 13.703	7.0	7.3	7.0	7.7	7.7	6.7	7.2
39	Georgetown	7.0	7.0	7.0	7.7	7.7	6.7	7.2
40	J-333	7.3	7.0	7.3	7.3	7.3	7.0	7.2
41	J34-99	7.0	7.0	7.3	8.0	7.0	6.7	7.2
42	Princeton 104	7.0	7.0	7.3	7.3	7.3	7.0	7.2
43	PST-0514	6.7	7.3	7.7	7.7	7.3	6.7	7.2
44	Ram-1	6.7	7.3	7.3	8.3	6.7	6.7	7.2
45	Shamrock (H86-712)	7.0	7.3	7.3	7.7	7.0	6.7	7.2
46	4 Aces (PST-RE-88)	6.7	7.0	7.7	7.3	7.3	6.7	7.1
47	BAR VB 852	7.0	7.0	7.0	8.0	7.0	6.7	7.1
48	Baronie (BAR VB 985)	7.0	7.0	7.0	7.7	7.3	6.3	7.1
49	Caliber (J-335)	7.0	7.0	7.7	7.0	7.3	6.3	7.1
50	Challenger	7.0	7.0	7.3	7.3	7.0	6.7	7.1
51	Classic	7.0	7.0	7.0	7.7	7.0	6.7	7.1
52	Cobalt	6.3	7.0	7.3	7.3	7.3	7.0	7.1
53	Cynthia	6.7	7.3	7.7	7.7	7.0	6.3	7.1
54	Destiny	7.0	7.0	7.0	8.0	7.3	6.3	7.1
55	Eclipse	6.7	7.3	7.0	7.3	7.3	6.7	7.1
56	Freedom	6.7	7.0	6.7	8.0	7.0	7.0	7.1
57	Glade	7.0	7.0	7.0	7.7	7.0	7.0	7.1
58	Gnome	7.0	7.0	7.3	7.3	7.3	6.7	7.1
59	HV 125	7.0	7.0	7.0	7.7	7.3	6.3	7.1
60	Liberty	7.0	7.0	7.0	7.3	7.3	6.7	7.1
61	Livingston	7.0	7.0	7.0	7.7	7.0	7.0	7.1
62	Trenton	7.3	7.0	7.0	7.7	7.3	6.3	7.1
63	BA 76-305	7.0	7.0	7.0	7.3	7.3	6.3	7.0
64	Banff	7.0	7.0	6.7	7.7	7.0	6.7	7.0
65	Barblue	7.0	7.0	7.0	7.7	6.7	6.7	7.0
66	Barzan	6.0	7.0	7.3	7.7	7.3	6.7	7.0
67	Broadway	7.0	7.0	7.0	7.5	7.3	6.7	7.0
68	Conni	6.3	7.3	7.0	7.7	7.0	6.7	7.0

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
69	Dawn	7.0	7.0	6.7	7.7	7.0	6.7	7.0
70	Haga	7.0	7.0	6.7	7.3	7.0	7.0	7.0
71	J13-152	7.0	7.0	6.7	7.7	7.0	6.7	7.0
72	Minstrel	6.7	7.0	6.7	8.0	7.0	6.7	7.0
73	PST-1DW	7.0	7.0	7.0	7.3	7.0	6.7	7.0
74	PST-A7-341	6.3	7.3	7.3	7.3	7.0	6.7	7.0
75	PST-HV-116	7.0	7.0	7.0	7.3	7.0	6.7	7.0
76	SR 2100	7.0	7.0	7.0	7.3	6.7	7.0	7.0
77	Touchdown	6.7	7.0	7.0	7.3	7.3	6.7	7.0
78	Trampas	6.7	7.0	7.0	7.3	7.0	7.0	7.0
79	1757	7.0	7.0	6.7	7.3	7.0	6.7	6.9
80	BA 77-700	7.0	7.0	7.0	7.0	7.0	6.7	6.9
81	Baron	7.0	7.0	7.0	7.7	7.0	6.0	6.9
82	Chelsea	6.7	7.0	7.3	7.0	6.7	6.7	6.9
83	Crest	6.3	7.0	7.0	7.3	7.0	6.7	6.9
84	Fortuna	7.0	7.0	7.0	7.3	6.7	6.3	6.9
85	J11-94	7.0	7.0	6.7	7.3	7.0	6.3	6.9
86	Kelly	7.0	6.7	7.3	7.0	6.7	6.7	6.9
87	Limousine	7.0	7.3	7.3	7.0	6.7	6.3	6.9
88	Melba	7.0	7.0	7.0	7.7	6.7	6.0	6.9
89	Merion	7.0	7.0	7.7	7.0	6.7	6.0	6.9
90	Merit	6.3	7.0	7.3	7.0	7.0	7.0	6.9
91	Monopoly	7.0	7.0	7.0	7.3	6.7	6.3	6.9
92	Nassau	6.3	6.7	6.7	7.3	7.7	7.0	6.9
93	Nublue (J-229)	7.0	7.0	7.0	7.3	7.0	6.0	6.9
94	Nustar	7.0	7.0	7.0	7.3	7.0	6.3	6.9
95	PST-R-740	7.0	7.0	7.0	7.3	7.0	6.3	6.9
96	PSU-151	7.0	7.0	7.0	7.7	6.3	6.3	6.9
97	R751A	6.7	6.7	7.0	7.0	7.0	7.0	6.9
98	Suffolk	7.0	7.0	6.7	7.3	7.3	6.3	6.9
99	Viva (BA 73-366)	7.0	7.0	7.0	7.3	7.0	6.3	6.9
100	Washington	6.7	6.7	7.0	7.7	6.7	6.7	6.9
101	Abbey	7.0	7.0	7.3	7.0	6.7	6.0	6.8
102	Ampellia	7.0	7.0	6.7	7.3	6.3	6.3	6.8
103	BA 73-382	7.0	7.0	6.7	6.7	7.0	6.7	6.8
104	EVB 13.863	7.0	7.0	6.3	7.3	6.7	6.7	6.8
105	Indigo	6.7	7.0	7.0	7.3	7.0	6.0	6.8
106	Miranda	6.7	7.0	7.0	7.3	6.7	6.3	6.8
107	NE 80-47	7.0	7.0	6.7	7.3	7.0	6.0	6.8
108	PST-A84-928	6.3	7.0	7.3	7.0	6.7	6.7	6.8
109	Silvia	7.0	7.0	7.3	7.3	6.7	5.7	6.8
110	Blue Star (PST-B8-13)	6.3	7.0	7.0	6.7	6.7	6.3	6.7
111	Buckingham (BA 74-114)	6.3	7.0	6.7	6.7	7.3	6.3	6.7
112	Cannon (BA 73-381)	5.7	7.0	7.0	6.3	7.0	7.0	6.7
113	J-386	6.7	7.0	7.0	6.7	6.7	6.0	6.7
114	Noblesse	6.3	7.0	7.0	6.3	7.0	6.7	6.7
115	Opal	6.7	7.3	7.3	6.7	6.7	5.7	6.7
116	Barmax (BAR VB 7037)	7.0	7.0	7.0	7.0	6.3	5.3	6.6
117	Eva (WW AG 508)	6.7	7.3	7.0	7.0	6.3	5.3	6.6
118	KWS PP 13-2	6.3	6.7	7.3	6.7	6.7	6.0	6.6
119	Ronde	6.7	7.0	7.0	7.0	6.3	5.3	6.6
120	Marquis	6.0	6.7	7.0	6.7	6.7	5.7	6.4
121	Greenley	6.3	6.3	6.3	7.3	6.0	5.3	6.3
122	Donna	6.7	6.7	7.0	6.3	5.7	5.0	6.2
123	South Dakota Cert.	6.3	6.7	6.3	6.3	6.0	5.0	6.1

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
124	Kenblue	6.0	6.0	5.7	7.0	5.3	5.0	5.8
125	Ginger	5.3	5.7	5.3	6.3	5.7	4.7	5.5
	$LSD_{(0.05)}$	0.9	0.6	0.8	1.3	1.0	1.0	0.4

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Table 2. The 1994 quality ratings for the high-maintenance, non-irrigated regional Kentucky bluegrass test.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Monopoly	7.3	7.3	7.3	6.7	7.3	6.7	7.1
2	Mystic	6.7	8.7	8.0	6.0	6.0	7.3	7.1
3	BA 72-500	7.3	8.0	7.3	5.7	7.0	7.3	7.1
4	NE 80-50	7.3	7.7	6.7	6.3	7.3	7.0	7.1
5	Sydsport	7.3	8.3	7.0	5.3	7.0	6.7	6.9
6	Blacksburg	7.3	7.7	7.0	6.3	7.0	6.3	6.9
7	NE 80-14	7.0	7.7	6.7	6.3	6.7	7.3	6.9
8	Cheri	7.3	7.7	6.3	5.7	6.7	7.0	6.8
9	Wabash	7.0	7.7	7.0	5.7	7.3	6.3	6.8
10	Asset	6.7	7.7	7.3	6.0	6.7	6.0	6.7
11	A-34	7.0	8.0	6.7	5.3	6.0	6.7	6.6
12	Midnight	6.3	7.3	6.7	5.7	6.3	7.0	6.6
13	NE 80-30	6.3	6.7	7.0	6.0	6.7	7.0	6.6
14	BA 70-139	8.0	7.0	5.7	4.7	7.3	6.3	6.5
15	BA 73-540	7.7	7.7	6.3	6.0	5.7	5.7	6.5
16	Somerset	6.3	7.0	7.0	5.0	7.0	6.3	6.4
17	BA 72-441	5.3	6.3	6.7	5.7	7.3	7.0	6.4
18	America	7.3	6.7	6.7	5.7	6.3	6.0	6.4
19	Compact	7.0	7.3	6.7	5.0	6.3	5.3	6.3
20	Haga	6.7	7.0	5.7	6.0	6.3	6.0	6.3
21	Georgetown	6.3	6.3	6.7	6.3	6.3	6.0	6.3
22	BA 70-242	6.7	6.7	6.7	5.7	6.0	6.0	6.3
23	BA 69-82	7.0	6.7	6.3	5.3	6.0	6.7	6.3
24	Merion	6.7	6.7	6.3	5.7	6.0	6.7	6.3
25	Aquila	5.7	6.3	6.7	6.3	6.3	6.3	6.3
26	Aspen	6.3	6.7	6.3	5.3	6.3	6.7	6.3
27	NE 80-48	6.7	7.0	6.3	5.3	6.0	6.3	6.3
28	Classic	6.7	6.7	6.3	5.0	6.0	6.3	6.2
29	P-104	6.0	6.3	6.7	6.3	6.0	5.7	6.2
30	BA 73-626	6.7	6.0	5.7	6.3	6.0	6.3	6.2
31	HV 97	6.7	6.3	6.3	5.3	7.0	5.7	6.2
32	Lofts 1757	6.3	6.3	6.7	6.0	6.7	5.3	6.2
33	Eclipse	6.0	6.7	6.0	5.7	6.7	6.3	6.2
34	Dawn	6.7	6.3	5.7	5.7	6.7	6.0	6.2
35	Amazon	6.3	7.0	6.0	6.0	6.0	5.7	6.2
36	Julia	6.7	5.3	6.7	5.7	6.7	6.3	6.2
37	PST-CB1	6.7	6.7	6.0	5.0	6.3	6.3	6.2
38	Ram I	6.7	7.3	5.7	5.7	5.3	6.0	6.1
39	Parade	6.0	6.3	6.0	6.3	6.3	5.7	6.1
40	Nassau	6.7	6.7	6.3	5.7	6.0	5.3	6.1
41	Huntsville	5.7	6.0	6.3	6.0	5.7	6.7	6.1
42	F-1872	5.7	6.7	5.7	5.3	6.7	6.7	6.1
43	NE 80-55	6.0	6.7	6.7	5.7	6.0	5.3	6.1
44	Conni	6.0	6.3	6.3	5.7	6.3	5.3	6.0
45	NE 80-88	6.0	6.3	6.0	6.0	5.7	6.0	6.0

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
46	WW AG 491	6.7	7.0	5.7	5.3	5.7	5.7	6.0
47	WW AG 495	6.3	6.7	6.3	6.0	5.0	5.7	6.0
48	NE 80-47	5.7	6.0	6.3	5.7	6.3	6.0	6.0
49	Able I	6.7	6.3	5.7	5.7	6.0	5.3	5.9
50	Cynthia	6.0	6.0	6.3	5.3	6.3	5.7	5.9
51	Glade	5.7	6.7	5.3	6.0	5.7	6.0	5.9
52	Rugby	5.7	6.3	6.0	5.7	6.3	5.7	5.9
53	K3-178	6.7	5.7	6.3	5.7	5.3	5.7	5.9
54	Barzan	6.3	6.0	6.0	5.3	5.3	6.0	5.8
55	BA 72-492	6.7	6.0	5.7	5.0	5.7	6.0	5.8
56	K1-152	6.3	6.0	5.7	5.3	6.0	5.3	5.8
57	Trenton	6.3	6.3	6.0	5.3	5.7	5.3	5.8
58	Challenger	6.0	6.7	5.7	5.0	5.7	5.7	5.8
59	Gnome	5.7	5.7	6.3	5.3	5.7	5.7	5.7
60	Merit	6.0	6.0	6.3	5.0	5.7	5.3	5.7
61	BAR VB 577	5.3	6.0	6.0	4.7	6.3	6.0	5.7
62	BAR VB 534	5.7	6.0	5.7	5.7	5.7	5.7	5.7
63	Liberty	5.0	6.0	6.0	5.3	5.7	6.0	5.7
64	Ikone	6.0	6.0	5.7	5.0	6.0	5.7	5.7
65	NE 80-110	6.7	6.7	6.0	4.3	5.7	4.7	5.7
66	Tendos	5.7	5.3	5.0	5.7	6.3	5.7	5.6
67	Destiny	5.7	6.0	5.7	5.3	5.7	5.3	5.6
68	Park	5.0	6.0	5.7	6.0	5.7	5.3	5.6
69	Victa	6.0	6.3	5.0	5.0	5.3	5.3	5.5
70	WW AG 496	6.3	6.0	5.3	5.0	5.3	5.0	5.5
71	Joy	4.7	5.3	5.3	6.0	6.3	5.0	5.4
72	Baron	5.7	5.0	5.0	5.7	6.0	5.3	5.4
73	Annika	5.7	6.7	5.3	5.0	5.3	4.7	5.4
74	Bristol	5.7	6.3	5.3	4.7	5.3	5.3	5.4
75	239	5.3	5.7	5.3	5.0	5.7	5.3	5.4
76	Harmony	5.7	6.0	5.7	5.0	5.3	5.0	5.4
77	WW AG 468	5.0	5.3	5.7	5.0	5.3	5.3	5.3
78	Kenblue	4.3	5.0	5.3	5.7	6.0	4.7	5.2
79	Welcome	5.3	5.3	5.3	4.7	5.0	5.0	5.1
80	South Dakota Cert.	4.7	5.0	5.0	5.3	5.0	4.7	4.9
	$LSD_{(0.05)}$	1.4	1.4	1.3	1.3	1.6	1.5	0.9

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Table 3. The 1994 quality ratings for the low-maintenance, non-irrigated Kentucky bluegrass trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	BAR VB 852	7.0	7.3	6.7	5.7	5.7	6.0	6.4
2	Bronco	6.3	6.3	6.7	5.0	5.7	6.7	6.1
3	ISI-21	6.0	6.0	6.7	5.0	6.0	6.3	6.0
4	Monopoly	6.7	6.3	6.0	5.0	6.0	6.0	6.0
5	GEN-RSP	7.7	6.3	6.0	4.3	5.3	6.0	5.9
6	PST-YQ	7.3	6.3	6.3	5.0	5.0	5.7	5.9
7	PST-C-391	6.0	6.3	5.7	5.7	5.7	5.7	5.8
8	Barmax (BAR VB 7037)	5.7	6.3	5.7	5.0	6.0	5.3	5.7
9	Baron	4.7	6.3	5.3	5.3	5.7	7.0	5.7
10	Baronie (BAR VB 985)	6.3	5.3	5.7	5.3	5.7	5.0	5.6
11	Nublue (J-229)	6.0	6.7	6.0	4.7	4.7	5.7	5.6
12	Suffolk	6.0	5.7	6.0	5.0	5.0	6.0	5.6

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
13	BA 78-376	5.3	5.3	5.3	5.0	6.3	5.7	5.5
14	Banjo (H76-1034)	6.0	5.0	5.7	4.7	5.7	5.3	5.4
15	Minnfine (MN 2405)	4.3	6.0	6.3	4.3	5.3	6.0	5.4
16	Park	6.0	5.7	5.0	4.0	5.7	6.0	5.4
17	South Dakota Cert.	6.3	5.3	6.0	5.0	5.0	5.0	5.4
18	Caliber (J-335)	5.7	6.0	5.3	4.7	5.0	5.0	5.3
19	Destiny	5.3	5.7	5.3	4.3	5.0	6.0	5.3
20	Freedom	6.3	6.0	5.3	4.7	5.0	4.7	5.3
21	Liberty	5.3	6.0	5.7	4.3	5.3	5.3	5.3
22	PST-C-303	5.0	5.7	6.0	4.3	5.0	5.7	5.3
23	Voyager	7.0	6.0	5.3	4.3	4.0	5.3	5.3
24	Barcelona (BAR VB 118)	5.3	5.7	5.3	4.3	5.0	5.7	5.2
25	Barzan	5.3	4.7	6.0	4.7	5.3	5.0	5.2
26	Merit	5.0	5.7	5.3	5.0	4.7	5.3	5.2
27	PST-A7-111	5.0	5.7	5.7	4.0	5.3	5.3	5.2
28	Ram-1	5.0	5.0	5.3	4.7	5.0	6.0	5.2
29	Alene	5.7	5.7	5.0	4.0	5.0	5.3	5.1
30	Cynthia	5.0	6.0	4.7	4.7	5.0	5.3	5.1
31	EVB 13.863	5.0	6.0	5.7	5.0	4.3	4.7	5.1
32	Gnome	5.3	5.7	5.7	4.3	4.7	5.0	5.1
33	Haga	5.7	5.3	5.7	4.3	5.0	4.3	5.1
34	Livingston	5.7	5.7	5.0	4.7	4.3	5.0	5.1
35	Midnight	5.3	6.3	6.0	4.0	3.7	5.0	5.1
36	Miracle	5.7	6.3	5.0	3.3	4.7	5.3	5.1
37	Sophia	5.3	5.7	5.0	4.7	4.7	5.0	5.1
38	Washington	5.3	5.3	5.3	3.7	5.3	5.3	5.1
39	NE 80-47	5.7	5.7	5.0	3.7	5.0	5.0	5.0
40	Amazon	5.3	5.3	5.0	4.7	4.0	5.0	4.9
41	Belmont (798)	6.0	5.7	5.3	4.3	4.0	4.3	4.9
42	Chelsea	5.7	5.0	4.7	4.0	4.7	5.7	4.9
43	Cobalt	5.0	5.3	5.7	3.7	4.7	5.0	4.9
44	EVB 13.703	6.0	5.7	5.3	3.7	3.7	5.0	4.9
45	ZPS-84-749	5.3	5.3	5.0	4.3	4.7	4.7	4.9
46	BA 74-017	5.0	5.7	5.0	4.0	4.0	5.0	4.8
47	J-386	5.3	5.3	5.0	4.3	3.7	5.0	4.8
48	Kyosti	5.3	6.0	5.0	4.0	4.0	4.3	4.8
49	Njic	6.3	5.0	5.0	3.3	4.3	4.7	4.8
50	Nustar	4.7	5.0	5.3	4.0	4.7	5.3	4.8
51	Unique (PST-C-76)	5.7	5.7	5.3	3.7	3.7	4.3	4.7
52	BAR VB 1169	5.7	5.3	5.3	3.7	3.3	4.0	4.6
53	Crest	5.0	5.3	4.7	3.7	3.7	5.0	4.6
54	Kenblue	4.3	5.0	5.0	3.7	4.7	4.7	4.6
55	Merion	5.3	5.3	4.7	3.7	4.3	4.0	4.6
56	Opal	5.7	6.0	5.0	3.3	3.7	4.0	4.6
57	SR 2000	5.0	5.3	4.0	4.0	4.3	5.0	4.6
58	KWS PP 13-2	5.7	5.0	4.7	4.0	4.0	3.7	4.5
59	Barsweet	5.3	5.3	5.3	3.3	3.7	3.3	4.4
60	Bartitia	4.3	5.0	5.0	3.7	4.0	4.0	4.3
61	Fortuna	4.7	6.0	4.0	3.7	3.3	3.7	4.2
62	Unknown	4.7	5.0	4.0	3.3	2.7	3.7	3.9
	$LSD_{(0.05)}$	1.4	4.6	2.3	4.6	2.8	3.5	2.0

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Recovery of Kentucky Bluegrass Cultivars Following Summer Dormancy - 1994

N. E. Christians

In earlier work at Iowa State University (Grounds Maintenance 24(8):49-50) it was shown that Kentucky bluegrass cultivars vary greatly in their recovery from summer dormancy. Common, or public varieties, generally recover much more rapidly from drought-induced dormancy than do the newer improved cultivars. The objectives of this study are to further evaluate four cultivars that were previously shown to recover rapidly from dormancy and four cultivars that were slower to recover when maintained under low and high fertility regimes: 1 lb N/1000 ft^2 in September and 4 lb N/1000 ft^2 applied in 1 lb applications in April, May, August, and September.

South Dakota Common, S-21, Kenblue, and Argyle (cultivars observed to recover rapidly in earlier studies) and Midnight, Nassau, Glade, and Ram I (cultivars observed to recover more slowly). Kentucky bluegrass was established in 21 ft^2 plots on September 26, 1989 on a non-irrigated site at the turfgrass research area of the Iowa State University Horticulture Research Station north of Ames, Iowa. The soil on the site is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with a pH of 6.8 and 2.3% organic matter, a P content of 20 lbs/A, and a K content of 216 lbs/A. The study was replicated three times. Each plot was split in half. The two fertility treatments were randomly applied to the two halves of the plots.

The 1990 season was very wet and at no time did the grasses on the study area go into summer dormancy. The spring of 1991 was also very wet and the late summer and fall were dry. The 1992 season was the opposite of the 1991 season. The spring and summer were very dry up to the 4th of July. The remainder of the summer and fall were very wet. The 1993 season was one of the wettest in history. The area remained saturated through most of the season. At no time was there any moisture stress. The 1994 season was moderate, with some slight moisture stress in late summer.

Data were collected in July, August, and September 1994 (Table 4). The improved varieties had deteriorated in quality during the drier years of 1990, 1991, and 1992, but recovered well in the wet conditions of 1993. In 1994, the performance of common and improved varieties was very similar, which would be expected in the moderate conditions experienced during the season.

Table 4. The 1994 quality ratings for the low-moderate maintenance bluegrass study.

	July		August		September	
Cultivar	1 lb N	4 lb N	1 lb N	4 lb N	1 lb N	4 lb N
S.D. Common	6.3	6.0	5.6	6.3	5.3	6.0
S-21	5.3	7.0	5.3	6.3	5.3	5.7
Kenblue	5.0	6.3	5.7	5.7	4.0	5.3
Argyle	5.7	6.3	5.3	5.7	5.0	5.3
Midnight	5.0	7.0	4.3	6.0	4.3	6.0
Nassau	4.0	4.3	4.3	5.0	4.0	5.0
Glade	6.3	6.0	6.3	6.0	5.3	6.3
RAM-I	5.3	6.7	5.0	5.0	4.7	4.7
$LSD_{(0.05)}$	.91		1.03		1.78	

National Perennial Ryegrass Study - 1994

J. D. Dickson and N. E. Christians

This trial began in the fall of 1990 with the establishment of 125 cultivars of perennial ryegrass at the Iowa State University Horticulture Research Station. The study was established on an irrigated area that was maintained at a 2-inch mowing height and fertilized with 3 to 4 lb N/1000 ft^2/yr. The area receives preemergence herbicide in the spring and was treated with a broadleaf herbicide in September of 1993. The trial was terminated following data collection in August of 1994 and was replaced by a new ryegrass trial.

Cultivars were evaluated for turf quality each month of the growing season. Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. The values listed under each month in Table 5 are the averages of ratings made on three replicated plots for the three studies. Yearly means of data from each month are listed in the last column. The cultivars are listed in descending order of average quality.

Winter kill of the ryegrasses was particularly severe in the spring of 1993. There was much less winter damage in the spring of 1994 and most cultivars showed no winter kill by the May rating. Few of the standard perennial ryegrass varieties used in Iowa ranked near the top, indicating that there are a number of new cultivars coming along in the next few years that should be well adapted to conditions here (Table 5).

Table 5. The 1994 quality ratings for the national perennial ryegrass study established in 1990.

	Cultivar	May	June	July	Aug	Mean
1	HE 311	7.3	7.7	7.7	7.7	7.6
2	Charger	7.0	7.7	7.7	7.7	7.5
3	Pick EEC	7.3	7.0	7.3	7.3	7.3
4	PR 9119	6.7	7.3	7.7	7.7	7.3
5	C-21	7.0	7.0	7.3	7.3	7.2
6	Cutless	7.3	7.3	7.0	7.0	7.2
7	Dandy	7.3	7.3	7.0	7.0	7.2
8	Delaware Dwarf (4DD)	7.3	7.3	7.0	7.0	7.2
9	Affinity (GEN-90)	7.0	7.3	7.0	7.0	7.1
10	Barrage ++	7.0	7.3	7.0	7.0	7.1
11	Cutter (Pick 89-4)	7.3	7.0	7.0	7.0	7.1
12	Elite (WVPB-88-PR-C-23)	7.0	7.3	7.0	7.0	7.1
13	Lindsay	7.0	7.3	7.0	7.0	7.1
14	Loretta	7.0	7.3	7.0	7.0	7.1
15	SR 4200	7.0	7.3	7.0	7.0	7.1
16	Stallion Select (PS-105)	7.0	7.3	7.0	7.0	7.1
17	WVPB 89-92	7.0	7.3	7.0	7.0	7.1
18	Assure	7.3	6.7	7.0	7.0	7.0
19	Derby Supreme	7.0	7.0	7.0	7.0	7.0
20	Express	7.0	7.0	7.0	7.0	7.0
21	Pronto (WVPB-89-87A)	7.0	7.0	7.0	7.0	7.0
22	PST-20G	7.0	7.0	7.0	7.0	7.0
23	PST-2ROR	7.0	7.0	7.0	7.0	7.0
24	Shining Star (PST-2B3)	7.0	7.0	7.0	7.0	7.0
25	APM	7.0	7.3	6.7	6.7	6.9
26	Buccaneer (KOOS 90-1)	6.7	7.0	7.0	7.0	6.9
27	Fiesta II	7.3	7.0	6.7	6.7	6.9

	Cultivar	May	June	July	Aug	Mean
28	Gator	7.3	7.0	6.7	6.7	6.9
29	Gettysburg	7.0	7.3	6.7	6.7	6.9
30	MVF 89-88	7.3	7.0	6.7	6.7	6.9
31	PR 9118	7.0	6.7	7.0	7.0	6.9
32	PST-290	7.3	7.0	6.7	6.7	6.9
33	Riviera II (Pick DKM)	7.3	7.0	6.7	6.7	6.9
34	Rodeo II	6.7	7.0	7.0	7.0	6.9
35	89-666	7.0	6.7	6.7	6.7	6.8
36	Achiever (Pick 1800)	7.0	7.0	6.7	6.7	6.8
37	Barrage	7.0	7.3	6.3	6.3	6.8
38	Citation II	7.0	7.0	6.7	6.7	6.8
39	CLP 144	7.0	7.0	6.7	6.7	6.8
40	Commander	7.0	7.0	6.7	6.7	6.8
41	Cowboy II (WM-II)	7.0	7.0	6.7	6.7	6.8
42	Danaro	6.3	6.7	7.0	7.0	6.8
43	Dimension (2H7)	7.0	7.0	6.7	6.7	6.8
44	Entrar	7.0	6.7	6.7	6.7	6.8
45	Equal	6.7	7.0	6.7	6.7	6.8
46	Greenland (Pick 9100)	6.7	6.7	7.0	7.0	6.8
47	KOOS 90-2	7.0	7.0	6.7	6.7	6.8
48	Lowgrow (Pick 89LLG)	7.0	7.0	6.7	6.7	6.8
49	Manhattan II (E)	7.0	7.0	6.7	6.7	6.8
50	Navajo (PST-2DPR)	7.0	7.0	6.7	6.7	6.8
51	Pennfine	6.7	7.0	6.7	6.7	6.8
52	Pleasure	6.3	7.0	7.0	7.0	6.8
53	Prelude II (2P2-90)	7.3	7.3	6.3	6.3	6.8
54	PS 89-90 (MVF 89-90)	7.0	7.0	6.7	6.7	6.8
55	PST-28M	7.0	7.0	6.7	6.7	6.8
56	Repell II (LDRD)	6.3	7.0	7.0	7.0	6.8
57	Riviera	7.0	7.0	6.7	6.7	6.8
58	Sherwood	7.0	7.0	6.7	6.7	6.8
59	Statesman (WVPB-88-PR-D-12)	7.0	7.0	6.7	6.7	6.8
60	Target	7.0	7.0	6.7	6.7	6.8
61	Taya	7.0	7.0	6.7	6.7	6.8
62	Toronto	7.0	7.3	6.3	6.3	6.8
63	Unknown	7.0	7.0	6.7	6.7	6.8
64	Yorktown III (LDRF)	6.7	6.7	7.0	7.0	6.8
65	Advent	7.0	7.0	6.3	6.3	6.7
66	BAR LP 086FL	6.3	7.0	6.7	6.7	6.7
67	BAR LP 852	7.0	7.0	6.3	6.3	6.7
68	Calypso	7.0	7.0	6.3	6.3	6.7
69	Capri (ZW 42-176)	6.7	6.7	6.7	6.7	6.7
70	Competitor	7.0	7.0	6.3	6.3	6.7
71	Danilo	6.7	7.3	6.3	6.3	6.7
72	Duet	7.0	7.0	6.3	6.3	6.7
73	Evening Shade (Poly-Sh)	6.7	6.7	6.7	6.7	6.7
74	N-33	7.0	7.0	6.3	6.3	6.7
75	Nighthawk (WVPB-89-PR-A-3)	7.0	7.0	6.3	6.3	6.7
76	Ovation	6.3	7.0	6.7	6.7	6.7
77	Patriot II	7.0	7.0	6.3	6.3	6.7
78	Precision (MOM LP 3147)	7.0	7.0	6.3	6.3	6.7
79	PST-23C	6.7	6.7	6.7	6.7	6.7
80	PST-2FF	6.7	6.7	6.7	6.7	6.7

	Cultivar	May	June	July	Aug	Mean
81	Quickstart (PST-2FQR)	7.0	7.0	6.3	6.3	6.7
82	Seville	6.7	6.7	6.7	6.7	6.7
83	Troubadour	6.3	7.0	6.7	6.7	6.7
84	CLP 39	6.7	7.0	6.3	6.3	6.6
85	Envy	6.7	7.0	6.3	6.3	6.6
86	Morning Star (Syn-P)	6.7	7.0	6.3	6.3	6.6
87	OFI-D4	6.7	7.0	6.3	6.3	6.6
88	Pinnacle	6.7	7.0	6.3	6.3	6.6
89	Premier	6.7	7.0	6.3	6.3	6.6
90	Stallion	6.7	7.0	6.3	6.3	6.6
91	Allegro	7.0	7.0	6.0	6.0	6.5
92	Essence (PR 8820)	7.3	6.7	6.0	6.0	6.5
93	Nomad	7.0	7.0	6.0	6.0	6.5
94	PR 9108	7.0	7.0	6.0	6.0	6.5
95	Repell	7.0	6.3	6.3	6.3	6.5
96	Topeka (WVPB-88-PR-D-10)	7.0	7.0	6.0	6.0	6.5
97	240 (Pebble Beach)	6.7	7.0	6.0	6.0	6.4
98	EEG 358	6.0	7.0	6.3	6.3	6.4
99	MOM LP 3184	6.3	6.7	6.3	6.3	6.4
100	Mulligan (NK 89001)	6.7	7.0	6.0	6.0	6.4
101	Pennant	7.0	6.7	6.0	6.0	6.4
102	PR 9121	6.3	6.7	6.3	6.3	6.4
103	Prizm (ZPS-28D)	6.7	7.0	6.0	6.0	6.4
104	Saturn	6.3	6.7	6.3	6.3	6.4
105	Brightstar (PST-GH-89)	6.3	6.7	6.0	6.0	6.3
106	Cartel	6.3	6.3	6.3	6.3	6.3
107	Legacy	7.0	7.0	5.7	5.7	6.3
108	Palmer II (P89)	6.7	6.0	6.3	6.3	6.3
109	PR 9109	6.7	6.7	6.0	6.0	6.3
110	ZPS-2EZ	7.0	6.3	6.0	6.0	6.3
111	Accolade	6.0	6.7	6.0	6.0	6.2
112	Caliente	6.7	6.7	5.7	5.7	6.2
113	Goalie	7.0	6.3	5.7	5.7	6.2
114	MOM LP 3111	7.0	6.3	5.7	5.7	6.2
115	MOM LP 3185	6.0	6.7	6.0	6.0	6.2
116	Surprise	5.7	7.0	6.0	6.0	6.2
117	Meteor	6.0	7.0	5.7	5.7	6.1
118	MOM LP 3182	6.3	6.3	5.7	5.7	6.0
119	OFI-F7	6.7	6.0	5.7	5.7	6.0
120	Regal	6.0	6.7	5.7	5.7	6.0
121	856	6.0	6.0	5.3	5.3	5.7
122	MOM LP 3179	6.0	5.7	5.0	5.0	5.4
123	Linn	5.0	4.3	3.0	3.3	3.9
	$LSD_{(0.05)}$	1.0	0.9	1.5	1.6	0.8

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Regional Fine Fescue Cultivar Evaluation - 1994

J. D. Dickson and N. E. Christians

This was the first full year of data from the new fine fescue trial. This is a National Turfgrass Evaluation Program (NTEP) trial. It is being conducted at many locations around the U.S. The purpose of the trial is to study the regional adaptation of 59 fine fescue cultivars. Cultivars were evaluated for quality each month of the growing season through October. The study is established in full sun. Three replications of the 59, 3 ft x 5 ft (15 ft^2) plots were established in September of 1993. The trial is maintained at a 2-inch mowing height, 3 to 4 lb N/1000 ft^2 were applied during the growing season, and the area was irrigated when needed to prevent drought. Preemergence herbicide was applied once in the spring.

Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Dawson received the highest rating in 1994.

Table 6. The 1994 quality ratings for the fine fescue regional cultivar trial

	Cultivar	Species	May	June	July	Aug	Sept	Oct	Mean
1	Dawson	SLC	6.7	7.3	7.3	5.3	7.0	6.0	6.6
2	Pick 4-91W	CF	6.0	7.7	5.7	6.0	7.3	7.0	6.6
3	PST-44D	CF	6.0	7.0	7.0	6.0	7.0	6.7	6.6
4	PST-4VB Endo.	STC	5.7	6.3	6.7	6.3	7.7	6.7	6.6
5	Rondo	STC	6.3	7.3	6.7	6.7	6.3	6.0	6.6
6	SR 5100	CF	6.0	7.7	5.3	6.0	7.0	7.0	6.5
7	Jasper (E)	STC	6.3	7.0	6.3	5.3	7.0	6.7	6.4
8	Aruba	STC	6.7	6.7	6.0	6.0	6.7	6.0	6.3
9	MB 61-93	CF	5.3	6.7	6.0	5.7	7.7	6.7	6.3
10	Shademaster II	STC	6.3	7.3	6.7	5.0	6.3	6.0	6.3
11	WX3-FFG6	STC	6.3	7.0	6.3	5.0	7.0	6.3	6.3
12	Medina	CF	6.0	7.0	5.7	5.3	6.3	6.7	6.2
13	NJ F-93	CF	6.0	7.3	5.7	5.0	6.7	6.3	6.2
14	PST-4DT	STC	6.0	6.7	5.3	5.3	6.7	7.0	6.2
15	WX3-FF54	CF	5.7	7.0	6.0	5.3	6.7	6.3	6.2
16	Jamestown II	CF	6.3	7.0	5.3	5.3	6.3	6.3	6.1
17	PRO 92/20	CF	6.0	7.3	6.3	4.3	6.0	6.3	6.1
18	PST-4ST	STC	6.0	7.0	6.3	4.0	7.0	6.3	6.1
19	TMI-3CE	CF	6.3	7.0	6.0	4.0	7.0	6.3	6.1
20	Seabreeze	SLC	5.7	6.7	6.3	4.7	6.7	6.0	6.0
21	ZPS-4BN	STC	6.0	6.3	5.7	5.0	6.3	6.7	6.0
22	Banner II	CF	6.0	7.0	5.3	4.3	6.0	6.7	5.9
23	MB 63-93	CF	5.3	6.7	6.3	5.0	6.0	6.0	5.9
24	MB 64-93	CF	5.7	6.7	5.7	5.0	6.0	6.7	5.9
25	Treazure (ZPS-MG)	CF	5.7	6.3	5.7	6.0	6.0	6.0	5.9
26	Common Creeping	STC	6.7	5.7	5.0	5.7	6.0	6.0	5.8
27	Jamestown	CF	6.7	7.0	5.7	4.3	5.3	6.0	5.8
28	MB 65-93	CF	5.3	7.0	5.7	5.0	5.7	6.0	5.8
29	MB 66-93	CF	5.7	6.3	5.7	4.7	7.0	5.7	5.8
30	Cascade	CF	7.0	6.7	5.7	4.3	5.3	5.3	5.7
31	Shadow (E)	CF	5.7	6.7	5.7	4.7	6.3	5.3	5.7
32	WVPB-STCR-101	STC	6.0	6.0	6.0	5.3	5.3	5.3	5.7
33	BAR Frr 4ZBD	STC	5.7	6.0	6.0	5.0	5.3	5.7	5.6
34	Brittany	CF	5.3	6.3	6.0	4.7	5.7	5.3	5.6
35	CAS-FR13	STC	6.3	5.7	5.7	4.3	5.3	6.3	5.6
36	Discovery	HF	6.0	6.7	7.0	3.0	5.3	5.3	5.6

	Cultivar	Species	May	June	July	Aug	Sept	Oct	Mean
37.	Darwin	CF	5.0	6.3	6.7	4.0	6.0	5.0	5.5
38	PRO 92/24	HF	6.0	7.3	6.0	2.7	5.7	5.3	5.5
39	Reliant II	HF	5.7	7.3	6.0	2.7	6.0	5.3	5.5
40	BAR UR 204	STC	6.0	6.0	5.0	4.0	6.0	5.7	5.4
41	ISI-FC-62	CF	5.3	6.7	6.0	3.3	5.7	5.3	5.4
42	Victory (E)	CF	5.3	6.3	5.7	3.3	6.0	5.7	5.4
43	SR 3100	HF	6.3	7.7	5.7	2.0	5.3	5.0	5.3
44	Tiffany	CF	5.7	6.7	5.0	3.7	5.7	5.3	5.3
45	Bridgeport	CF	5.3	6.3	5.3	4.3	5.0	4.7	5.2
46	MB 82-93	HF	5.7	6.7	5.0	2.7	5.3	4.7	5.0
47	Molinda	CF	5.3	5.7	5.3	4.7	5.0	4.0	5.0
48	Brigade	HF	6.3	7.0	4.3	2.3	4.3	4.7	4.8
49	Ecostar	HF	6.0	6.7	4.3	2.3	4.7	4.7	4.8
50	Flyer	STC	6.0	6.0	4.7	3.3	4.3	4.3	4.8
51	Quatro (FO 143)	SF	6.3	6.7	4.0	3.3	5.0	3.3	4.8
52	Spartan	HF	6.3	6.7	4.3	2.3	5.0	4.0	4.8
53	Scaldis	HF	5.7	6.7	4.7	2.7	4.7	3.7	4.7
54	MB 81-93	HF	6.0	7.0	4.3	2.3	4.3	3.7	4.6
55	Nordic	HF	5.7	6.7	3.7	2.3	5.0	4.0	4.6
56	Aurora w/endo.	HF	5.0	6.3	4.0	2.7	5.0	4.0	4.5
57	MB 83-93	HF	5.7	6.7	4.0	2.0	4.7	4.0	4.5
58	Pamela	HF	5.0	6.0	4.0	2.3	4.0	3.7	4.2
59	67135	SF	5.0	4.0	1.3	1.7	2.7	2.7	2.9
	$LSD_{(0.05)}$	---	1.4	0.9	1.4	1.6	2.1	1.6	1.0

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
CF = Chewings Fescue
HF = Hard Fescue
SF = Sheep Fescue
SLC = Slender Creeping Fescue
STC = Strong Creeping Fescue

Shade Adaptation Study - 1994

N. E. Christians

A shade adaptation study was established in the fall of 1987 to evaluate the performance of 35 species and cultivars of grasses. The species include creeping red fescue (C.R.F.), hard fescue (H.F.), tall fescue (T.F.), Kentucky bluegrass (K.B.), and rough bluegrass (*Poa trivialis*).

The area was located under the canopy of a mature stand of Siberian elm trees (*Ulmus pumila*) at the Iowa State University Horticulture Research Station north of Ames, Iowa. Grasses were mowed at a 2-inch height and received 2 lb N/1000 ft^2/year. No weed control has been required on the area, but turf was irrigated during extended droughts.

Monthly quality data were collected from May through October (Table 7). Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. This trial has been observed through the extremes of the drought year 1988 and the very wet conditions of 1993. Turf quality among species varied greatly with moisture conditions. In dry weather, the fine fescues, especially the hard fescues, do well, whereas rough bluegrass (*Poa trivialis*) quickly deteriorates. In extended wet periods, rough bluegrass does very well. Some of the tall fescues and chewings fescues also tend to perform better in wet conditions.

The 1994 season was neither too wet, nor too dry. Growing conditions were nearly ideal through most of the year. The chewings fescues were among the highest rated cultivars in 1994. Tall fescue also performed well. Kentucky bluegrass did not perform well in 1994 and most bluegrass varieties were near the bottom of the list.

A new shade trial was added in the fall of 1994 and will be reported on in next year's report. The older shade trial will also be maintained for a few more seasons.

Table 7. 1994 quality ratings for grasses in the 1987 shade trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Victor (C.F.)	7.3	7.7	6.7	6.7	7.0	7.3	7.1
2	Jamestown (C.F.)	7.7	7.0	5.7	6.0	7.0	6.3	6.6
3	Shadow (C.F.)	7.0	7.0	5.7	6.3	6.7	6.7	6.6
4	Mary (C.F.)	6.7	7.0	6.3	6.0	6.7	7.0	6.6
5	Falcon (T.F.)	6.7	6.7	5.0	5.7	7.0	6.7	6.3
6	Waldorf (C.F.)	5.3	7.3	5.7	6.0	6.0	7.0	6.2
7	Sabre (Poa trivialis)	7.7	7.3	5.7	4.3	6.0	6.0	6.2
8	Rebel II (T.F.)	6.7	6.3	5.0	6.0	7.0	6.3	6.2
9	Bonanza (T.F.)	6.3	6.3	5.7	5.7	6.7	6.3	6.2
10	Estica (C.R.F.)	5.3	6.0	6.3	6.0	6.3	6.7	6.1
11	ST-2 (SR 3000) (H.F.)	5.7	6.0	5.7	6.3	6.3	6.3	6.1
12	BAR FO 81-225 (H.F.)	5.0	6.0	5.3	5.7	7.3	7.0	6.1
13	Rebel (T.F.)	6.7	6.3	4.3	5.7	6.7	6.0	5.9
14	Waldina (H.F.)	5.3	6.0	5.0	5.3	6.0	7.0	5.8
15	Koket (C.F.)	6.0	5.7	4.7	6.3	6.0	5.7	5.7
16	Atlanta (C.F.)	5.0	7.0	4.7	5.7	6.3	5.3	5.7
17	Banner (C.F.)	6.0	6.0	4.3	5.3	6.0	6.0	5.6

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
18	Aridf (T.F.)	6.0	6.3	5.0	4.7	6.3	5.3	5.6
19	Pennlawn (C.R.F.)	5.3	6.0	4.7	5.0	6.3	5.7	5.5
20	Ensylva (C.R.F.)	6.0	5.3	4.7	5.3	5.7	5.7	5.4
21	Apache (T.F.)	6.0	6.0	4.3	4.7	6.3	5.3	5.4
22	Agram (C.F.)	5.0	6.0	4.0	5.3	5.7	5.7	5.3
23	Biljart (H.F.)	4.7	5.7	4.3	4.7	5.7	5.3	5.1
24	Spartan (H.F.)	4.7	4.7	4.7	4.7	6.0	5.7	5.1
25	Wintergreen (C.F.)	4.7	5.7	4.7	4.7	5.0	5.3	5.0
26	Reliant (H.F.)	5.0	6.0	3.7	4.3	5.3	5.0	4.9
27	Highlight (C.F.)	4.3	4.3	4.0	4.3	5.7	6.0	4.8
28	Coventry (K.B.)	4.3	7.0	4.7	4.7	4.7	3.0	4.7
29	Midnight (K.B.)	4.0	5.3	4.3	4.3	4.7	4.7	4.6
30	Scaldis (H.F.)	4.3	4.3	4.0	4.0	5.0	5.0	4.4
31	Ram I (K.B.)	4.3	5.0	4.0	4.0	4.3	4.0	4.3
32	Chateau (K.B.)	3.3	5.7	4.3	3.7	4.3	3.3	4.1
33	Bristol (K.B.)	4.0	5.0	3.0	4.0	4.7	4.0	4.1
34	Nassau (K.B.)	3.7	3.7	3.0	3.0	3.3	3.0	3.3
35	Glade (K.B.)	3.3	4.3	2.7	3.0	3.7	2.7	3.3
	$LSD_{(0.05)}$	1.7	1.7	2.3	2.2	2.3	1.9	1.7

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality

USGA Buffalograss Trial - 1994

N. E. Christians

The USGA buffalograss trial consists of 5 buffalograss (*Buchloe dactyloides*) varieties developed as part of the USGA turfgrass breeding program that are being compared to a standard buffalograss variety 'Texoka'.

The trial was established in August, 1988, and suffered considerable winter kill because of the late planting date. Only variety 84-315 survived the first winter in a satisfactory condition. In November 1989, plugs of all varieties were established in the greenhouse and maintained during the winter of 1989-1990. All six field plots were reestablished in the last week of May, 1990. The summer of 1990 was very wet. These plugs became well established during the growing season and all reached 100% cover by dormancy in September, 1990.

The first quality ratings were taken in 1991 and the data included in this report is from the third full season of data collection (Table 8). Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. In 1994, 84-315 was the highest rated variety. Varieties 84-304 and 84-409 were severely damaged during the winters of 1993 and 1994. Very little grass remains on plots established to these two grasses.

Table 8. The 1994 quality ratings for the USGA buffalograss study.

	Cultivar	May	June	July	Sept	Mean
1	84-315	7.0	7.0	6.7	6.7	6.8
2	84-378	4.7	6.3	7.3	6.0	6.1
3	TEXOKA	6.3	5.7	6.0	5.0	5.8
4	84-609	4.2	2.3	3.3	5.0	3.8
5	84-304	2.3	1.3	1.0	1.3	1.5
6	84-409	1.0	1.0	1.3	1.3	1.2
	$LSD_{(0.05)}$	3.7	1.9	1.7	2.4	1.8

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality

Green Height Bentgrass Cultivar Trial - 1994
(Native Soil)

N. E. Christians and J. D. Dickson

This is the first year of data from the Green Height Bentgrass Cultivar trial established in the fall of 1993. Data collection began after the cultivars were fully established in July. The area was maintained at a 0.5 in. mowing height in 1994 and will be lowered to 3/16 in. in 1995. This is a National Turfgrass Evaluation (NTEP) trial and is being conducted at several research stations in the U.S. It contains 28 cultivar including some of the newest seeded varieties available and a number of experimental varieties.

The cultivars are to be maintained with a fertilizer program of 1/4 lb N applied at 14-day intervals with an approximate total of 4 to 5 lbs of N/1000 ft^2/growing season. Fungicides are used as needed in a preventative program. Herbicides and insecticides are applied as needed.

Table 9 contains the averages of monthly visual quality ratings for July through October 1994. This is the initial data from this study and the varieties were maintained at a higher than normal mowing height during this establishment year. The study will be conducted for several years and data will be needed from more years before conclusions can be drawn concerning the adaptation of these cultivars to Iowa conditions. Earlier years of this report contain several years of data on older green height bentgrass studies.

Table 9. The 1994 ratings for the green height bentgrass trial.

	Cultivar	July	August	Sept	Oct	Mean
1	A-4	5.7	7.0	7.0	7.0	6.7
2	Cato	6.7	6.7	6.7	6.3	6.6
3	L-93	5.7	6.7	6.7	7.3	6.6
4	Providence	4.7	7.0	7.0	7.3	6.5
5	G-6	5.0	6.3	6.3	7.3	6.3
6	Southshore	5.3	6.7	6.7	6.0	6.2
7	A-1	5.3	5.7	6.7	6.7	6.1
8	Crenshaw	5.0	6.3	6.3	5.7	5.8
9	SYN 92-1-93	6.7	6.3	5.3	4.7	5.8
10	SYN 92-5-93	4.7	6.3	5.3	6.7	5.8
11	Regent	4.3	6.3	6.0	6.0	5.7
12	SR 1020	5.0	6.0	5.7	5.7	5.6
13	ISI-AP-89150	3.7	5.7	6.0	6.7	5.5
14	Lopez	5.0	5.3	5.7	6.0	5.5
15	Pennlinks	5.0	5.7	5.3	6.0	5.5
16	G-2	4.0	5.3	6.0	6.3	5.4
17	MSUEB	4.7	5.3	5.7	6.0	5.4
18	BAR WS 42012	4.0	5.3	5.3	6.3	5.3
19	Penncross	5.0	5.3	5.3	5.3	5.3
20	SYN 92-2-93	5.0	5.3	5.7	5.0	5.3
21	18th Green	3.7	5.7	6.3	5.0	5.2
22	Trueline	4.3	5.7	5.3	5.3	5.2
23	Pro/Cup	3.7	5.3	5.3	5.0	4.8
24	DG-P	3.3	4.3	5.3	5.7	4.7
25	SYN-1-88	3.3	4.7	5.0	4.0	4.3
26	BAR AS 493	3.0	3.7	4.0	3.7	3.6
27	Seaside	2.7	3.3	4.3	3.7	3.5
28	Tendenz	2.7	3.7	3.7	3.7	3.4
	$LSD_{(0.05)}$	1.5	1.1	1.1	1.6	0.9

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Fairway Height Bentgrass Study - 1994

N. E. Christians and J. D. Dickson

This is the first year of data from the Fairway Height Bentgrass Cultivar trial established in the fall of 1993. Data collection began after the cultivars were fully established in July. The area was maintained at a 0.5 in. mowing height in 1994 and will be maintained at that height throughout the study. This is a National Turfgrass Evaluation (NTEP) trial and is being conducted at several research stations in the U.S. It contains 21 cultivar including standard cultivars, some of the newest seeded cultivars available and a number of experimental varieties.

The cultivars are to be maintained with 4 to 5 lbs of N/1000 ft^2/growing season. Fungicides are used as needed in a preventative program. Herbicides and insecticides are applied as needed.

Table 10 contains monthly visual quality ratings from July through October 1994. Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = acceptable quality, and 1 = poorest quality. This was the establishment year for this study and more years of data will be needed before conclusions can be drawn. Earlier years of this report contain several years of data on older fairway height bentgrass studies.

Table 10. The 1994 quality ratings for the fairway height bentgrass study.

	Cultivar	July	August	Sept	Oct	Mean
1	Cato	7.0	7.0	7.0	7.0	7.0
2	Penneagle	6.7	6.3	6.7	7.3	6.8
3	Southshore	6.3	6.7	6.7	7.3	6.8
4	Providence	5.7	6.7	6.7	7.3	6.6
5	Crenshaw	7.0	6.3	6.3	5.7	6.3
6	G-6	6.0	6.0	5.7	7.3	6.3
7	Trueline	6.0	6.3	5.7	6.3	6.1
8	BAR WS 42102	5.7	5.7	6.0	6.7	6.0
9	Lopez	6.3	5.7	5.3	5.7	5.8
10	G-2	5.0	5.0	6.0	6.7	5.7
11	Pro/Cut	5.3	5.7	5.7	6.0	5.7
12	18th Green	5.0	6.7	5.7	5.0	5.6
13	DF-1	5.3	5.3	6.0	5.7	5.6
14	Penncross	5.7	5.3	5.0	5.3	5.3
15	SR 7100	5.0	4.3	4.0	4.3	4.4
16	ISI-AT-90162	4.0	4.3	4.3	4.7	4.3
17	Seaside	3.3	4.0	4.3	4.3	4.0
18	OM-AT-90163	3.7	4.3	3.7	4.0	3.9
19	BAR AS 493	3.0	4.3	4.3	3.7	3.8
20	Tendenz	3.7	3.3	4.0	4.0	3.8
21	Exeter	2.7	3.3	3.7	3.0	3.2
	$LSD_{(0.05)}$	1.2	1.2	1.3	1.5	0.8

Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Herbicide and Growth Regulator Studies

Preemergence Weed Control Study - 1994

B. R. Bingaman and N. E. Christians

Several herbicides were tested for efficacy as preemergence materials for crabgrass control in turf areas. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The site of the experiment was an established Indigo Kentucky bluegrass area. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.5%, a pH of 6.25, 23 ppm P, and 114 ppm K. This area was seeded prior to the beginning of this testing with a mixture of large hairy crabgrass (*Digitaria sanguinalis* (L.) Scop.) and smooth crabgrass (*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl). Supplemental irrigation was applied as needed throughout the duration of the study.

Individual experimental plots were 5 x 5 ft and there were 20 treatments including 19 herbicides and an untreated control (Table 11). The study was arranged in a randomized complete block design and 3 replications were conducted.

All treatments (except the Dimension + fertilizer material) were applied on April 27, 1994. The Dimension + fertilizer product (treatment #14) was received and applied on April 30, 1994. A 6 week sequential application of Dimension 1EC (treatment #15) was made on June 9. Cardboard containers with holes punched in the lids were used as shaker dispensers for the granular products. A backpack carbon dioxide sprayer equipped with 8006 nozzles with a spray pressure of 20-25 psi was used to apply the liquid materials. Liquid treatments were applied with the equivalent of 3 gal water/1000 ft^2.

Temperatures for the first week after treatment application were quite cool with subfreezing low temperatures recorded for April 28 thru May 2. Rainfall occurred on the first 3 days following treatment application.

Phytotoxicity and visual quality data were taken on May 11 (14 days after treatment) and at 2 week intervals thereafter throughout the duration of the study. Crabgrass germination was not evident until early June and slow growth and development of the plants prevented taking percentage of crabgrass cover data until July 6. Subsequent percentage data were collected on July 15 and 21 and August 2 and 19.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of crabgrass control among the various herbicide materials. Least significant difference (LSD) tests were used to compare means among the treatments.

No visible toxicity was observed at any time during the study (Table 11). None of the treatments were 100% effective. Ronstar, Lesco Pre-M at 3.00 lb ai/A, Dimension, Scott's Halts and Dacthal came close to providing complete control. The Scott's Pre-M, at the low application rate of 1.18 lb ai/A, was not effective. Several of the experimental (EXP) materials were also ineffective.

Table 11. The visual quality[1] of Kentucky bluegrass treated with several preemergence herbicides[2].

	Treatment	Rate (# a.i./A)	5/11	5/25	6/8	6/24	6/29	7/6	7/15	7/21	8/2	8/19
1	Untreated Control	----	9	9	9	9	9	9	9	9	9	9
2	EXP31130A 75 WG	0.18	9	9	9	9	9	9	9	9	9	9
3	EXP31130A 75 WG	0.36	9	9	9	9	9	9	9	9	9	9
4	EXP31198A 0.37 GR	0.18	9	9	9	9	9	9	9	9	9	9
5	EXP31198A 0.37 GR	0.36	9	9	9	9	9	9	9	9	9	9
6	EXP31199A 1 GR	1.00	9	9	9	9	9	9	9	9	9	9
7	EXP31199A1 GR	2.00	9	9	9	9	9	9	9	9	9	9
8	Chipco Ronstar 2 GR	3.00	9	9	9	9	9	9	9	9	9	9
9	Lesco Pre-M 60 WG	3.00	9	9	9	9	9	9	9	9	9	9
10	Barricade 65 WG	0.33	9	9	9	9	9	9	9	9	9	9
11	Barricade 65 WG	0.50	9	9	9	9	9	9	9	9	9	9
12	Barricade 65 WG	0.65	9	9	9	9	9	9	9	9	9	9
13	Dimension 1EC	0.38	9	9	9	9	9	9	9	9	9	9
14	Dimension + fertilizer 0.072% GR	0.19	9	9	9	9	9	9	9	9	9	9
15	Dimension 1EC (6 wk sequential appl.)	0.25/ 0.125*	9	9	9	9	9	9	9	9	9	9
16	Scotts Halts 1.21 GR	1.51	9	9	9	9	9	9	9	9	9	9
17	Scotts Pro-turf 1.15 GR	1.50	9	9	9	9	9	9	9	9	9	9
18	Dacthol 75 WP	10.50	9	9	9	9	9	9	9	9	9	9
19	Scotts Pro-turf 60 WP	1.18	9	9	9	9	9	9	9	9	9	9
20	Lesco Pre-M + fertilizer 0.86 GR	1.50	9	9	9	9	9	9	9	9	9	9
	$LSD_{0.05}$	----	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = acceptable quality, and 1 = poorest quality.
[2]Preemergence materials applied 4/27/94 except treatment #14 that was received and applied 4/30/94.
NS = not significantly different at the 0.05 level.

Table 12. The percentage of crabgrass cover in Kentucky bluegrass treated with preemergence herbicides[1].

	Treatment	Rate (# a.i./A)	% Crabgrass Cover July 6	July 15	July 21	August 2	August 19
1	Untreated Control	----	10	22	35	40	50
2	EXP31130A 75 WG	0.18	15	28	42	47	48
3	EXP31130A 75 WG	0.36	10	17	25	40	43
4	EXP31198A 0.37 GR	0.18	8	23	33	40	45
5	EXP31198A 0.37 GR	0.36	10	18	33	40	52
6	EXP31199A 1 GR	1.00	4	9	10	25	16
7	EXP31199A1 GR	2.00	2	1	2	8	6
8	Chipco Ronstar 2 GR	3.00	1	1	4	12	4
9	Lesco Pre-M 60 WG	3.00	0	0	1	3	4
10	Barricade 65 WG	0.33	2	2	4	15	7
11	Barricade 65 WG	0.50	0	1	4	12	5
12	Barricade 65 WG	0.65	0	0	0	3	2
13	Dimension 1EC	0.38	0	1	2	5	5
14	Dimension + fertilizer 0.072% GR	0.19	1	2	1	8	3
15	Dimension 1EC (6 wk sequential application)	0.25/ 0.125*	1	0	0	3	2
16	Scotts Halts 1.21 GR	1.51	2	0	4	17	7
17	Scotts Pro-turf 1.15 GR	1.50	1	2	5	18	14
18	Dacthol 75 WP	10.50	1	2	3	17	7
19	Scotts Pro-turf 60 WP	1.18	5	15	20	35	35
20	Lesco Pre-M + fertilizer 0.86 GR	1.50	4	7	8	27	20
	$LSD_{0.05}$	----	4	8	11	10	13

[1]Preemergence materials applied 4/27/94 except treatment #14 that was received and applied 4/30/94.

Postemergence Crabgrass Control Study - 1994

B. R. Bingaman and N. E. Christians

Several herbicides were tested for efficacy as postemergence materials for crabgrass control in turf areas. Dimension, Barricade, Acclaim, Lesco Pre-M, Dimension + fertilizer, HOE 46360 (3.1 EW) and HOE 46360 (0.57 EW) were applied at a range of rates and at different stages of crabgrass development. Preemergence (PRE) , early- (EPO), mid- (MPO), and late-postemergence (LPO) applications were made (Table 13). This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The site of the experiment was an established Ram I Kentucky bluegrass area. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.5%, a pH of 6.25, 23 ppm P, and 114 ppm K. This area was seeded prior to the beginning of this testing with a mixture of large hairy crabgrass (*Digitaria sanguinalis* (L.) Scop.) and smooth crabgrass (*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl). Supplemental irrigation was applied as needed throughout the duration of the study.

Individual experimental plots were 5 x 5 ft and there were 27 herbicide treatments and an untreated control (Table 13). The study was arranged in a randomized complete block design with 3 replications.

Cardboard containers with holes punched in the lids were used as shaker dispensers for the granular products. A backpack carbon dioxide sprayer equipped with 8006 nozzles with a spray pressure of 20-25 psi was used to apply the liquid materials. Liquid treatments were applied with the equivalent of 3 gal water/1000 ft^2.

All PRE materials were applied before crabgrass germination. The HOE premix treatments 26, 27, and 28 were applied on April 27. These treatments were mixed incorrectly so the proper rates were applied on April 30 as treatments 2, 3, and 4. Temperatures for the first week after treatment application were quite cool and subfreezing low temperatures were recorded for April 28 thru May 2. Rainfall occurred on April 28, 29 and 30.

Crabgrass germination was detected on June 8 and the EPO products were applied on June 22 when the plants were in the 3-4 leaf stage but untillered. Within 24 hours after application, 3.3 inches of rainfall were received. Mid-postemergence applications were made on July 13 when the crabgrass was in the 1-2 tiller stage. There was no substantial rainfall until July 27.

Once the crabgrass was in the 3-5 tiller stage the LPO materials were applied. Application was made on August 4 and rainfall occurred on August 9-12.

The plots were surveyed throughout the duration of the study for possible phytotoxicity to the herbicide products. Visual quality data were taken to assess phytotoxicity at approximately 2 week intervals beginning May 11 and ending on August 19. Data collection was scheduled to correspond with the application dates of the PRE, EPO, MPO, and LPO products.

Percentage of crabgrass cover data were not taken until July 15 because of late crabgrass germination, and slow plant growth and development. Percentage data were subsequently collected on July 21 and August 2 and 19.

The Statistical Analysis System version 6.06 (SAS Institute, 1989) and the Analysis of Variance (ANOVA) were utilized to test the significance of crabgrass control among the various herbicide treatments. Least significant difference (LSD) tests were used to compare means among the treatments.

Table 13. The visual quality[1] of Kentucky bluegrass treated with preemergence (PRE), early- (EPO), mid- (MPO), and late- (LPO) postemergence herbicides.

	Treatment	Rate (# a.i./A)	5/11	5/25	6/8	6/29	7/6	7/15	8/2	8/11	8/19
1	Untreated Control	NA	9	9	9	8	8	8	8	7	7
2	HOE premix - 3.1EC - PRE	1.54	8	9	6	8	8	8.	9	8	8.
3	HOE premix - 3.1EC - PRE	2.06	6	6	6	7	8	9	9	9	8
4	Dimension - 1EC - PRE	0.50	9	9	9	8	8	8	7	8	7
5	Barricade - 64WG - PRE	0.50	9	9	9	7	8	8	7	7	7
6	HOE premix - 3.1EC - EPO	1.54	9	9	9	7	7	8	7	7	8
7	HOE premix - 3.1EC - EPO	2.06	9	9	9	8	8	8	8	8	8
8	Acclaim - 1.0EC + Lesco PRE-M - 60WP - EPO	0.08 1.50	9	9	9	7	8	8	8	8	7
9	Dimension - 1EC - EPO	0.50	8	9	9	8	8	8	7	8	7
10	HOE premix - 3.1EC - EPO	3.08	9	9	9	8	7	7	8	8	8
11	HOE premix - 3.1EC - EPO	4.12	9	9	9	7	6	7	8	8	9
12	HOE 360 - 0.57EW - EPO	0.04	9	9	9	8	8	8	8	8	8
13	HOE 360 - 0.57EW - EPO	0.06	9	9	9	7	7	7	8	8	8
14	HOE 360 - 0.57EW + Lesco PRE-M - 60WP - EPO	0.04 2.00	9	9	9	7	8	7	8	7	7
15	Acclaim - 1.0EC - EPO	0.12	9	9	9	7	7	7	8	8	8
16	HOE 360 - 0.57EW - MPO	0.06	9	9	9	8	8	8	6	8	8
17	HOE 360 - 0.57EW - MPO	0.09	9	9	9	8	8	8	6	7	8
18	HOE 360 - 0.57EW - MPO	0.13	9	9	9	7	8	8	6	7	8
19	Acclaim - 1.0EC - MPO	0.18	9	9	9	8	7	7	6	7	8
20	HOE 360 - 0.57EW - LPO	0.09	9	9	9	7	8	8	7	6	6
21	HOE 360 - 0.57EW - LPO	0.13	9	9	9	8	8	7	7	6	5
22	HOE 360 - 0.57EW - LPO	0.18	9	9	9	8	8	7	7	6	6
23	Acclaim - 1.0EC - LPO	0.25	9	9	9	8	8	8	7	6	6
24	Dimension - 1EC - LPO	0.50	9	9	9	7	8	8	7	7	7
25	Dimension + fertilizer 0.072% GR - EPO	0.25	9	9	9	9	9	9	9	8	8
26	HOE premix - 3.1 EW - PRE	3.81	5	5	5	8	9	9	9	9	9
27	HOE premix - 3.1 EW - PRE	5.09	4	4	4	7	9	9	9	9	8
28	Dimension - 1EC - PRE	1.24	9	9	9	9	8	8	8	9	8
	$LSD_{0.05}$		1	0.3	0.5	NS	1	1	1	1	1

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
NS=not significantly different at the 0.05 level.

Table 14. The percentage of crabgrass cover in Kentucky bluegrass treated with preemergence (PRE), early- (EPO), mid- (MPO), and late- (LPO) postemergence herbicides.

	Treatment	Rate (# a.i./A)	% Crabgrass Cover			
			July 15	July 21	August 2	August 19
1	Untreated Control	NA	5	13	22	27
2	HOE premix - 3.1EC - PRE	1.54	7	8	23	14
3	HOE premix - 3.1EC - PRE	2.06	1	5	10	12
4	Dimension - 1EC - PRE	0.50	0	2	0	2
5	Barricade - 64WG - PRE	0.50	0	0	1	1
6	HOE premix - 3.1EC - EPO	1.54	0	1	3	2
7	HOE premix - 3.1EC - EPO	2.06	0	0	0	0
8	Acclaim - 1.0EC + Lesco PRE-M - 60WP - EPO	0.08 1.50	0	1	7	4
9	Dimension - 1EC - EPO	0.50	0	0	2	2
10	HOE premix - 3.1EC - EPO	3.08	0	0	0	1
11	HOE premix - 3.1EC - EPO	4.12	0	0	0	0
12	HOE 360 - 0.57EW - EPO	0.04	0	0	5	5
13	HOE 360 - 0.57EW - EPO	0.06	0	1	1	4
14	HOE 360 - 0.57EW + Lesco PRE-M - 60WP - EPO	0.04 2.00	0	2	1	3
15	Acclaim - 1.0EC - EPO	0.12	0	2	2	4
16	HOE 360 - 0.57EW - MPO	0.06	5	2	1	2
17	HOE 360 - 0.57EW - MPO	0.09	12	10	0	1
18	HOE 360 - 0.57EW - MPO	0.13	12	9	3	1
19	Acclaim - 1.0EC - MPO	0.18	15	10	5	2
20	HOE 360 - 0.57EW - LPO	0.09	20	28	40	13
21	HOE 360 - 0.57EW - LPO	0.13	20	27	40	3
22	HOE 360 - 0.57EW - LPO	0.18	10	13	27	2
23	Acclaim - 1.0EC - LPO	0.25	5	13	25	2
24	Dimension - 1EC - LPO	0.50	8	18	28	34
25	Dimension + fertilizer 0.072% GR - EPO	0.25	3	8	7	2
26	HOE premix - 3.1 EC- PRE	3.81	2	2	2	5
27	HOE premix - 3.1 EC - PRE	5.09	0	0	0	1
28	Dimension - 1EC - PRE	1.24	0	1	0	0
	$LSD_{0.05}$	----	7	8	11	8

1994 Dithiopyr Pre- and Postemergence Weed Control Study

B. R. Bingaman and N. E. Christians

Seven fertilizer and crabgrass herbicide materials were evaluated for their suitability as nitrogen sources for Kentucky bluegrass and for their efficacy in controlling crabgrass. Crab-Buster Plus, Crab-Buster Plus II, Crab-Buster Plus III, Super Team, Scott's Halts, Green Charm, and an untreated check (consisting of a 29-4-10 fertilizer) were supplied by Parcel Inc. for screening. Each material was applied to 2 plots. One plot received a preemergent (PRE) application before crabgrass germination had begun. The other was given an early postemergent (POST) application when the crabgrass was in the 2-3 leaf stage but before tillering had begun.

This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The site of the experiment was an established Indigo Kentucky bluegrass area. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.5%, a pH of 6.25, 23 ppm P, and 114 ppm K. This area was seeded prior to the beginning of this testing with a mixture of large hairy crabgrass (*Digitaria sanguinalis* (L.) Scop.) and smooth crabgrass (*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl). Supplemental irrigation was applied as needed throughout the duration of the study.

Individual experimental plots were 5 x 5 ft and there were 14 treatments including 13 herbicides and a control (Table 15). The study was arranged in a randomized complete block design with 3 replications.

Cardboard containers with holes punched in the lids were used as shaker dispensers for the granular products. All PRE materials were applied on April 27 before crabgrass germination was detected. Temperatures for the first week after treatment application were quite cool with subfreezing low temperatures recorded for April 28 thru May 2. Rainfall occurred on April 28, 29 and 30.

Crabgrass germination was detected on June 8 and the POST products were applied on June 21 when the plants were in the 2-4 leaf stage with no tillering. Within 48 hours after application, 3.3 inches of rainfall were received.

Kentucky bluegrass was evaluated for possible phytotoxicity to herbicide products. Visual quality data were taken to assess phytotoxicity at approximately 2 week intervals beginning May 11 and ending August 19. Data collection was scheduled to correspond with application dates of PRE and POST products.

Percent crabgrass cover was not evaluated until July 6 because of late crabgrass germination, and slow plant growth. Percentage data were subsequently collected on July 15, July 21, and August 19.

Data were analyzed with Statistical Analysis System version 6.06 (SAS Institute, 1989) by using Analysis of Variance (ANOVA) to test significance of crabgrass control among various herbicide materials and times of application. Least significant difference (LSD) tests were used to compare means among treatments.

No turfgrass phytotoxicity was observed during the study (Table 15). Crab-buster was generally quite effective in both pre- and post-applications (Table 16). The Scott's material was initially effective, but some breakthrough occurred in late summer.

Table 15. Visual quality[1] of Kentucky bluegrass treated with preemergence (PRE) and postemergence (POST) herbicides[2] containing active ingredients Dithiopyr[3], Pendimethalin[4], and Prodiamine[5].

	Treatment	Rate (# a.i./A)	5/11	5/25	6/8	6/24	6/29	7/6	7/15	7/21	8/2	8/19
1	Crab-Buster Plus-.16GR- PRE[3]	0.24	9	9	9	9	9	9	9	9	9	9
2	Crab-Buster Plus-.16GR- POST[3]	0.24	9	9	9	9	9	9	9	9	9	9
3	Crab-Buster Plus II-.14GR- PRE[3]	0.24	9	9	9	9	9	9	9	9	9	9
4	Crab-Buster Plus II-.14GR- POST[3]	0.24	9	9	9	9	9	9	9	9	9	9
5	Crab-Buster Plus III-.18GR- PRE[3]	0.24	9	9	9	9	9	9	9	9	9	9
6	Crab-Buster Plus III-.18GR- POST[3]	0.24	9	9	9	9	9	9	9	9	9	9
7	Super Team-2GR-PRE[3]	3.00	9	9	9	9	9	9	9	9	9	9
8	Super Team-2GR-POST[3]	3.00	9	9	9	9	9	9	9	9	9	9
9	Scotts Halts-1.21GR-PRE[4]	1.50	9	9	9	9	9	9	9	9	9	9
10	Scotts Halts-1.21GR-POST[4]	1.50	9	9	9	9	9	9	9	9	9	9
11	Green Charm C.P.-.20GR[5]	0.35	9	9	9	9	9	9	9	9	9	9
12	Green Charm C.P.-.20GR[5]	0.35	9	9	9	9	9	9	9	9	9	9
13	Untreated Control	0.00	9	9	9	9	9	9	9	9	9	9
14	Untreated Control	0.00	9	9	9	9	9	9	9	9	9	9
	$LSD_{(0.05)}$	----	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

[2]Preemergence materials applied 4/27/94. Postemergence materials applied 6/21/94 when crabgrass was in the 2-4 leaf stage.

NS = not significant at the 0.05 significance level.

Table 16. Percent crabgrass cover in Kentucky bluegrass treated with preemergence (PRE) and postemergence (POST) herbicides[1] containing active ingredients Dithiopyr[2], Pendimethalin[3], and Prodiamine[4].

	Treatment	Rate (# a.i./A)	% Crabgrass Cover 7/6	7/15	7/21	8/19
1	Crab-Buster Plus-.16GR- PRE[2]	0.24	1	0	4	3
2	Crab-Buster Plus-.16GR- POST[2]	0.24	0	2	8	3
3	Crab-Buster Plus II-.14GR- PRE[2]	0.24	1	2	4	3
4	Crab-Buster Plus II-.14GR- POST[2]	0.24	0	4	4	4
5	Crab-Buster Plus III-.18GR- PRE[2]	0.24	0	0	1	2
6	Crab-Buster Plus III-.18GR- POST[2]	0.24	0	1	1	2
7	Super Team-2GR-PRE[2]	3.00	0	0	2	2
8	Super Team-2GR-POST[2]	3.00	10	14	15	17
9	Scotts Halts-1.21GR-PRE[3]	1.50	0	2	5	10
10	Scotts Halts-1.21GR-POST[3]	1.50	8	17	18	25
11	Green Charm C.P.-.20GR-PRE[4]	0.35	1	4	10	14
12	Green Charm C.P.-.20GR-POST[4]	0.35	15	18	22	27
13	Untreated Control	0.00	13	23	32	42
14	Untreated Control	0.00	17	25	37	52
	$LSD_{(0.05)}$	----	6	8	11	8

[1]Preemergence materials applied 4/27/94. Postemergence materials applied 6/21/94 when crabgrass was in the 2-4 leaf stage.

Broadleaf Weed Control Study - 1994

B. R. Bingaman and N.E. Christians

Several herbicides were tested for efficacy as postemergence materials for broadleaf weed species in turf areas. Products from, DowElanco, O. M. Scott & Sons Co., PBI Gordon, Rhone-Poulenc Ag Company, and Sandoz Agro Inc. were included.

This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The site of the experiment was a common Kentucky bluegrass area with a heavy infestation of dandelion (*Taraxacum officianale* Weber) and white clover (*Trifolium repens* L.). The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.5%, a pH of 5.95, 28 ppm P, and 162 ppm K.

Individual experimental plots were 5 x 10 ft and there were 19 treatments including 18 herbicides and an untreated control (Table 17). The experimental design was a randomized complete block with 3 replications.

The 5 x 10 ft plots that received granular Confront, S-4779, and S-4953, were subdivided into 5 x 5 ft plots so that a comparison study could be conducted. Granular materials in subplots were applied to either dry or wet foliage.

Treatments were applied on 26 May 1994, between 6:00 and 8:15 p.m. Cardboard containers with holes punched in the lids were used as shaker dispensers for the granular products. A backpack carbon dioxide sprayer equipped with 8006 nozzles with a spray pressure of 20-25 psi was used to apply the liquid materials. Liquid treatments were applied with the equivalent of 3 gal water/1000 ft^2. A sprayer also was used to moisten the foliage in the subplots being treated with Confront S-4779 and S-4953 on wet foliage.

Weather conditions after treatment application were very favorable. Temperatures were seasonable and no rainfall occurred until June 1, 1994.

On June 2 and June 9 (7 and 14 days after treatment, respectively) the degree of damage to the weeds in each individual plot was recorded by assessing the weeds for leaf curl, discoloration, and mortality. Damage was determined using a visual rating scale from 9 to 1, with 9 indicating dead weeds and 1 indicating no damage. Percentage weed cover was estimated 4 and 6 weeks after treatment applications. Data for dandelion, knotweed (*Polygonum aviculare* L.), plantain (*Plantago lanceolata* L.), black medic (*Medicago lupulina* L.), oxalis (*Oxalis stricta* L.), curly dock (*Rumex crispus* L.), and white clover were recorded on June 22. On July 6 percentages were recorded for these 7 species and for purslane (*Portulaca oleracea* L.), prostrate spurge (*Euphorbia supina* Raf. ex Boiss.), velvetleaf (*Abutilon theophrasti* Medic.), redroot pigweed (*Amaranthus retroflexus* L.), Pennsylvania smartweed (*Polygonum pensylvanicum* L.), and common lambsquarters (*Chenopodium album* L.). No additional data were taken after July 6 because germination of new plants had begun.

Data were analyzed with Statistical Analysis System version 6.06 (SAS Institute, 1989) by using Analysis of Variance (ANOVA) to test significance of broadleaf weed control among various herbicide materials. Least significant difference (LSD) tests were used to compare means among treatments.

Buctril, a contact herbicide, provided the quickest knockdown of weeds (Table 17), however, dandelion and clover both recovered in Buctril treated plots by July 6. The granular Confront materials (treatments 9-12) were effective on both dry and wet tissue. The addition of Garlon (Tryclopyr) to Vanquish (Dicamba) provided improved clover control at the 0.125 lb ai/A level of Vanquish. Trimec Classic and Super Trimec provided near complete weed control in all plots.

Table 17. Visible damage[1] to broadleaf weeds in Kentucky bluegrass treated with postemergence herbicides[2].

	Treatment	Rate (# a.i./A)	June 2	June 9
1	Untreated Control	---	1	1
2	Buctril 2EC	2.000	8	6
3	Vanquish 4EC	0.125	1	5
4	Vanquish 4EC	0.250	3	7
5	Vanquish 4EC + Garlon 3A	0.125/0.500	3	7
6	Vanquish 4EC + Garlon 3A	0.125/1.000	4	7
7	Vanquish 4EC + Garlon 3A	0.250/0.500	3	8
8	Vanquish 4EC + Garlon 3A	0.250/1.000	3	7
9	Confront S-4779 on dry foliage	0.650	2	6
9A	Confront S-4779 on wet foliage	0.650	3	6
10	Confront S-4779 on dry foliage	0.750	2	5
10A	Confront S-4779 on wet foliage	0.750	4	7
11	Confront S-4953 on dry foliage	0.750	2	7
11A	Confront S-4953 on wet foliage	0.750	3	7
12	Confront S-4953 on dry foliage	1.000	2	5
12A	Confront S-4953 on wet foliage	1.000	4	6
13	Confront 3SL - XRM-5085	0.750	5	8
14	Confront 3SL - CRM-5085	0.380	3	8
15	Confront + fert - NAF-86 - 0.47 GR	0.820	1	5
16	Turflon Ester 4EC	1.000	4	7
17	Turflon Ester 4EC + 2,4-D - 3.8EC	1.000/1.000	4	7
18	Trimec Classic 3.32EC	1.250	5	7
19	Super Trimec	0.180	3	7
	$LSD_{0.05}$		1	1

[1]The symptoms of herbicide damage were leaf curl, discoloration, and deformity. Damage was assessed on a scale of 9 to 1; 9 = dead plants, 1 = no weed damage.
[2]All herbicide materials applied 5/26/94

Table 18. The percentage of cover of several broadleaf weed species on June 22, 1994 in Kentucky bluegrass 28 days after application of postemergence herbicides[1].

	Treatment	Rate (# a.i./A)	dandelion	knotweed	broadleaf plantain	black medic	oxalis	curly dock	white clover
1	Untreated Control	---	28	8	7	2	0	0	43
2	Buctril 2EC	2.000	28	5	0	0	0	3	35
3	Vanquish 4EC	0.125	4	2	7	0	0	1	20
4	Vanquish 4EC	0.250	1	0	4	0	2	3	0
5	Vanquish 4EC + Garlon 3A	0.125 0.500	0	0	2	0	0	3	0
6	Vanquish 4EC + Garlon 3A	0.125 1.000	0	0	5	0	0	0	0
7	Vanquish 4EC + Garlon 3A	0.250 0.500	0	1	0	0	0	1	0
8	Vanquish 4EC + Garlon 3A	0.250 1.000	0	0	0	0	0	1	0
9	Confront S-4779 on dry foliage	0.650	0	1	0	0	0	3	0
9A	Confront S-4779 on wet foliage	0.650	0	0	0	0	0	3	0
10	Confront S-4779 on dry foliage	0.750	3	7	0	0	0	2	0
10A	Confront S-4779 on wet foliage	0.750	1	0	0	0	0	1	0
11	Confront S-4953 on dry foliage	0.750	0	5	0	0	0	3	0
11A	Confront S-4953 on wet foliage	0.750	1	4	0	0	0	3	0
12	Confront S-4953 on dry foliage	1.000	2	12	0	0	0	2	2
12A	Confront S-4953 on wet foliage	1.000	0	0	0	0	0	2	0
13	Confront 3SL - XRM-5085	0.750	0	1	0	0	0	0	0
14	Confront 3SL - XRM-5085	0.380	1	2	0	0	1	1	0
15	Confront + fertilizer (NAF-86) - 0.47 GR	0.820	5	2	0	0	1	0	2
16	Turflon Ester 4EC	1.000	1	0	2	0	0	0	0
17	Turflon Ester 4EC + 2,4-D - 3.8EC	1.000 1.000	0	0	0	0	0	0	0
18	Trimec Classic 3.32EC	1.250	0	0	1	0	0	0	3
19	Super Trimec	0.180	0	0	0	0	0	0	0
	$LSD_{0.05}$		6	NS	NS	NS	NS	NS	7

[1]All postemergence materials applied 5/26/94.
NS = not significantly different at the 0.05 level.

Table 19. The percentage of cover of several broadleaf weed species on July 6, 1994 in Kentucky bluegrass 42 days after application of postemergence herbicides[1].

	Treatment	Rate (# a.i./A)	dandelion	knotweed	broadleaf plantain	black medic	oxalis	curly dock	white clover
1	Untreated Control	---	30	0	4	0	0	1	40
2	Buctril 2EC	2.000	20	3	0	0	0	1	32
3	Vanquish 4EC	0.125	5	2	3	0	0	2	4
4	Vanquish 4EC	0.250	4	1	3	0	1	1	0
5	Vanquish 4EC +	0.125							
	Garlon 3A	0.500	2	1	1	0	0	2	0
6	Vanquish 4EC +	0.125					0		
	Garlon 3A	1.000	2	2	4	0		1	0
7	Vanquish 4EC +	0.250							
	Garlon 3A	0.500	1	1	2	0	0	2	0
8	Vanquish 4EC +	0.250							
	Garlon 3A	1.000	0	2	2	0	1	0	0
9	Confront S-4779 on dry foliage	0.650	2	1	0	0	0	1	0
9A	Confront S-4779 on wet foliage	0.650	5	1	1	0	0	1	0
10	Confront S-4779 on dry foliage	0.750	4	9	2	0	0	2	1
10A	Confront S-4779 on wet foliage	0.750	1	1	1	0	0	0	1
11	Confront S-4953 on dry foliage	0.750	1	2	1	0	1	2	1
11A	Confront S-4953 on wet foliage	0.750	1	3	1	0	0	1	0
12	Confront S-4953 on dry foliage	1.000	2	7	1	0	0	1	1
12A	Confront S-4953 on wet foliage	1.000	1	4	0	0	0	1	1
13	Confront 3SL - XRM-5085	0.750	0	5	0	0	1	0	0
14	Confront 3SL - XRM-5085	0.380	2	1	1	0	0	2	0
15	Confront + fertilizer (NAF-86) - 0.47 GR	0.820	6	3	1	1	1	0	0
16	Turflon Ester 4EC	1.000	3	0	3	0	0	0	0
17	Turflon Ester 4EC +	1.000							
	2,4-D - 3.8EC	1.000	3	0	0	0	0	0	0
18	Trimec Classic 3.32EC	1.250	0	2	2	0	1	1	1
19	Super Trimec	0.180	0	0	0	0	1	0	0
	$LSD_{0.05}$			NS	NS	NS	NS	NS	11

[1]All herbicide materials applied 5/26/94.
NS = not significantly different at the 0.05 level.

Table 20. The percentage of cover of several broadleaf weed species on July 6, 1994 in Kentucky bluegrass 42 days after application of postemergence herbicides[1].

	Treatment	Rate (# a.i./A)	purslane	prostrate spurge	velvetleaf	redroot pigweed	Pennsylvania smartweed	common lambsquarters
1	Untreated Control	---	0	0	0	1	0	0
2	Buctril 2EC	2.000	1	0	0	1	0	1
3	Vanquish 4EC	0.125	1	0	0	1	0	0
4	Vanquish 4EC	0.250	1	0	0	1	1	0
5	Vanquish 4EC + Garlon 3A	0.125 0.500	1	1	0	1	0	0
6	Vanquish 4EC + Garlon 3A	0.125 1.000	2	2	0	0	0	0
7	Vanquish 4EC + Garlon 3A	0.250 0.500	1	0	0	0	0	0
8	Vanquish 4EC + Garlon 3A	0.250 1.000	3	1	0	0	0	0
9	Confront S-4779 on dry foliage	0.650	0	0	0	0	0	1
9A	Confront S-4779 on wet foliage	0.650	0	0	0	0	1	0
10	Confront S-4779 on dry foliage	0.750	0	0	0	1	0	0
10A	Confront S-4779 on wet foliage	0.750	0	0	0	1	0	0
11	Confront S-4953 on dry foliage	0.750	0	0	0	1	0	1
11A	Confront S-4953 on wet foliage	0.750	1	0	0	1	0	0
12	Confront S-4953 on dry foliage	1.000	0	0	0	0	1	0
12A	Confront S-4953 on wet foliage	1.000	0	1	0	1	0	0
13	Confront 3SL - XRM-5085	0.750	0	1	0	1	1	0
14	Confront 3SL - XRM-5085	0.380	1	0	0	1	0	0
15	Confront + fertilizer (NAF-86) - 0.47 GR	0.820	1	1	0	1	0	0
16	Turflon Ester 4EC	1.000	1	1	0	1	0	0
17	Turflon Ester 4EC + 2,4-D - 3.8EC	1.000 1.000	4	1	0	1	2	0
18	Trimec Classic 3.32EC	1.250	1	0	0	1	0	0
19	Super Trimec	0.180	0	0	0	1	0	0
	$LSD_{0.05}$		NS	NS	NS	NS	NS	NS

[1]All herbicide materials applied 5/26/94.

NS = not significantly different at the 0.05 level.

The Effect of Two Adjuvants on Plant Response to Primo

B. R. Bingaman and N. E. Christians

Primo growth regulator was evaluated for efficiency of uptake when applied in combination with different adjuvants. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was an established Midnight Kentucky bluegrass area. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.3%, a pH of 6.7, 9 ppm P and 86 ppm K. This site was not fertilized this season.

Individual experimental plots were 5 ft x 5 ft and there were 10 treatments. Primo was applied at 3 different rates and at 2 different rates in combination with Turfex and X77. Both adjuvants were applied without Primo and an untreated control also was included.

The study was arranged in a randomized complete block design. Three replications were conducted and 3 ft barrier rows were left between replications.

All treatments were applied on July 22 . Prior to application the experimental site was examined and the turf was found to be quite uniform in color, density, and overall quality. It was sunny with a temperature in the mid 80's and a southerly breeze. The grass foliage was dry.

A backpack carbon dioxide sprayer equipped with 8006 nozzles with a spray pressure of 20-25 psi was used to apply the materials. Liquid treatments were applied with the equivalent of 3 gal water/1000 ft^2.

Rainfall did not occur until July 27 and was sporatic for the duration of this study. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Visual quality and fresh clipping weight data were taken at 7 day intervals on July 29 and August 4. The next set of data (21 days after treatment) were taken on August 16 because of rainfall, subsequent saturated ground and wet foliage. The experimental area was very dry 7 days later and the data collection scheduled for this day was delayed until August 25 so that supplemental irrigation could be used.

Visual quality assessments were based on color, density, and phytotoxicity and recorded using a scale of 9 to 1 (9 = best, 6 = acceptable, and 1 = poorest quality). Mowing height for collecting clippings was 2".

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of the treatments on the visual quality and clipping weights. Least significant difference (LSD) tests were used to compare means among the treatments.

Table 21. The visual quality[1] of Kentucky bluegrass treated with Primo growth regulator in combination with 2 adjuvants[2].

	Treatment	Rate (# a.i./A)	fl oz/ 1000 ft²	Week 1 July 29	Week 2 August 4	Week 3 August 16[3]	Week 4 August 25[4]
1	Untreated Control	---	---	9	8	9	9
2	Primo 1E @ 1.00 X	0.255	0.75	9	7	9	9
3	Primo 1E @ 0.50 X	0.128	0.38	9	7	9	9
4	Primo 1E @ 0.38 X	0.097	0.29	9	7	9	9
5	Primo 1E @ 0.50 X + 0.5% Turfex	0.128	0.38	9	7	9	9
6	Primo 1E @ 0.38 X + 0.5% Turfex	0.097	0.29	9	7	9	9
7	Primo 1E @ 0.50 X + 0.5% X77	0.128	0.38	9	7	9	9
8	Primo 1E @ 0.38 X + 0.5% X77	0.097	0.29	9	7	9	9
9	Turfex 0.5%	---	5.00	9	8	9	9
10	X77 0.5%	---	5.00	9	8	9	9
	$LSD_{0.05}$		---	NS	1	NS	NS

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality

[2]Treatments were applied 7/22/94.

[3]Collection of these data was delayed because of heavy rainfall and saturated conditions.

[4]Collection of these data was delayed because of moisture shortage. The plot was irrigated intensely before data were taken.

NS = not significantly different at the 0.05 level

Table 22. The clipping weights of Kentucky bluegrass treated with Primo growth regulator in combination with 2 adjuvants[1].

	Treatment	Rate (# a.i./A)	fl oz/ 1000 ft²	Week 1 July 29	Week 2 August 4	Week 3 August 16[2]	Week 4 August 25[3]
1	Untreated Control	---	---	340	232	180	129
2	Primo 1E @ 1.00 X	0.255	0.75	294	159	103	116
3	Primo 1E @ 0.50 X	0.128	0.38	325	201	151	133
4	Primo 1E @ 0.38 X	0.097	0.29	304	190	160	136
5	Primo 1E @ 0.50 X + 0.5% Turfex	0.128	0.38	309	165	127	130
6	Primo 1E @ 0.38 X + 0.5% Turfex	0.097	0.29	332	204	164	137
7	Primo 1E @ 0.50 X + 0.5% X77	0.128	0.38	279	167	122	119
8	Primo 1E @ 0.38 X + 0.5% X77	0.097	0.29	316	187	146	132
9	Turfex 0.5%	---	5.00	309	239	194	126
10	X77 0.5%	---	5.00	345	243	201	141
	$LSD_{0.05}$	---	---	NS	43	47	NS

[1]Treatments were applied 7/22/94.

[2]Collection of these data was delayed because of heavy rainfall and saturated conditions.

[3]Collection of these data was delayed because of moisture shortage. The plot was irrigated intensely before data were taken.

[4]Clipping weights expressed as grams fresh weight.

NS = not significantly different at the 0.05 level

Plant Growth Regulators Applied at Low Volumes of Water

B. R. Bingaman and N. E. Christians

Primo growth regulator was evaluated for efficiency of uptake and phytotoxicity when applied with low volumes of water. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was an established Kentucky bluegrass area. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.0%, a pH of 7.05, 8 ppm P, and 67 ppm K. This site was not fertilized for the 1994 growing season.

Individual experimental plots were 5 ft x 5 ft and there were 6 treatments (5 with Primo and 1 untreated control). The study was arranged in a randomized complete block design. Three replications were conducted and there were 3 ft barrier rows between replications.

All treatments were applied on May 27 at 9:00 a.m. to an experimental site that was uniform in color, density, and overall quality. It was mostly sunny with a temperature in the mid 60's and a slight, southerly breeze. The grass foliage was dry. Primo was used at the label rate for Kentucky bluegrass (0.75 ft oz/1000 ft^2) in volumes of water ranging from 40-800 GPA.

A backpack carbon dioxide sprayer equipped with 8006 nozzles with a spray pressure of 20-25 psi was used to apply materials. Uniform application of Primo in 40 GPA of water was quite difficult. When converted to an area of 25 ft^2, the volume was so small that it was not possible to make 1 pass of the sprayer over the entire individual plot. The other volumes were sufficient to make at least 2 passes over the individual plots.

Rainfall did not occur until June 1 and was sporadic for the duration of this study. Turf was irrigated as needed to prevent wilting.

Visual quality and fresh clipping weight data were taken weekly for 6 weeks from 3 June to 8 July. Visual quality assessments were based on color, density, and phytotoxicity and recorded using a scale of 9 to 1 (9 = best, 6 = acceptable, and 1 = poorest quality). Mowing height for collecting clippings was 2 inches.

Data were analyzed with Statistical Analysis System version 6.06 (SAS Institute, 1989) by using Analysis of Variance (ANOVA) to test significance of treatments for visual quality and clipping weights. Least significant difference (LSD) tests were used to compare means among the treatments.

Table 23. Visual quality[1] of Kentucky bluegrass treated with Primo in different volumes of water [2].

Treatment	Week 1 6/3/94	Week 2 6/10/94	Week 3 6/17/94	Week 4 6/24/94	Week 5 7/1/94	Week 6 7/8/94	Overall Quality
1. Control	8	8	7	7	7	8	8
2. Primo + 40 GPA H_2O	8	7	7	7	8	8	7
3. Primo + 80 GPA H_2O	8	8	8	8	8	9	8
4. Primo + 160 GPA H_2O	8	7	8	8	8	8	8
5. Primo + 400 GPA H_2O	7	8	7	7	8	8	8
6. Primo + 800 GPA H_2O	8	8	7	8	8	8	8
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = acceptable quality, and 1 = poorest quality.
[2]This test was started on 5/27/94. Primo growth regulator was applied at the label rate of 0.75 fl oz/1000 ft^2.
NS = not significantly different at the 0.05 level.

Table 24. Clipping weights of Kentucky bluegrass treated with Primo in different volumes of water[1].

Treatment	Week 1 6/3/94	Week 2 6/10/94	Week 3 6/17/94	Week 4 6/24/94	Week 5 7/1/94	Week 6 7/8/94	Total Yield
1. Control	390.6	229.4	156.1	115.2	140.2	159.6	198.5
2. Primo + 40 GPA H_2O	364.8	155.4	132.0	113.9	159.3	198.5	187.3
3. Primo + 80 GPA H_2O	433.2	187.5	147.0	121.0	168.8	217.9	212.6
4. Primo + 160 GPA H_2O	373.0	165.8	136.4	109.9	150.3	203.6	189.8
5. Primo + 400 GPA H_2O	339.2	162.7	132.8	104.4	144.5	191.9	179.2
6. Primo + 800 GPA H_2O	396.8	171.5	149.8	120.3	164.9	188.8	198.7
$LSD_{(0.05)}$	NS	36.8	NS	NS	NS	NS	19.3

[1]This test was started on 5/27/94. Primo growth regulator was applied at the label rate of 0.75 fl oz/1000 ft^2.
NS = not significantly different at the 0.05 level.
Clipping weights expressed as grams fresh weight.

The Effect of Spring Applications of Ethofumesate (Prograss) on a Golf Course Fairway at Indian Creek Country Club in Nevada, Iowa

J. B. Unruh and N. E. Christians

Ethofumesate (Prograss) is marketed as an annual bluegrass *(Poa annua)* control for golf course fairways. It is labeled for use on Kentucky bluegrass *(Poa pratensis)*, perennial ryegrass *(Lolium perenne)*, and creeping bentgrass *(Agrostis palustris)* maintained at fairway mowing heights.

Prior research on the efficacy of spring applications of ethofumesate following fall application showed ethofumesate to be effective at controlling annual bluegrass in creeping bentgrass and perennial ryegrass and spring application was subsequently added to the Prograss label in 1992. A single spring application, not preceded by fall applications, has been ineffective. Because of the sensitivity of Kentucky bluegrass to ethofumesate, more information on effective rates needs to be obtained. The objective of this study was to assess annual bluegrass control from spring applications of ethofumesate that followed three fall applications of 0.75 lb ai/acre each.

The experiment was initiated on September 16, 1994. The West half of a North - South oriented Kentucky bluegrass--Perennial Ryegrass fairway at Indian Creek Country Club in Nevada, Iowa was treated with 0.75 lb ai/acre on September 16, October 14, and November 10. Spring treatments were applied on April 28, 1995 as indicated in Table 25. Spring treatments were arranged as a randomized complete block study with 3 replications. Plots measured 180 ft. by 10 ft. Estimates of percent annual bluegrass were taken on May 18, 1995 (Table 25).

The initial population of annual bluegrass was estimated to be 75% on the untreated (East) half of the fairway. The fall application of ethofumesate alone resulted in a reduction of annual bluegrass to 38% in the area of the fairway that had received 3 fall applications but no spring application (control), a nearly 50% reduction of annual bluegrass. Spring applications of 0.25 and 0.5 lb ai/A numerically reduced annual bluegrass infestation to 22%, although this reduction was not statistically significant. The 0.75 lb ai/A Prograss spring treatment reduced annual bluegrass to 5% of the total stand, a 93% reduction from the untreated section of the fairway.

We observed no damage to the Kentucky bluegrass or to the Perennial Ryegrass at any time during the study.

Table 25. The effect of spring applications of Ethofumesate (Prograss) on a golf course fairway following 3 applications in the fall.

Treatment	lb ai / acre	% *Poa annua*
Control	0	38
Prograss EC	0.25	22
Prograss EC	0.5	22
Prograss EC	0.75	5
$LSD_{0.05}$	---	17

Turfgrass Disease and Insect Research

Evaluation of Fungicides for Control of Snow Molds on Creeping Bentgrass at Nashua, IA - 1994-1995

M. L. Gleason

The trial was conducted on a bentgrass green (cv. unknown) at the Nashua Town and Country Club Golf Course, Nashua, IA. This green has a high thatch content, is subject to drifting snow, and has had severe outbreaks of snow mold in most of the last 10 years. The experimental design was a randomized complete block with 4 replications. All plots measured 4 ft x 5 ft. Fungicides were applied on November 14, 1994, using a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1000 ft^2.

Snow cover persisted from about December 8, 1994, until March 13, 1995. On March 15, symptoms of gray snow mold were evident on the part of the green where snow cover persisted longest. Snow mold development on untreated check plots was moderate, with an average of about 10% of the plot area symptomatic (Table 1). About half of the fungicide treatments gave significantly better control of snow mold than the untreated check. Several treatments were completely free of symptoms, including Thalonil 90 DF at 4.75 oz + Chipco 26019 50 WDG at 2 oz/1000 ft^2, Chipco at 2 oz + Daconil Ultrex 82.5 WDG at 5 oz, EXP 10452 50 WG at 4 oz + Daconil Ultrex at 5 oz, Sentinel at 0.33 oz, Sentinel at 0.33 oz + Chipco at 2 oz, FF2 at 16 oz a.i., Banner 1.1 EC at 3 oz + CGA 173 at 0.5 oz, and Curalan DF at 4 oz + Daconil 2787 at 8 oz. No phytotoxicity symptoms were observed.

Table 26. Snow Mold Trials, 1994-95, Nashua Town and Country Club, Nashua, Iowa.

Company	Products	Rate/1000 ft^2	Disease rating[1]
	Check	---	1.75 abc[2]
Terra	Thalonil 90DF	4.75 oz	0.00 e
	+ Chipco 26019 50WDG	2.0 oz	
	Thalonil 4L	8.0 oz	0.50 cde
	+ Chipco 26019 50WDG	2.0 oz	
Cleary	Defend 2F	24 fl oz	0.25 de
	3336 50 WP	2.0 oz	1.25 abcde
	+ Spotrete 75 WDG	6.0 oz	
	Spotrete 75 WDG	8.0 oz	0.5 cde
	+ Clearspray	2.0 fl oz	
	Spotrete 75 WDG	8.0 oz	1.75 abc
Rhone-Poulenc	Chipco 26019 50 WDG	4.0 oz	0.25 de
	+ Daconil 2787 4.17SC	8.0 oz	
	Chipco 26019 50 WDG	4.0 oz	0.25 de
	+ Daconil Ultrex 82.5WDG	5.0 oz	
	Chipco 26019 50 WDG	2.0 oz	0.00 e
	+ Daconil Ultrex 82.5WDG	5.0 oz	
	Chipco 27019 50 WDG	2.0 oz	0.50 cde
	+ PCNB 75WP	2.7 oz	
	EXP 10452 50WG	4.0 oz	0.00 e
	+ Daconil Ultrex 82.5WDG	5.0 oz	
	Chipco 26019 50 WDG	4.0 oz	2.25 a
	Chipco 26019 50 WDG	4.0 oz	1.5 abcd
	+ Cleary's 3336 50WP	4.0 oz	
	EXP 10452 50WG	4.0 oz	0.25 de
Sandoz	Sentinel	0.33 oz	0.25 de
	+ PCNB 75WP	4.0 oz	
	Sentinel	0.33 oz	0.00 e

Company	Products	Rate/1000 ft^2	Disease rating[1]
Sandoz	Sentinel + Chipco 26019 WDG	0.33 oz 2.0 oz	0.00 e
O.M. Scott	S-4902	8 oz ai	0.75 bcde
	S-4902	16 oz ai	0.00 e
	FF2	8 oz ai	0.25 de
Ciba	Banner 1.1 EC + PCNB 75 WP	3.0 oz 4.0 oz	1.25 abcde
	Banner 1.1 EC + CGA 173	3.0 oz 0.5 oz	0.00 e
BASF	Curalan DF	4.0 oz	1.25 abcde
	Curalan DF + Daconil 2787	4.0 oz 8.0 oz	0.00 e

[1]0=no disease, 1=<5% plot area diseased, 2=5-15%, 3=15-30%, 4=30-50%, 5=>50%
[2] means of 4 replications. Means followed by the same letter are not significantly different (DMRT, P=0.05)

Evaluation of Fungicides for Control of Pink and Gray Snow Mold at the ISU Horticulture Farm, Gilbert, IA - 1994-1995

M. L. Gleason

Separate trials for pink snow mold (pathogen: Microdochium nivale) and gray snow mold (Typhula incarnata) were conducted on a 'Penncross' creeping bentgrass green at the Iowa State University Horticulture Farm's turfgrass research area near Gilbert, IA. In order to help insure disease activity, the test plots were inoculated with the target pathogens and covered with straw and shade cloth to simulate snow cover according to the protocol of Schumann (Fungicide and Nematicide Tests 46:304, 1991). The experimental design was a randomized complete block with 4 replications. All plots measured 3 ft x 5 ft. Approximately 75 g of inoculum (a combination of infested rye grain and dried fragments of colonized agar) per 15 ft^2 plot was spread on the plots on November 7, 1994. The pink snow mold plot received only inoculum infested with the pink snow mold pathogen, and the gray snow mold plot received only inoculum infested with the gray snow mold pathogen. Fungicides were applied on November 8, 1994, using a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1000 ft^2. On November 11, 1994, the plots were covered with a 6" layer of oat straw, then a layer of shade cloth (55% shade) was placed over the straw and secured to the turf with metal staples.

Snow cover persisted from about December 9, 1994, until March 1, 1995. When the shade cloth and straw were removed on March 14, 1995, symptoms of gray snow mold were evident on the gray snow mold plot and symptoms of pink snow mold were evident on the pink snow mold plot. However, the symptoms were atypical in that patches of affected grass were not bleached to as light a tan color as patches located outside the covered areas. Snow mold development on untreated check plots was moderate, with an average of about 20% of the area symptomatic in both the gray and pink snow mold plots. All of the pink snow mold and gray snow mold treatments gave significantly better control than the untreated check, and many were completely symptom-free. No phytotoxicity symptoms were observed.

These trials indicated the feasibility of the method of Schumann (inoculation plus covering) for conducting pink and gray snow mold trials in central Iowa.

Table 27. Pink Snow Mold Trials, 1994-1995.

Company	Products	Rate/1000 ft^2	Disease rating[1]
	Check	---	3.25 a[2]
Terra	Thalonil 90DF + Chipco 26019 50WDG	4.75 oz 2.0 oz	0.25 bc
	Thalonil 4L + Chipco 26019 50WDG	8.0 oz 2.0 oz	0.00 c
Cleary	Defend 2F	24 fl oz	0.50 bc
	3336 50 WP + Spotrete 75 WDG	2.0 oz 6.0 oz	0.75 bc
	Spotrete 75 WDG + Clearspray	8.0 oz 2.0 fl oz	0.25 bc
	Spotrete 75 WDG	8.0 oz	0.75 bc
Rhone-Poulenc	Chipco 26019 50 WDG + Daconil 2787 4.17SC	4.0 oz 8.0 oz	0.75 bc
	Chipco 26019 50 WDG + Daconil Ultrex 82.5WDG	4.0 oz 5.0 oz	0.00 c

Company	Products	Rate/1000 ft²	Disease rating[1]
Rhone-Poulenc	Chipco 26019 50 WDG + Daconil Ultrex 82.5WDG	2.0 oz 5.0 oz	0.25 bc
	Chipco 27019 50 WDG + PCNB 75WP	2.0 oz 2.7 oz	0.00 c
	EXP 10452 50WG + Daconil Ultrex 82.5WDG	4.0 oz 5.0 oz	0.00 c
	Chipco 26019 50 WDG	4.0 oz	0.25 bc
	Chipco 26019 50 WDG + Cleary's 3336 50WP	4.0 oz 4.0 oz	0.00 c
	EXP 10452 50WG	4.0 oz	0.00 c
Sandoz	Sentinel + PCNB 75WP	0.33 oz 4.0 oz	0.00 c
	Sentinel	0.33 oz	0.00 c
	Sentinel + Chipco 26019 WDG	0.33 oz 2.0 oz	0.25 bc
O.M. Scott	S-4902	8 oz ai	0.25 bc
	S-4902	16 oz ai	0.00 c
Ciba	Banner 1.1 EC + PCNB 75 WP	3.0 oz 4.0 oz	0.00 c
	Banner 1.1 EC + CGA 173	3.0 oz 0.5 oz	0.00 c
BASF	Curalan DF	4.0 oz	0.25 bc
	Curalan DF + Daconil 2787	4.0 oz 8.0 oz	0.25 bc

[1]0=no disease, 1=<5% plot area diseased, 2=5-15%, 3=15-30%, 4=30-50%, 5=>50%
[2] means of 4 replications. Means followed by the same letter are not significantly different (DMRT, P=0.05)

Table 28. Gray Snow Mold Trials, 1994-1995.

Company	Products	Rate/1000 ft²	Disease rating[1]
	Check	---	3.00 a[2]
Terra	Thalonil 90DF + Chipco 26019 50WDG	4.75 oz 2.0 oz	1.00 b
	Thalonil 4L + Chipco 26019 50WDG	8.0 oz 2.0 oz	0.00 b
Cleary	Defend 2F	24 fl oz	1.25 b
	3336 50 WP + Spotrete 75 WDG	2.0 oz 6.0 oz	0.50 b
	Spotrete 75 WDG + Clearspray	8.0 oz 2.0 fl oz	0.00 b
	Spotrete 75 WDG	8.0 oz	0.50 b
Rhone-Poulenc	Chipco 26019 50 WDG + Daconil 2787 4.17SC	4.0 oz 8.0 oz	0.25 b
	Chipco 26019 50 WDG + Daconil Ultrex 82.5WDG	4.0 oz 5.0 oz	0.75 b
	Chipco 26019 50 WDG + Daconil Ultrex 82.5WDG	2.0 oz 5.0 oz	0.50 b
	Chipco 27019 50 WDG + PCNB 75WP	2.0 oz 2.7 oz	0.00 b

Company	Products	Rate/1000 ft^2	Disease rating[1]
Rhone-Poulenc	EXP 10452 50WG + Daconil Ultrex 82.5WDG	4.0 oz 5.0 oz	0.00 b
	Chipco 26019 50 WDG	4.0 oz	0.00 b
	Chipco 26019 50 WDG + Cleary's 3336 50WP	4.0 oz 4.0 oz	0.25 b
	EXP 10452 50WG	4.0 oz	0.00 b
Sandoz	Sentinel + PCNB 75WP	0.33 oz 4.0 oz	0.25 b
	Sentinel	0.33 oz	1.00 b
	Sentinel + Chipco 26019 WDG	0.33 oz 2.0 oz	0.25 b
O.M. Scott	S-4902	8 oz ai	0.25 b
	S-4902	16 oz ai	0.00 b
Ciba	Banner 1.1 EC + PCNB 75 WP	3.0 oz 4.0 oz	0.00 b
	Banner 1.1 EC + CGA 173	3.0 oz 0.5 oz	0.00 b
BASF	Curalan DF	4.0 oz	1.00 b
	Curalan DF + Daconil 2787	4.0 oz 8.0 oz	0.00 b

[1]0=no disease, 1=<5% plot area diseased, 2=5-15%, 3=15-30%, 4=30-50%, 5=>50%

[2] means of 4 replications. Means followed by the same letter are not significantly different (DMRT, P=0.05).

Evaluation of Fungicides for Control of Brown Patch in Creeping Bentgrass - 1994

M. L. Gleason

Trials were conducted at Veenker Golf Course on the campus of Iowa State University, Ames, IA. Fungicides were applied to creeping bentgrass maintained at 5/32-inch cutting height, using a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1000 ft^2. The experimental design was a randomized complete block with three replications. All plots measured 4 ft x 5 ft. All plots were surrounded by 1-ft-wide strips of untreated turf in order to help create uniform disease pressure.

Fungicide applications began on June 9 and were repeated at recommended intervals on June 16, 23, 30, and July 7, 14, and 21.

June and July 1994 were approximately normal in rainfall and temperature, but mid-July was somewhat cooler and drier than average. Disease development on the untreated check plots was moderate to severe on all rating dates.

Most formulations suppressed disease significantly on each rating date. Several treatments provided excellent control on all rating dates; two treatments, 1) Thalonil 4 L at 6.0 oz and 7-day interval, 2) EXP 10452A at 2.0 oz and 14 days, showed no disease on any rating date. Treatments that exhibited an enhanced gree color on one or more rating dates included: Sentinel 40 WG at 28-day interval; Eagle 40 W; EXP 10452A at both rates; and Banner plus ProStar at 1- and 2-oz rates, respectively, and a 28-day interval. No phytotoxicity symptoms were observed.

PCNB 75 W formulations at the 4-oz rate and 7-day intervals caused moderately severe yellowing and browning of the turf in July and August. Sentinel 40 WG caused a slightly enhanced green color of the turf by early August.

Table 29. 1994 Fungicide Trial for Brown Patch.

Company	Product	Rate/1000 ft²	Interval (days)	Disease Rating[a]		
				June 23	July 7	July 21
	Check	---	---	2.50 b-c	2.50 a-c	3.00 ab
Miles	Lynx 25DF	1.0 oz	21	0.00 f	0.25 gh	0.00 f
	Bayleton 25DF	2.0 oz, 1.oz[b]	21	2.75 a-c	1.75 b-f	0.50 ef
	Bayleton 25DF + Prostar 50 WP	1.0 oz 2.0 oz	21	0.00 f	0.00 h	0.25 f
Sandoz	Sentinel 40WG	0.25 oz	28	0.00 f	0.25 gh	0.25 f
	Sentinel 40WG	0.25 oz	42	0.00 f	0.50 f-h	2.00 a-d
Rhone-Poulenc	Chipco 26019 WDG	2.0 oz	14	0.00 f	0.50 f-h	0.75 d-f
	EXP10452A	2.0 oz	14	0.00 f	0.00 h	0.00 f
	EXP10452A	1.5 oz	14	0.00 f	0.00 h	0.50 ef
	Chipco Aliette WDG + Fore 80 WP	4.0 oz 8.0 oz	14	0.75 f	1.00 d-h	1.75 b-d
	Chipco Aliette WDG + Fore 80 WP	2.0 oz 4.0 oz	14	0.75 f	1.75 b-f	0.75 d-f
	Chipco Aliette WDG	8.0 oz	14	3.50 a	3.25 a	3.25 a
	Fore 80 WP	8.0 oz	14	1.00 ef	1.50 b-g	0.00 f
	EXP 10361 A	6.0 oz	14	0.00 f	1.00 d-h	1.50 c-f
ISK Biotech	Daconil 2787 F	6.0 oz	14	2.00 dc	2.25 a-d	1.50 c-f
	Daconil 825 SDG	3.8 oz	14	0.50 f	1.00 d-g	.025 f
	Fluazinam 500 F	1.0 oz	21	0.25 f	0.75 e-h	1.25 c-f
	ASC-67098-Z	3.6 oz	21	0.00 f	0.75 e-h	2.50 a-c
	Fluazinam 75 SDG	0.67 oz	21	0.00 f	0.50 f-h	1.25 c-f
Rohm & Haas	Eagle 40 W	0.6 oz	14	0.25 f	0.50 f-h	0.00 f
	Fore FL	6.4 oz	14	1.75 de	2.25 a-d	1.25 c-f
AgrEvo	ProStar 50 WP (NA 211)	3.0 oz	21	0.25 f	0.25 gh	0.00 f
	ProStar 50 WP + Daconil 2787 F	1.0 oz 8.0 oz	21	0.00 f	0.00 h	1.50 c-f
O.M. Scott	S 4404	2.236 g	14	1.00 ef	1.25 c-g	0.50 ef
	S 4404	2.236 g	21	1.00 ef	0.50 f-h	2.00 a-d
BASF	Curalan DF	2.0 oz	14	3.00 ab	2.75 ab	1.25 c-f

Company	Product	Rate/1000 ft²	Interval (days)	Disease Rating[a]		
				June 23	July 7	July 21
Terra	Thalonil 90 DF	3.5 oz	7	0.00 f	0.00 h	0.75 d-f
	Thalonil 90 DF	3.5 oz	14	0.00 f	0.25 gh	0.00 f
	Thalonil 4L	6.0 oz	7	0.00 f	0.00 h	0.00 f
	Thalonil 4L	6.0 oz	14	0.50 f	0.25 gh	0.50 ef
Ciba	Banner 1.1 E	1.0 oz	14	0.50 f	1.00 d-h	0.75 d-f
	Banner 1.1 E + Daconil 2787	1.0 oz 4.0 oz	21	0.00 f	0.50 f-h	1.75 b-d
	Banner 1.1 E + Daconil 2787	1.0 oz 4.0 oz	28	0.50 f	2.25 a-d	0.25 f
	Banner 1.1 E + ProStar 50 WP	1.0 oz 2.0 oz	21	0.00 f	0.25 gh	0.00 f
	Banner 1.1 E + ProStar 50 WP	1.0 oz 2.0 oz	28	0.00 f	2.00 b-d	0.00 f

[a]Means of replications. 0 = no disease; 1 = 1-10% of plot showing symptons; 2 = 11-25%; 3 = 26-50%; 4 = >50% of plot. Means followed by the same letter are not signifcantly different (DMRT, $p = 0.05$).

[b]First application was at 2.0 oz rate, subsequent applications were at 1.0 oz rate.

Evaluation of Fungicides for Control of Dollar Spot in 'Penncross' Bentgrass - 1994

M. L. Gleason

Trials were conducted at the Turfgrass Research Area of Iowa State University's Horticulture Research Farm, Gilbert, IA. Fungicides were applied to Penncross creeping bentgrass maintained at 5/32-inch cutting height, using a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1000 ft^2. The experimental design was a randomized complete block with four replications. All plots measured 4 ft x 5 ft.

After inoculation of the entire plot with pathogen-infested rye grain, spray applications began on June 7. Subsequent applications were made at specified intervals on June 14, 21, 28, and July 5, 12, and 19.

Dollar spot symptoms appeared in the plot during the week of June 19 (Table 30). Disease development was moderately severe during late June through early July, but subsided in late July as relatively dry, cool weather became prevalent. Almost all treatments gave significant (P=0.05) disease suppression in comparison to the untreated check. Exceptions were Rubigan 50 W at 0.25 oz, applied curatively at a 14-day interval (until late July, when this treatment became effective), and Chipco 26019 WDG at 1.5 oz and a 14-day schedule on June 25. S 6044 gave the plots an enhanced green color on July 5 and 21.

Table 30. 1994 Fungicide trial for Dollar spot.

				Number of Infection centers[a]		
Company	Product	Rate/1000 ft^2	Interval (days)	June 25	July 5	July 21
	Check	---	---	70 ab	113 a	116 a
Terra	Thalonil 90 DF	3.5 oz	7	0 f	0 i	0 d
	Thalonil 90 DF	3.5 oz	14	36 c-e	30 c-i	0 d
	Thalonil 4L	6.0 oz	7	0 f	0 i	0 d
	Thalonil 4L	6.0 oz	14	24 c-f	43 c-f	0 d
Ciba	Banner 1.1 E	1.0 oz	14	1 f	0 i	0 d
	Banner 1.1 E + Daconil 2787	0.5 oz 4.0 oz	21	2 f	2 hi	0 d
	Banner 1.1 E + Daconil 2787	1.0 oz 4.0 oz	28	0 f	34 c-i	0 dj
	Banner 1.1 E + ProStar 50 WP	0.5 oz 2.0 oz	21	21 c-f	27 f-i	2 d
	Banner 1.1 E + ProStar 50 WP	1.0 oz 2.0 oz	28	0 f	44 c-f	0 d
Miles	Lynz 25DF	0.75 oz	28	8 ef	56 b-d	2 d
	Bayleton 25DF	1.0 oz	28	19 c-f	79 b	3 d
Sandoz	Sentinel 40WG	0.25 oz	28	1 f	24 d-i	1 d
	Sentinel 40WG	0.25 oz	42	1 f	22 d-i	25 cj
Rhone-Poulenc	EXP 10452A	0.5 oz	14	13 d-f	12 f-i	0 d
	EXP 10452A	0.75 oz	14	9 ef	2 hi	0 d
	Chipco 26019 WDG	1.5 oz	14	47 bc	59 bc	5 d
	Chipco 26019 WDG	2.0 oz	14	27 c-f	33 c-i	0 d
Dow-Elanco	Rubigan 50W	0.25 oz	14	37 c-e	23 e-i	0 d
	Rubigan 50W	0.25 oz	21	35 c-e	5 g-i	0 d
	Rubigan 50W	0.25 oz	14[b]	90 a	85 ab	8 cd
	ASC67098	4.0 oz	21	11.0 ab	12.3 fg	91.0 cde
Rohm & Haas	Eagle 40W	0.6 oz	28	1 f	39 c-g	0 d
BASF	Curalan DF	2.0 oz	28	7 ef	45 c-f	2 d

Company	Product	Rate/1000 ft^2	Interval (days)	Number of Infection centers[a]		
				June 25	July 5	July 21
AgrEvo	Flutolanil 70WP + Bayleton 25DF	1.43 oz 1.0 oz	14	5 ef	6 g-i	0 d
	Flutolanil 70WP + Daconil 2787F	1.43 oz 6:0 oz	14	22 c-f	47 c-e	1 d
O.M. Scott	S 4404	1,118 g	14	10 d-f	18 c-i	0 d
	S 4404	2,236 g	14	2 f	0 i	0 d
	S 6044	638 g	14	41 cd	36 c-h	46 b

[a]Means of replications. Means followed by the same letter are not significantly different (DMRT, $P = 0.05$).
[b]Treatments were stated when symptoms appeared (week of June 14).

Evaluation of Fungicides for Control of Leaf Spot in 'Park' Bluegrass - 1994

M. L. Gleason

Trials were conducted at the Turfgrass Research Area of Iowa State University's Horticulture Research Farm, Gilbert, IA. Fungicides were applied to 'Park' Kentucky bluegrass maintained at 2 ½-inch cutting height, using a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1000 ft^2. The experimental design was a randomized complete block with four replications. All plots measured 4 ft x 5 ft. To stimulate disease development, the plot was irrigated for 15 min at 2 am, five nights per week, from June 7 through mid-July.

Fungicide applications began on June 7 and continued at recommended intervals on June 21, July 5 and 19, and Aug 2.

Disease development was very light during the test period. Although results indicated statistically significant differences in disease control, interpretation of these differences is questionable due to the lack of substantial disease pressure.

Table 31. 1994 Fungicide Trial for Leaf Spot.

Company	Product	Rate/1000 ft^2	Interval (days)	Disease Rating[a]		
				July 5	July 21	August 19
	Check	---	---	1.25 a	1.88 ab	2.13 a
BASF	Curalan DF	2.0 oz	28	1.00 a	1.38 bc	1.38 abc
Rhone-Poulenc	Chipco 26019 WDG	2.0 oz	28	1.13 a	1.25 bc	1.13 bc
ISK Biotech	Daconil 2787F	6.0 oz	14	0.50 ab	1.13 bc	0.50 c
	Daconil 825 SDG	3.8 oz	14	0.00 b	1.00 c	0.50 c
	ASC-67098-Z	3.6 oz	14	0.50 ab	1.00 c	0.75 bc
	ASC-67098-X	2.5 oz	14	0.75 a	1.13 bc	0.50 c
	Fluzinam 500 F	1.0 oz	14	0.75 a	2.13 ab	1.63 ab

[a]Means of 4 replications. 0 = no disease; 1 = trace of disease; 2 = light disease development; 3 = moderate; 4 = severe disease development. Means followed by the same letter are not significantly different (DMRT, $P = 0.05$).

Percolation Depth and Persistence of Bacillus thuringiensis japonensis in Soil under Various Application and Irrigation Regimes

T. Michaels

Bacillus thuringiensis japonensis (Btj) is a strain of Bt bacterium discovered in Japan in 1991 that is lethal to white grubs. Btj must be eaten by a grub to be toxic. Btj will control larvae of the Japanese beetle Popillia japonica, masked chafers Cyclocephala spp., and the green June beetle, Cotinis spp. It will be a bioinsecticide product named M-PressTM by 1998. This study was funded by Mycogen Corporation, San Diego, CA and is part of commercial development efforts to optimize M-PressTM.

The purpose of this study was to determine how three application volumes of 465, 930, and 1860 liters/hectare (corresponding to 50, 100, and 200 gallons/acre) and three immediate post-treatment irrigation volumes of 0, 1, and 2 cm would affect the percolation depth of M-PressTM. The study was performed on the USGA bentgrass green at the ISU Horticulture Farm which has soil of approximately 80% sand, 10% peat and 10% native loam. The intent was to gather information on which spray volume and irrigation regimin with a fixed number of Btj spores (2.5 x 108 spores per cm) would deliver the most bioinsecticide to the depth of 0-5 cm where white grubs feed. Treatments were set up in a randomized complete block design with four replicates. Two randomly assigned soil cores samples were taken to a depth of 11 cm from each 122 x 88-cm treatment plot. The cores were sectioned at increments of 0-1 cm (thatch), 1-3 cm, 3-5 cm, 5-7 cm, 7-9 cm, and 9-11 cm, pooled, and placed in a sterile whirlpac bag and frozen at 4 degrees Celsius until analysis. The treatments were sampled on day 0, 1, 2 , 4, 6, 14, 30, and 60 for the purposes of determining the persistence of the bioinsecticide. No rain or irrigation was applied to the site until after day 6 of the study. The soil samples were plated on selective microbiological medium to quantify the number of colony forming units (CFU's) per gram of soil. Also, a dot-blot immunoassay system is being developed to monitor the persistence of the Btj toxin in the soil.

The data collection and analysis are not yet completed, and spore counts in soil can be highly variable. Preliminary results of three replicates from day 6 are presented below. The one and two-cm post-treatment irrigation (PTI) delivered a greater number of spores to the 1-3 cm and 9-11 cm depths than zero cm post-treatment irrigation. Depth 9-11 cm had fewer spores recovered for each treatment than the 1-3 cm depth.

Table 32. AVERAGE CFU'Sa/GRAM SOIL (X 1,000); DAY 6, Three Blocks

Treatment		Depth of Soil Sample	
GPAb	PTIc(cm)	1-3 cm	9-11 cm
50	0	1,440	77
50	1	25,300	4,860
50	2	16,166	3,010
100	0	6,343	253
100	1	21,933	151
100	2	18,766	13,310
200	0	8,463	203
200	1	19,733	1,090
200	2	29,420	3,103

aCFU- colony forming units; bGPA-gallons per acre (spray volume); cPTI-post-treatment irrigation

Preliminary interpretation of the results show post-treatment irrigation to have more influence on the final distribution of the spores in the soil than the initial application volume. Both post-treatment irrigation regimens delivered more spores than zero post-treatment irrigation to the 1-3 cm depth where grubs would likely feed.

Pythium Root Diseases and Disease Complexes of Creeping Bentgrass

C. F. Hodges and D. A. Campbell

The research literature and general textbooks on diseases of turfgrasses have made little distinction between the pathogenicity of *Pythium* on primary roots (seedling roots) and on adventitious roots (roots from nodes that support the plant for most of its life) of creeping bentgrass. Most studies have been conducted on primary roots and it has seemingly been assumed that the lesions and rotting of primary roots also occur on adventitious roots. The few studies that have evaluated pathogenicity of *Pythium* species to adventitious roots of creeping bentgrass do not show the development of lesions and/or rotting. The isolation of *Pythium* from brown and/or rotted roots has contributed to the assumption that these symptoms of adventitious roots are due to *Pythium* infection. There is growing evidence, however, that *Pythium* is not an efficient rotter of adventitious roots and that their presence in rotted roots may be the result of their association with other organisms in a disease complex. Studies involving controlled inoculations of adventitious roots in my laboratory and those of other researchers suggest that there are two relatively distinct ways in which *Pythium* species attack adventitious roots of creeping bentgrass. One form of attack is characterized by *Pythium*-induced root dysfunction and occurs during the establishment of creeping bentgrass on high-sand content greens as young adventitious roots develop from nodal regions of the shoot. The second form of attack occurs in mature stands (3 years old or older) of creeping bentgrass turf in which the *Pythium* species may function in a complex with other weak root-infecting pathogens that can result in browning and/or rotting of infected roots.

Pythium-Induced Root Dysfunction

Pythium-induced root dysfunction occurs primarily on old golf courses where greens have been reconstructed with high-sand content mixes, and to a lesser extent on newly constructed high-sand content golf greens. Creeping bentgrass established on renovated greens in late summer or fall is successfully established and grows well during the mild periods of the following spring and early summer. With the arrival of hot, humid weather, the turf shows chlorotic or wilted patches that die in a random pattern without evidence of foliar pathogens. Examination of the root system reveals what appears to be healthy white roots that are shorter than normal. No lesions or rot are present on the roots. When such roots are incubated under laboratory conditions, *Pythium arrhenomanes* or *P. aristosporum* grow from the root tips, and cortical cells within 6 to 12 h. Large areas of infected greens can be killed within two weeks and cultural and chemical control methods have not proven effective for this disorder. The primary characteristic of this disease is that it occurs the first growing season following establishment of the turf. The disease may reoccur the next year, but with much reduced severity. By the third year the disease is usually no longer present. If symptoms typical of root dysfunction occur on a green for the first time two or more years after establishment, the symptoms are due to a disease other than *Pythium*-induced root dysfunction.

Inoculation of young, developing adventitious roots of creeping bentgrass with *P. arrhenomanes* or *P. aristosporum* decreases total weight of plants to 16 and 32% of healthy plants, respectively. Examination of roots 3 to 4 weeks after inoculation reveal *Pythium* hyphae in root hairs and in somewhat swollen regions behind root tips. It seems that root hairs and root tips provide the primary sites for infection. Roots examined 10 weeks after inoculation show extensive infection of the cortex. Some root tips are devitalized and the roots may be slightly tan-colored compared to healthy roots, but there are no visible lesions or rot. With time, the roots deteriorate (due to age and infection) and hyphae will then penetrate the vascular cylinder.

Pythium Root Infection in Mature Stands of Creeping Bentgrass

For the purposes of this presentation, a mature stand of creeping bentgrass is one that is at least three years old and is supported exclusively by adventitious roots. *Pythium* species are commonly found in soils supporting mature stands of turfgrass and they are often associated with both healthy and diseased adventitious roots. The fact that *Pythium* species are commonly isolated from turf soils and from diseased crowns and roots showing browning and/or rotting does not establish that they are responsible for the problems observed. Healthy plants must be reinoculated, and the disease reproduced before responsibility can be established. When diseased roots of any turfgrass species are examined and cultured in a laboratory the presence of any *Pythium* species is known very quickly because they will appear on the culture plates long before any other fungal pathogen. This characteristic of *Pythium* species can result in a hastily arrived at conclusion that the *Pythium* isolate is responsible for the disease in question. It has been our experience, that if these same cultures are observed for a longer period of time the diseased roots usually yield other minor root pathogens. The question of assigning responsibility for the disease then becomes very complex.

The question of the pathogenicity of *Pythium* species to adventitious roots of older stands of creeping bentgrass remains unclear. Over the last several years, numerous species of *Pythium* have been collected from the brown and/or rotted adventitious roots of mature stands of creeping bentgrass displaying symptoms of wilt, chlorosis, nondescript thinning, and irregular patches of dead turf. Many of the isolates are not capable of infecting healthy roots. Of the isolates that infected adventitious roots, six reduced plant dry weight 42 to 81% of healthy plants only at high temperatures (95°F day/75°F night), three reduced weight 49% to 75% only at low temperatures (75°F day/55°F night), and seven reduced weight at both high and low temperatures (high temperatures 67 to 84%, low temperatures 35 to 60%).

In all our observations, *Pythium* species behave as minor root pathogens with infection restricted to root tips and hairs, and cortical tissues without penetration of the vascular cylinder. Roots are typically shortened and are white to light tan. The symptoms produced in controlled studies are relatively mild and have not resulted in the death of any plants. However, the more severe reduction in growth (30 to 40 percentile range of healthy plants) caused by some isolates could feasibility result in substantial damage or death of plants under the stress of field conditions. Conversely, those isolates that result in mild reductions in growth (70 to 80 percentile range of healthy plants) might have no effect or result in turf with low vigor and/or thinning when subjected to field stress, but they may not be responsible for direct killing of turf.

Pythium and Disease Complexes of Adventitious Roots of Creeping Bentgrass

Pythium species isolated from diseased adventitious roots of mature stands of creeping bentgrass are commonly associated with other minor root pathogens. In controlled studies, inoculation of adventitious roots of creeping bentgrass results in a decrease in total weight of the plant and some degree of root tanning, but it does not result in the severe root rot or plant death that is sometimes observed in the field. This suggests that the *Pythium* species isolated from severely diseased adventitious roots of mature stands of creeping bentgrass in the field may not be the sole cause of the disease. None of our observations to date provide evidence that *Pythium* species are major pathogens (capable of producing all field symptoms independently) of adventitious roots of mature stands of creeping bentgrass. If these observations are representative, then it is probable that the *Pythium* species associated with severe rot of adventitious roots are functioning as part of a root disease complex involving other minor root pathogens.

Two groups of fungal organisms have been found associated with *Pythium*-infected roots. The first group includes species of *Curvularia, Fusarium, Bipolaris, Drechslera,* and *Rhizoctonia*, all of which are typically found with *Pythium* in the upper 2 cm of the sand. Most of these organisms seem associated with the nodal regions of the stolons and extend into the upper part of the root system. The second group of fungal organisms includes *Acremonium (Cephalosporium), Microdochium (Idriela), Polymyxa*, and genera that typically produce ectotrophic hyphae. These various associations are most common on adventitious roots collected from high-sand content greens. Preliminary (unpublished) adventitious root inoculation studies with *C. lunata, C. geniculata, M. bolleyi, and Acremonium* species reveal that most will infect the roots and that they, like the *Pythium* species, behave like minor pathogens in that they colonize root tips, root hairs, and cortical tissue. Like the *Pythium* species, these organisms reduce the dry weight of the infected plants, but also fail to kill plants in controlled studies. *Curvularia lunata* and *C. geniculata* reduce the dry weight of creeping bentgrass in a range of 48 to 76% and 42 to 79% of healthy plants, respectively. Isolates of *M. bolleyi* and *Acremonium* sp. reduce the weight in a range of 56 to 93% and 59 to 95% of healthy plants, respectively. It is probable that one or more of these organisms in combination with *Pythium* could produce a disease complex that results in brown and/or rotted adventitious roots.

Fertilizer Trials and Soil Studies

Kentucky Bluegrass Response to Fertilizers - 1994

B. R. Bingaman and N. E. Christians

Fertilizer formulations supplied by Lesco were tested with Sustane, Sustane + iron, Pursell Polyon, Lesco Poly +, Toro Nuture, and Scott's Poly-S for effects on Kentucky bluegrass growth and quality (Table 1). This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot of 'Park' Kentucky bluegrass was maintained at a 2" mowing height. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.0%, a pH of 7.05, 8 ppm P, and 67 ppm K. This site was not fertilized prior to the beginning of this test.

Individual experimental plots were 5 x 5 ft and there were 10 treatments including an untreated control . The study was arranged in a randomized complete block design. Three replications were conducted and there were 3 ft barrier rows between replications.

The fertilizer materials were applied at 0, 8, and 16 weeks at an annual rate of 3 lbs/1000 ft^2 (Table 33). All fertilizers were applied in the granular formulation using plastic lined cardboard cups with holes punched into the lid. These shaker dispensers allowed for uniform material application throughout the individual plots.

Initial application was made on June 15, 1994. Prior to application the experimental site was examined and the turf was found to be quite uniform in color, density, and overall quality. It was sunny with a temperature in the mid 80's and southwesterly winds that were gusty at times. Lesco fertilizer #9352 was quite difficult to apply uniformly under these windy conditions because of the very small particle size. The size and weight of the other products was adequate so that they could be spread evenly throughout the individual plots.

The 8 week application was made under nearly ideal weather conditions on August 16. The temperatures was in the mid 80's, the skies were mostly sunny, and there was only a slight breeze. This application was delayed because of rainfall on August 10-12. The weather was quite favorable for application of the 16 week materials on October 4. It was mostly sunny, calm, with temperatures in the mid 60's.

Rainfall was sporadic for the duration of this study. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Visual quality and fresh clipping weight data were taken weekly beginning June 21. Variations from the weekly data collection were necessary to adjust for special events, application dates, and adverse weather conditions. Visual quality assessments were based on color, density, and phytotoxicity and recorded using a scale of 9 to 1 (9 = best, 6 = acceptable, and 1 = poorest quality). Mowing height for collecting clippings was 2".

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of the treatments on the visual quality and clipping weights. Least significant difference (LSD) tests were used to compare means among the treatments.

While numerical differences in both quality and clipping yield developed early in the season, many of the weekly evaluations showed no significant differences before mid-August (Tables 34 to 37). In the late summer and early fall, the differences were much more pronounced and most weekly evaluations were significantly different.

Table 33. The yearly rates and application dates of the fertilizer products used in this study.

Fertilizer Material	Yearly rate lb N/1000 ft^2	Date of Application (lb N/1000 ft^2)		
		6/15/94 Week 1	8/10/94 Week 8	10/5/94 Week 16
Untreated Control	NA	NA	NA	NA
Sustane (5-2-4)	3	1	1	1
Sustane + Fe (5-2-4)	3	1	1	1
Lesco 9352 (39% N) - mini size	3	1	1	1
Lesco 6152 (43% N) - elite size	3	1	1	1
Lesco 2952 (43% N) - slow release	3	1	1	1
Lesco Poly + (39% N) - sulfur coated	3	1	1	1
Pursell Polyon (42% N)	3	1	1	1
Toro Nuture (22-2-3)	3	1	1	1
Scott's Poly-S (40% N)	3	1	1	1

Table 34. Visual quality[1] of Kentucky bluegrass treated with Lesco and other fertilizer materials for the period from June 21 to August 15.

Treatment	6/21	6/29	7/6	7/12	7/20	7/29	8/4	8/15
Untreated Control	8	7	7	7	8	7	8	8
Sustane (5-2-4)	9	7	8	8	8	8	7	8
Sustane + Fe (5-2-4)	9	8	7	7	8	8	8	8
Lesco 9352 (39% N) - mini size	9	8	9	8	8	9	8	8
Lesco 6152 (43% N) - elite size	9	8	8	9	8	9	8	8
Lesco 2952 (43% N) - slow release	9	8	9	9	9	8	8	8
Lesco Poly + (39% N)	9	8	8	8	9	9	8	9
Pursell Polyon (42% N)	8	7	8	8	9	8	8	9
Toro Nuture (22-2-3)	9	8	8	8	8	8	8	8
Scott's Poly-S (40% N)	9	8	8	9	9	8	8	8
$LSD_{0.05}$	NS	NS	1	NS	1	1	NS	1

[1]Visual quality values are based on a scale of 9 to 1: 9=best quality, 6=acceptable quality, and 1=poorest quality.
NS = not significantly different at the 0.05 level.

Table 35. Visual quality[1] of Kentucky bluegrass treated with Lesco and other fertilizer materials for the period from August 23 - October 20.

Treatment	8/23	8/30	9/8	9/15	9/23	9/30	10/13	10/20
Untreated Control	7	6	7	6	6	6	6	6
Sustane (5-2-4)	8	8	8	7	7	7	7	7
Sustane + Fe (5-2-4)	8	8	8	7	7	7	8	8
Lesco 9352 (39% N) - mini size	8	9	9	8	9	8	9	8
Lesco 6152 (43% N) - elite size	8	8	9	9	9	9	9	9
Lesco 2952 (43% N) - slow release	8	8	9	9	9	8	8	8
Lesco Poly + (39% N)	8	9	9	8	8	8	9	9
Pursell Polyon (42% N)	8	8	8	8	8	8	8	8
Toro Nuture (22-2-3)	9	9	9	8	8	8	9	9
Scott's Poly-S (40% N)	9	9	9	8	8	8	9	9
$LSD_{0.05}$	1	1	1	1	1	1	1	1

[1]Visual quality values are based on a scale of 9 to 1: 9=best quality, 6=acceptable quality, and 1=poorest quality.
NS = not significantly different at the 0.05 level.

Table 36. Clipping weights[1] of Kentucky bluegrass treated with Lesco and other fertilizer materials for the period from June 21 to August 15.

Treatment	6/21	6/29	7/6	7/12	7/20	7/29	8/4	8/15
Untreated Control	243	311	245	190	254	202	179	196
Sustane (5-2-4)	261	382	283	215	263	226	180	223
Sustane + Fe (5-2-4)	253	347	280	223	291	234	210	223
Lesco 9352 (39% N) - mini size	259	401	323	230	289	237	204	216
Lesco 6152 (43% N) - elite size	220	371	302	219	260	217	191	204
Lesco 2952 (43% N) - slow release	262	429	360	263	296	254	201	213
Lesco Poly + (39% N)	268	396	291	225	268	236	225	227
Pursell Polyon (42% N)	254	319	268	222	277	249	201	260
Toro Nuture (22-2-3)	272	391	295	221	273	230	200	223
Scott's Poly-S (40% N)	238	388	294	239	289	240	199	225
$LSD_{0.05}$	NS	NS	54	NS	NS	NS	NS	NS

[1]Clipping weights are fresh weights and mowing height is 2".
NS = not significantly different at the 0.05 level.

Table 37. Clipping weights[1] of Kentucky bluegrass treated with Lesco and other fertilizer materials for the period from August 23 - October 20.

Treatment	8/23	8/30	9/8	9/15	9/23	9/30	10/13	10/20
Untreated Control	120	105	53	31	49	19	34	27
Sustane (5-2-4)	167	155	103	42	56	23	40	38
Sustane + Fe (5-2-4)	195	160	106	50	63	27	56	41
Lesco 9352 (39% N) - mini size	144	153	137	56	78	34	65	46
Lesco 6152 (43% N) - elite size	141	141	133	53	83	37	61	48
Lesco 2952 (43% N) - slow release	146	173	149	65	93	41	63	54
Lesco Poly + (39% N)	175	168	109	47	67	31	63	47
Pursell Polyon (42% N)	163	122	86	48	66	35	69	48
Toro Nuture (22-2-3)	178	203	27	43	69	25	63	62
Scott's Poly-S (40% N)	188	176	112	50	65	28	50	62
$LSD_{0.05}$	43	28	27	NS	21	11	18	16

[1]Clipping weights are fresh weights and mowing height is 2".
NS = not significantly different at the 0.05 level.

Polymer Coated Urea Fertilizer Study - 1994

B. R. Bingaman and N. E. Christians

Polymer coated fertilizer materials with 60, 90, and 120 day duration (UHS 2002, 2003, and 2004) from United Horticultural Supply were tested with Urea, Lesco Poly +, Blue chip methylene urea, and Polyon for effects on Kentucky bluegrass growth and overall quality (Table 1). This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. An established Kentucky bluegrass area was used as the experimental plot. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.3%, a pH of 6.9, 7 ppm P, and 76 ppm K. This site was not fertilized prior to the beginning of this test.

Individual experimental plots were 5 x 5 ft and there were 17 treatments including an untreated control. The study was arranged in a randomized complete block design. Three replications were conducted and there were 3 ft barrier rows between replications.

All fertilizers were applied in the granular formulation using plastic lined cardboard cups with holes punched into the lid. These shaker dispensers allowed for uniform material application throughout the individual plots.

The fertilizer materials were applied 0, 8, 12, 16, and 24 weeks into the study at an annual rate of 4 lbs/1000 ft^2 (Table 38). The initial application of all fertilizer materials was April 27, 1994. It was cloudy with a temperature in the mid 50's and a light northwesterly breeze. Prior to application the experimental site was examined and the turf was found to be quite uniform in color, density, and overall quality except in the area covered by plots 1 and 2 of Replication 2. In this area the quality of the bluegrass suggested that there was a carry over from past fertilizer studies.

The 8 week application was made on June 21 under nearly ideal weather conditions with temperatures in the mid 80's, mostly sunny skies, and a slight breeze. The 12 week application was performed on July 18. It was mostly sunny, calm, and temperatures were in the upper 80's. On August 16 the 16 weeks application was made under sunny skies, with light winds, and temperatures in the upper 70's. The 16 weeks application of the UHS #2004 materials was made on August 26. It was sunny, breezy, and temperatures were in the upper 80's. The final application (24 weeks) was made on October 17. It was cloudy with a light mist and temperatures in the mid 60's (Table 38).

Rainfall was sporadic for the duration of this study. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Visual quality and fresh clipping weight data were taken weekly beginning May 9 (Tables 39-42). Variations from the weekly data collection were necessary to adjust for special events, sequential application dates, and adverse weather conditions. Visual quality assessments were based on color, density, and phytotoxicity and recorded using a scale of 9 to 1 (9 = best, 6 = acceptable, and 1 = poorest quality). Mowing height for collecting clippings was 2".

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of the treatments on the visual quality and clipping weights. Least significant difference (LSD) tests were used to compare means among the treatments.

Table 38. The rates and timing of the application of materials for the 1994 UHS #2000 fertilizer study.

Treatment	Yearly rate lb N/1000 ft^2	Application Rates (1b N/1000 ft^2)				
		Week 1	Week 8	Week 12	Week 16	Week 24
UHS #2002 - 60 Day Duration						
100% polymer coat (41% N)	4	1.0	1.0		1.0	1.0
80% polymer coat + 20% urea (42% N)	4	1.0	1.0		1.0	1.0
60% polymer coat + 40% urea (43% N)	4	1.0	1.0		1.0	1.0
40% polymer coat + 60% urea (44% N)	4	1.0	1.0		1.0	1.0
UHS #2003 - 90 Day Duration						
100% polymer coat (41% N)	4	1.5		1.0		1.5
80% polymer coat + 20% urea (42% N)	4	1.5		1.0		1.5
60% polymer coat + 40% urea (43% N)	4	1.5		1.0		1.5
40% polymer coat + 60% urea (44% N)	4	1.5		1.0		1.5
UHS #2004 - 120 Day Duration						
100% polymer coat (41% N)	4	2.0			2.0	
80% polymer coat + 20% urea (42% N)	4	2.0			2.0	
60% polymer coat + 40% urea (43% N)	4	2.0			2.0	
40% polymer coat + 60% urea (44% N)	4	2.0			2.0	
Urea (46% N)	4	1.0	1.0		1.0	1.0
Lesco poly + - sulphur coated (39% N)	4	1.0	1.0		1.0	1.0
Blue chip methylene urea (38% N)	4	1.0	1.0		1.0	1.0
Pursell Polyon (42% N)	4	1.0	1.0		1.0	1.0

Table 39. The visual quality[1] of Kentucky bluegrass treated with UHS polymer and other fertilizer formulations from May 9 - July 28.

Fertilizer Material	5/9	5/23	5/31	6/6	6/13	6/20	6/27	7/5	7/11	7/18	7/28
Untreated Control	7	5	5	6	6	6	6	6	7	7	6
#2002											
100% polymer coat	7	7	8	7	8	8	7	8	8	8	8
80% polymer coat + 20% urea	7	6	7	7	8	8	8	9	9	9	8
60% polymer coat + 40% urea	8	7	8	7	8	8	8	9	9	9	8
40% polymer coat + 60% urea	7	6	7	7	7	7	8	8	8	9	8
#2003											
100% polymer coat	6	6	7	7	7	7	7	7	7	7	7
80% polymer coat + 20% urea	7	7	8	8	8	8	8	7	8	8	9
60% polymer coat + 40% urea	8	7	8	8	8	8	7	7	7	7	9
40% polymer coat + 60% urea	7	7	8	7	8	8	7	7	7	7	8
#2004											
100% polymer coat	7	6	7	8	9	9	8	8	8	9	7
80% polymer coat + 20% urea	8	8	8	8	9	9	8	8	8	7	7
60% polymer coat + 40% urea	7	7	8	7	8	8	7	7	7	7	7
40% polymer coat + 60% urea	9	8	9	8	9	9	8	8	8	8	8
100% urea	7	7	7	7	7	7	8	8	8	8	7
Lesco Poly +	8	7	7	7	7	7	8	8	9	8	8
Methylene blue chip	7	6	7	7	6	6	7	7	7	7	7
Pursell Polyon	7	6	7	7	7	7	7	8	8	9	9
$LSD_{0.05}$	NS	1	1	1	1	1	1	1	1	1	1

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = acceptable quality, and 1 = poorest quality.

NS = not significantly different at the 0.05 level.

Table 40. The visual quality[1] of Kentucky bluegrass treated with UHS polymer and other fertilizer formulations from August 4 -October 20.

Fertilizer Material	8/4	8/15	8/25	9/2	9/8	9/15	9/23	9/30	10/6	10/13	10/20
Untreated Control	7	6	7	6	6	6	6	6	6	6	5
#2002											
100% polymer coat	8	8	8	8	8	8	8	8	7	8	6
80% polymer coat + 20% urea	8	7	9	9	8	8	8	8	8	8	7
60% polymer coat + 40% urea	8	7	9	9	9	8	8	8	8	8	7
40% polymer coat + 60% urea	8	7	9	9	8	8	8	7	8	8	7
#2003											
100% polymer coat	8	8	8	7	7	7	7	7	7	7	6
80% polymer coat + 20% urea	9	8	8	7	7	7	7	7	7	7	6
60% polymer coat + 40% urea	9	9	9	7	7	7	7	6	7	7	6
40% polymer coat + 60% urea	8	8	8	7	7	7	7	7	6	6	5
#2004											
100% polymer coat	7	7	7	7	7	8	9	9	9	9	8
80% polymer coat + 20% urea	7	7	7	9	9	9	9	8	9	9	8
60% polymer coat + 40% urea	7	6	7	8	8	8	9	8	8	8	7
40% polymer coat + 60% urea	7	7	7	9	9	9	9	9	9	9	8
100% urea	7	7	8	8	8	8	8	7	7	8	7
Lesco Poly +	8	8	9	9	8	8	8	8	7	8	7
Methylene blue chip	7	7	8	7	7	7	7	6	7	7	6
Pursell Polyon	8	8	9	8	8	8	8	8	8	8	7
$LSD_{0.05}$	1	1	1	1	1	1	1	1	1	1	1

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = acceptable quality, and 1 = poorest quality.

NS = not significantly different at the 0.05 level.

Table 41. The clipping weights[1] of Kentucky bluegrass treated with UHS polymer and other fertilizer formulations from May 9 -July 28.

Fertilizer Material	5/9	5/16	5/23	5/31	6/6	6/13	6/20	6/27	7/5	7/11	7/18	7/28
Untreated Control	371	177	66	112	66	72	63	77	108	80	84	99
#2002												
100% polymer coat	386	169	74	121	95	112	84	103	149	137	154	173
80% polymer coat + 20% urea	521	216	76	175	138	148	141	168	241	211	229	238
60% polymer coat + 40% urea	515	255	67	174	130	145	106	174	240	191	192	208
40% polymer coat + 60% urea	528	237	70	161	114	121	101	156	240	184	202	215
#2003												
100% polymer coat	311	155	75	124	97	111	101	123	132	100	110	118
80% polymer coat + 20% urea	504	241	70	186	144	163	132	153	167	136	145	234
60% polymer coat + 40% urea	597	234	92	203	142	156	118	134	162	127	148	254
40% polymer coat + 60% urea	491	218	83	163	116	120	96	121	112	111	117	226
#2004												
100% polymer coat	583	225	85	189	161	215	165	245	270	205	219	216
80% polymer coat + 20% urea	538	257	91	201	170	191	159	172	185	143	156	159
60% polymer coat + 40% urea	608	326	119	232	160	175	136	163	182	143	158	168
40% polymer coat + 60% urea	545	325	113	214	158	175	143	162	182	151	151	154
100% urea	626	279	89	184	117	125	88	170	275	194	188	187
Lesco Poly +	652	290	83	172	121	121	93	147	222	184	187	219
Methylene blue chip	504	215	60	133	91	101	77	111	152	123	141	159
Pursell Polyon	619	227	69	142	103	121	109	145	185	166	209	249
$LSD_{0.05}$	NS	NS	28	67	49	55	56	72	86	70	78	NS

[1]Clipping weights expressed as grams fresh weight and mowing height was 2".
NS = not significantly different at the 0.05 level.

Table 42. The clipping weights[1] of Kentucky bluegrass treated with UHS polymer and other fertilizer formulations from August 4 -October 20.

Fertilizer Material	8/4	8/15	8/25	9/2	9/8	9/15	9/23	9/30	10/6	10/13	10/20	Total Clippings
Untreated Control	101	112	92	46	28	19	29	10	17	11	81	1850
#2002												
100% polymer coat	155	152	114	76	57	30	42	22	27	26	108	2482
80% polymer coat + 20% urea	199	203	160	109	78	44	56	26	41	33	152	3486
60% polymer coat + 40% urea	183	186	151	112	72	38	53	22	38	35	144	3310
40% polymer coat + 60% urea	174	187	168	121	71	44	70	24	40	29	143	3286
#2003												
100% polymer coat	138	180	144	73	48	29	42	15	24	14	99	2279
80% polymer coat + 20% urea	257	265	181	91	49	37	47	16	35	27	143	3294
60% polymer coat + 40% urea	234	245	157	78	48	28	44	14	29	21	143	3284
40% polymer coat + 60% urea	208	211	145	69	47	33	39	10	20	15	121	2787
#2004												
100% polymer coat	186	186	128	70	55	53	84	56	80	57	164	3780
80% polymer coat + 20% urea	149	141	106	89	86	56	90	47	71	48	145	3346
60% polymer coat + 40% urea	147	162	113	129	149	107	106	54	71	46	161	3692
40% polymer coat + 60% urea	155	155	121	117	124	85	96	47	70	50	154	3543
100% urea	174	178	198	149	83	42	56	21	33	32	153	3512
Lesco Poly +	208	205	189	123	78	50	68	26	45	33	154	3543
Methylene blue chip	153	150	127	75	46	28	44	16	26	22	112	2572
Pursell Polyon	224	225	167	88	60	42	62	30	48	33	146	3356
$LSD_{0.05}$	NS	NS	NS	32	22	25	30	12	23	10	11	NS

[1]Clipping weights expressed as grams fresh weight and mowing height was 2".
NS = not significantly different at the 0.05 level.

Natural Organic Rate Study - 1994

B. R. Bingaman and N. E. Christians

Natural organic fertilizer materials were tested for their effects on Kentucky bluegrass growth and quality. Sustane, Country Club, and Milorganite were applied at 0.5 and 1.0 lbs/1000 ft^2 on May 11, July 15 and August 30 for a total of 1.5 and 3.0 lbs/1000 ft^2 annually. This study was initiated in 1993 and continued in 1994 at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experiment was conducted in a 'Bronco' Kentucky bluegrass area. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.3%, a pH of 6.9, 7 ppm P, and 76 ppm K.

Individual experimental plots were 5 x 5 ft and there were 7 treatments including an untreated control. The study was arranged in a randomized complete block design. Three replications were conducted and there were 2.5 ft barrier rows between replications.

All fertilizers were applied in the granular formulation using plastic lined cardboard cups with holes punched into the lid. These shaker dispensers allowed for uniform material application to the individual plots.

Rainfall was sporadic during the study. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Visual quality data and fresh clippings were taken weekly beginning May 13. Deviations from this schedule were necessary to adjust for adverse weather conditions, fertilizer applications, and special events. In addition, data collection was delayed at various times to allow the grass to accumulate sufficient growth for clipping collection.

Visual quality assessments were based on color, density, and phytotoxicity and recorded using a scale of 9 to 1 (9 = best, 6 = acceptable, and 1 = poorest quality). Mowing height for collecting clippings was 2". The fresh clippings from a single mower strip for each plot were placed into paper sacks and dried at 67 C for 48 hours prior to weighing.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of the treatments on the visual quality and clipping weights. Least significant difference (LSD) tests were used to compare means among the treatments.

The materials produced a relatively uniform response through the season in both quality and clipping yield. The Country Club material produced a very rapid initial response and maintained good color through the season. The Sustane and Milorganite showed a slower initial release, but provided a high uniform quality through most of the season.

Table 43. Visual quality[1] of Kentucky bluegrass treated with natural organic nitrogen materials for the period from May 13 to July 12.

Treatment	lbs product /1000 ft^2	5/13	5/23	5/31	6/6	6/13	6/20	6/28	7/5	7/12
Sustane 5-2-4	1.0	7	7	8	8	8	8	8	7	8
Sustane 5-2-4	0.5	6	6	7	7	7	7	7	7	8
Country Club	1.0	8	9	9	9	9	8	8	8	7
Country Club	0.5	6	7	7	7	7	7	7	7	7
Milorganite	1.0	7	6	7	7	8	8	8	8	8
Milorganite	0.5	7	6	7	7	7	7	8	7	8
Untreated Control	0.0	5	4	5	5	5	5	5	5	6
$LSD_{0.05}$	----	1	1	1	1	1	1	1	1	1

[1]Visual quality values are based on a scale of 9 to 1: 9=best quality, 6=acceptable quality, and 1=poorest quality.

Table 44. Visual quality[1] of Kentucky bluegrass treated with natural organic nitrogen materials for the period from July 18 to October 20.

Treatment	lbs product /1000 ft^2	7/18	7/29	8/4	8/16	8/23	9/8	9/23	9/30	10/20
Sustane 5-2-4	1.0	8	8	9	9	8	8	9	9	7
Sustane 5-2-4	0.5	7	7	7	7	7	7	7	7	6
Country Club	1.0	8	9	9	9	7	9	9	8	6
Country Club	0.5	7	8	8	7	7	8	8	7	5
Milorganite	1.0	8	7	8	8	8	7	7	7	6
Milorganite	0.5	7	6	7	7	7	7	7	7	6
Untreated Control	0.0	5	4	6	5	7	6	6	6	3
$LSD_{0.05}$	----	1	1	1	1	1	1	1	1	1

[1]Visual quality values are based on a scale of 9 to 1: 9=best quality, 6=acceptable quality, and 1=poorest quality.

Table 45. Clipping weights[1] of Kentucky bluegrass treated with natural organic nitrogen materials for the period from May 13 to July 12.

Treatment	lbs product /1000 ft^2	5/13	5/23	5/31	6/6	6/13	6/20	6/28	7/5	7/12
Sustane 5-2-4	1.0	7	9	6	8	10	6	8	6	3
Sustane 5-2-4	0.5	5	7	5	6	7	5	5	4	3
Country Club	1.0	10	17	10	11	11	7	8	5	3
Country Club	0.5	8	11	6	8	8	5	6	4	2
Milorganite	1.0	7	9	6	8	10	6	7	5	4
Milorganite	0.5	5	7	5	6	6	4	5	4	3
Untreated Control	0.0	3	4	3	3	2	1	1	1	1
$LSD_{0.05}$	----	NS	4	3	3	3	2	2	2	1

[1]Clipping weights are expressed as grams dry weight.
NS = not significantly different at the 0.05 level.

Table 46. Clipping Weights[1] of Kentucky bluegrass treated with natural organic nitrogen materials for the period from July 18 to October 20.

Treatment	lbs product /1000 ft^2	7/18	7/29	8/4	8/16	8/23	9/8	9/23	9/30	10/20
Sustane 5-2-4	1.0	4	6	7	7	4	8	13	3	6
Sustane 5-2-4	0.5	3	4	4	3	3	4	6	1	3
Country Club	1.0	4	11	9	10	4	11	14	3	6
Country Club	0.5	3	6	5	4	2	5	7	1	2
Milorganite	1.0	3	6	6	7	4	7	10	2	4
Milorganite	0.5	3	6	4	3	2	4	7	1	3
Untreated Control	0.0	1	1	1	1	1	1	1	0.3	1
$LSD_{0.05}$	----	1	NS	4	2	1	3	6	1	2

[1]Clipping weights are expressed as grams dry weight.
NS = not significantly different at the 0.05 level.

Natural Organic Source Study - 1994

B. R. Bingaman and N. E. Christians

Natural organic fertilizer materials were tested for their effects on Kentucky bluegrass growth and quality. Blood meal, corn gluten meal, leather meal, Sustane (composted turkey manure), and Milorganite (activated sewage sludge) were selected for testing as natural organic nitrogen sources. This study began in 1993 and continued in 1994 at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experiment was conducted in an area of 'Midnight' Kentucky bluegrass established in 1993. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.6%, a pH of 7.4, 11 ppm P, and 88 ppm K.

Individual experimental plots were 5 x 5 ft and there were 6 treatments including an untreated control. The study was arranged in a randomized complete block design. Three replications were conducted and there were 2.5 ft barrier rows between replications.

Fertilizer materials were applied during the growing season at 3.0 lbs N/1000 ft^2/yr. One lb N applications were made on May 4, July 15, and August 30. All fertilizers were applied in the granular formulation using plastic lined cardboard cups with holes punched into the lid. These shaker dispensers allowed for uniform material application to the individual plots.

Rainfall was sporadic during this study. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Visual quality data and fresh clippings were taken weekly beginning May 13. Deviations from this schedule were necessary to adjust for adverse weather conditions, fertilizer applications, and special events. In addition, data collection was delayed at various times to allow the grass to accumulate sufficient growth for clipping collection.

Visual quality assessments were based on color, density, and uniformity and recorded using a scale of 9 to 1 (9 = best, 6 = acceptable, and 1 = poorest quality). Mowing height for collecting clippings was 2". Fresh clippings from a single mower strip for each plot were placed into paper sacks and dried at 67°C for 48 hours prior to weighing.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of the treatments on the visual quality and clipping weights. Least significant difference (LSD) tests were used to compare means among the treatments.

Each of the natural organic materials produced acceptable quality throughout the growing season (Table 47 and 48). Quality of leather meal treated plots dropped late in the season. Response to this material still produced better quality than the untreated control.

Clipping response was similar to quality response through the growing season for nitrogen sources. Lower turf quality was associated with lower clipping yields for leather meal (Table 49 and 50).

Table 47. Visual quality[1] of Kentucky bluegrass treated with natural organic nitrogen materials for the period from May 13 to July 12.

Treatment	lbs product /1000 ft^2	5/13	5/23	5/31	6/6	6/13	6/20	6/28	7/5	7/12
Blood Meal	3.0	5	5	6	6	8	7	8	8	7
Corn Gluten Meal	3.0	5	6	6	7	8	8	8	8	7
Leather Meal	3.0	5	5	6	6	7	7	7	7	7
Sustane	3.0	6	6	6	7	7	7	7	7	7
Milorganite	3.0	5	5	6	6	7	6	7	7	7
Untreated Control	0.0	4	4	5	5	5	5	5	6	6
$LSD_{(0.05)}$	----	1	1	1	1	1	1	1	1	1

[1]Visual quality values are based on a scale of 9 to 1: 9=best quality, 6=lowest acceptable quality, and 1=poorest quality.

Table 48. Visual quality[1] of Kentucky bluegrass treated with natural organic nitrogen materials for the period from July 18 to October 20.

Treatment	lbs product /1000 ft^2	7/18	7/29	8/4	8/16	8/23	9/8	9/23	9/30	10/20
Blood Meal	3.0	8	8	8	8	8	8	8	8	9
Corn Gluten Meal	3.0	7	8	8	8	8	8	9	8	9
Leather Meal	3.0	7	7	7	6	6	7	7	7	7
Sustane	3.0	7	7	7	7	7	8	8	7	7
Milorganite	3.0	7	7	7	7	7	7	7	7	8
Untreated Control	0.0	5	5	6	5	5	5	6	6	5
$LSD_{(0.05)}$	----	1	1	1	1	1	0.4	1	1	1

[1]Visual quality values are based on a scale of 9 to 1: 9=best quality, 6=lowest acceptable quality, and 1=poorest quality.

Table 49. Clipping dry weights(g) of Kentucky bluegrass treated with natural organic nitrogen materials for the period from May 13 to July 12.

Treatment	lbs product /1000 ft^2	5/13	5/23	5/31	6/6	6/13	6/20	6/28	7/5	7/12
Blood Meal	3.0	3	6	7	7	8	6	8	5	4
Corn Gluten Meal	3.0	3	6	7	7	8	6	7	5	4
Leather Meal	3.0	2	5	5	5	6	4	4	4	3
Sustane	3.0	4	7	7	7	8	6	6	4	4
Milorganite	3.0	3	6	6	6	6	4	5	4	3
Untreated Control	0.0	1	2	4	2	3	2	1	2	1
$LSD_{(0.05)}$	----	1	3	3	4	3	2	2	1	2

Clipping weights are expressed as grams dry weight.
NS = not significantly different at the 0.05 level.

Table 50. Clipping dry weights(g) of Kentucky bluegrass treated with natural organic nitrogen materials for the period from July 18 to October 20.

Treatment	lbs product /1000 ft^2	7/18	7/29	8/4	8/16	8/23	9/8	9/23	9/30	10/20
Blood Meal	3.0	4	8	7	10	7	11	15	5	8
Corn Gluten Meal	3.0	3	6	9	10	7	8	16	5	9
Leather Meal	3.0	3	5	5	5	4	6	11	3	4
Sustane	3.0	4	7	6	6	5	8	13	4	6
Milorganite	3.0	3	4	5	6	6	8	13	3	6
Untreated Control	0.0	1	3	1	1	2	2	2	1	1
$LSD_{(0.05)}$	----	3	4	4	4	1	4	5	2	2

Clipping weights are expressed as grams dry weight.
NS = not significantly different at the 0.05 level.

Environmental Research

The Use of a Natural Product for the Preemergence Control of Annual Weeds

N. E. Christians

In 1985, it was observed that unprocessed corn meal applied in large quantities to soil areas had an inhibitory effect on the establishment of germinating plants. Further evaluations showed that there was a naturally occurring, organic compound (or compounds) within the corn meal that had a growth regulating effect on the root system of germinating plants. Studies were conducted to determine if any corn meal components contained higher concentrations of the inhibitory substance. It was discovered that high levels of inhibitor were found in corn gluten meal, the protein fraction of corn grain.

Corn gluten meal contains 10% nitrogen by weight and was shown to be a good natural source of fertilizer nitrogen for mature plants that had well established root systems. Further studies demonstrated that corn gluten meal could be used as a natural "weed and feed" material for lawn areas. Nitrogen in the product serves as a nutrient source to improve lawn quality, while the inhibitory substance acts to prevent germinating weeds, such as crabgrass, from infesting the lawn. Several grassy and broadleaf weeds have been shown to be controlled by preemergence application of corn gluten meal. United States patent 5,030,268 was issued for use of corn gluten meal as a natural preemergence herbicide in July, 1991 and reissued with broader claims as Re. 34,594 on April 26, 1994. A marketing agreement has been reached with Gardens Alive Corporation of Lawrenceburg, Indiana. They registered the product with the Environmental Protection Agency (EPA) under the EPA Registration No. 56872-1 and EPA Est. No. 56872-IN-1 in late summer of 1994. Marketing began in the fall of 1994 under the name A-MAIZING LAWN.

Corn gluten meal is a byproduct of the wet-milling process. It has been used for decades as an animal feed for dogs, poultry, fish, and many other animal species. The product is being promoted as an environmentally safe, natural herbicide that can be used to control weeds preemergently in turf areas without the use of synthetic preemergence herbicides that are presently used in large quantities in the U.S.

Work has also been conducted on other crop systems, such as strawberries, floral crops, and vegetable crops. It is anticipated that corn gluten meal will find a market for these crop systems as well as for home gardening.

The objectives of the following study were to observe the effects of corn gluten meal on weed control and turf quality of Parade Kentucky bluegrass under field conditions. Corn gluten meal was applied to the same 5 ft x 5 ft plots at the research station during 1991, 1992, 1993 and 1994 at levels of 0, 2, 4, 6, 8, 10, and 12 lb N/1000 ft^2 (0, 20, 40, 60, 80, 100, 120 lbs corn gluten meal/1000 ft^2). Application dates were April 22 in 1991, April 28 in 1992, April 26 in 1993, and April 27 in 1994. Very high rates were included to determine if corn gluten meal has any detrimental effects on turf over extended periods of use.

Table 51 includes data on crabgrass control over the 4 year period from 1991 to 1994 and data on clover and dandelion control for 1994. In the first year of the study, the 2 lb N (20 lb CGM)/1000 ft^2 rate reduced crabgrass by 58% and the 4 lb rate reduced infestation by 86%. Control improved to 85% at the 2 lb rate in 1992 and to 91% in the 1993 season. Crabgrass was nearly eliminated in plots treated with CGM rates above 2 lb N/1000 ft^2 in 1992 and 1993. The 1993 season was one of the wettest seasons in history. Grass on the plots often became very long between mowing, resulting in some turf thinning. Crabgrass control dropped to 70% at the 2 lb rate in the spring of 1994, although it remained good at higher rates of application. No detrimental effect was observed at any time during the 4-year period.

There is no postemergence effect of CGM on weeds, the effect is entirely preemergence. Little effect was expected on the infestation of perennial broadleaf weeds was anticipated in the study. By the end of 1994, however, there was a considerable difference in clover and dandelion infestation between nontreated and treated plots. Over the 4 year period, clover and dandelion infestation in the area surrounding the plots and in the control plots began to increase, whereas treated plots maintained very low infestation levels (Table 51). Clover infestation was very uneven, with most of the clover in the control of the first replication, resulting in no statistical significant differences among plots. Numerically, plots treated with 2 lb N/1000 ft^2 had 81% less clover than control plots. Areas receiving higher levels of CGM had even less clover. Dandelion infestation was reduced by 71% in plots treated for 4 years with the 2 lb N rate of CGM. Plots treated with higher levels were almost completely clean of dandelions. Control plots showed an average infestation of 16% cover of clover and had 14 dandelion plants in the 25 ft^2 plots. The reduction in broadleaf weeds is likely due to a combination of the CGM inhibiting germination of these species and the competition of the grass in the treated plots with the competing weeds. Broadleaf infestation will be monitored in future years of the study.

The study continues and corn gluten meal has been applied at the same rate and to the same plots in the spring of 1995.

Table 51. Weed control with corn gluten meal in the field over a 4 year period.

	Percent Reduction from Control					
Level lb N/1000 ft^2	1991 Crabgrass	1992 Crabgrass	1993 Crabgrass	1994 Crabgrass	1994 Clover	1994 Dandelion
0	0	0	0	0	0	0
2	58	85	91	70	81	71
4	86	98	98	97	90	100
6	97	98	93	98	98	100
8	87	93	93	87	100	98
10	79	94	95	86	94	100
12	97	100	100	98	90	100
$LSD_{(0.05)}$	26	44	31	39	N.S.	50

Greenhouse Screening Study of Eleven Corn Gluten Meal Related Samples for Their Inhibitory Activity on the Germination of Creeping Bentgrass (Agrostis palustris)

D. L. Liu, D. Gardner and N. E. Christians

This study was initiated on Feburary 8, 1995 to compare the herbicidal activity of eleven samples from Grain Processing Corporation, Muscatine, Iowa. Four inch plastic pots (Belden Plastics, St. Paul, MN) were filled with Nicollet field soil to a surface of 54 cm^2. Creeping bentgrass (*Agrostis palustris* Huds.) was seeded at rate of 0.030 g per pot. The eleven samples used for this study are listed as follows:

Sample #	Description
1	Thick gluten residue #1
2	Thick gluten residue #2
3	Thick gluten overs #1
4	ISU EXP #1
5	Hydrolyzed gluten
6	Hydrolyzed gluten residue
7	Hydrolyzed gluten overs
8	Spent carbon
9	Carbon treated filtrate
10	Adsorption resin eluate
11	ISU EXP #2

Samples #1, 2, 3 and 4 are experiment materials derived from corn gluten meal. Each of the 11 samples was applied to the surface of the seeded pots at the rates of 0, 1.0, 2.0, 4.0, 6.0, and 8.0 g/dm^2. The experimental design was a randomized block with three replicates for each treatment. The total of 198 pots were placed on a mist bench where constant moisture was supplied for one week. The pots were then moved to a conventional greenhouse bench and were watered every day. Five days before the final data were taken, all pots were subjected to a water stress period. Data on the percent coverage of plants, number of plants, fresh clipping weight, and the average root length were taken four weeks after the application.

The effects of the 11 samples on the germination of creeping bentgrass were expressed in four parameters: the pecentage of live plant coverage, the number of live plants, average root length, and fresh clipping weight in each pot. Data were analyzed by using the General Linear Models Procedure in SAS System (6.07 version). The F-test indicated that treatments due to samples, rates, and interaction between samples and rates were significantly different for all four variables at the 0.01 level.

Plant survival four weeks after seeding was expressed as the percentage of live plant coverage (Table 52) and the number of live plants in each pot (Table 53). At the rates of 4 g/dm^2 and above, most of the samples except #3, #6, and #8 had more than 50% reduction in plant coverage as shown in Table 52. Sample #5 completely inhibited plant germination at the rates of 6 g/dm^2 and above. Table 53 shows that most samples except #3 and #8 at the rates of 4 g/dm^2 and above had less than 50% plant survival compared to the control. Both Table 52 and Table 53 show that with sample #5 there was no plant survival at rates of 6 g/dm^2 and above.

The examination of root length gave the details of plant survival and the results are shown in Table 54. It was demonstrated that all samples except #3 and #8 had less than 50% root growth compared to the control at rates of 6 g/dm^2 and above. Sample #5 was the most effective of the 11 samples, which completely inhibited root development at rates higher than 6 g/dm^2, followed by samples #4, and #11. Table 55 shows that all samples except #7 and #8 had less than 50% shoot growth compared to the control and sample #5 had no shoot growth which resulted in no fresh clippings at rates of 6 g/dm^2 and above.

From the results for all four variables, sample #5 (hydrolyzed gluten) was the most effective sample in inhibiting grass germination and root development, followed by samples #4 (ISU EXP #1) and #11 (ISU EXP #2). Samples #7 and #8 were the least effective of the samples tested.

Table 52. The effect of the eleven samples on the germination of creeping bentgrass. Data expressed as the percent of plant survival is refered to the perecentage of live plant coverage in each pot compared to the control.

Sample	Percentage of Live Plant Coverage Per Pot (%)*				
#	1 g/dm^2	2 g/dm^2	4 g/dm^2	6 g/dm^2	8 g/dm^2
1	98	68	32	2	0
2	93	85	27	5	0
3	105	98	88	8	0
4	100	83	12	7	1
5	100	92	10	0	0
6	110	98	68	8	0
7	108	100	44	40	8
8	103	90	82	53	55
9	107	90	32	8	18
10	107	68	18	0	5
11	120	110	2	8	2

*Data were taken four weeks after the treatments. Each number is the average of the measurements of 3 replicates (n=3). The control which did not receive any sample is considered having 100% coverage (n=11). The $LSD_{(0.05)}$= 24%.

Table 53. The effect of the eleven samples on the germination of creeping bentgrass. Data were expressed as the number of live plants in each pot.

Sample	Number of Live Plants Per Pot*				
#	1 g/dm^2	2 g/dm^2	4 g/dm^2	6 g/dm^2	8 g/dm^2
1	85	69	27	3	0
2	92	81	33	9	0
3	96	85	63	9	0
4	92	72	14	6	2
5	89	76	6	0	0
6	89	75	32	3	0
7	89	84	38	36	12
8	93	87	79	71	54
9	96	76	29	10	14
10	96	69	18	0	3
11	95	91	3	10	3

*Data were taken four weeks after the treatments. Each number is the average of the measurements of 3 replicates (n=3). The control had average of 88 plants (n=11). The $LSD_{(0.05)}$= 21.

Table 54. The effect of the eleven samples on the germination of creeping bentgrass. Data were expressed as the average root length which was the mean of 3 plants in each pot .

Sample	Average Root Length Per Pot (mm)*				
#	1 g/dm^2	2 g/dm^2	4 g/dm^2	6 g/dm^2	8 g/dm^2
1	64	57	25	0	0
2	71	57	41	3	0
3	65	56	59	12	0
4	72	65	16	0	0
5	65	59	0	0	0
6	71	70	32	4	0
7	68	60	22	18	2
8	73	74	71	77	66
9	67	69	22	0	0
10	76	57	5	0	1
11	63	64	1	18	1

*Data were taken four weeks after the treatments. Each number is the average of the measurements of 3 replicates (n=9). The control had 77 mm (n=11). The $LSD_{(0.05)}$= 19 mm.

Table 55. The effect of the eleven samples on the germination of creeping bentgrass. Data expressed as the fresh clipping weight in each pot were taken four weeks after the treatments.

Sample	Fresh Clipping Weight (mg)				
#	1 g/dm^2	2 g/dm^2	4 g/dm^2	6 g/dm^2	8 g/dm^2
1	425	269	94	17	0
2	399	258	69	36	0
3	547	511	390	55	0
4	587	458	80	44	0
5	450	465	17	0	0
6	699	464	307	9	0
7	661	537	285	229	37
8	325	279	387	175	122
9	503	436	116	14	21
10	760	377	212	0	25
11	717	544	12	79	11

*Data were taken four weeks after the treatments. Each number is the average of the measurements of 3 replicates (n=3). The control had 262 mg (n=11). The $LSD_{(0.05)}$= 206 mg.

Field Study of Corn Gluten Meal and Corn Gluten Hydrolysate for Crabgrass Control

D. L. Liu, B. R. Bingaman, and N. E. Christians

The weed control activity of corn gluten hydrolysate has been demonstrated in petri dish and greenhouse bioassays and proved to be more effective than that of corn gluten meal. Hydrolysate was not available in sufficient quantities for field work until 1994. A field study was initiated on April 29, 1994 at Iowa State University Research Station to evaluate corn gluten meal, and two corn gluten hydrolysate materials (CGH-A and CGH-B) for crabgrass control. CGH-A was prepared by treating an aqueous slurry of corn gluten meal with amylases, followed by filtration to remove the solubilized carbohydrates. CGH-B was prepared by a simplified procedure which did not include amylase in the treatment.

The experiment was conducted in an area of Indigo Kentucky bluegrass plot and arranged in a randomized complete block. The individual plots were 1 ft. by 1 ft. with 3 replications. The small plot size was necessary because of the limited availability of the hydrolysate. Crabgrass was seeded in the experimental area before the application of treatments. The three samples were applied at rates of 0, 5, 10, 20, 30, and 40 lbs materials per 1000 ft^2 (Table 56).

Visual turf quality data were taken weekly for 10 weeks (Table 57). The degree of crabgrass control was asessed by counting the number of crabgrass plants per individual plot weekly beginning on July and continuing for 3 weeks (Table 58).

The results on percent of crabgrass reduction demonstrate that corn gluten hydrolysate was more effective in crabgrass control than corn gluten meal (Table 58). In general, CGH-B was less effective than CGH-A in crabgrass control. However, a great variation in crabgrass germination among the replications was observed. This same trial is being repeated on the same area in 1995 by Jason Gates, an undergraduate honors student who is performing his work under the direction of Dr. Liu.

Table 56. Granular corn gluten meal and corn gluten hydrolysate treatments.

	Treatment*		
Sample	Rate (lb /1000 ft^2)	gram /plot	ml H_2O/Plot
1. Untreated Control	NA	NA	NA
2. Granular CGM	5	2.268	NA
3. Granular CGM	10	4.536	NA
4. Granular CGM	20	9.072	NA
5. Granular CGM	30	13.608	AA
6. Granular CGM	40	18.144	NA
7. Gluten Hydrolysate A	5	2.268	150
8. Gluten Hydrolysate A	10	4.536	150
9. Gluten Hydrolysate A	20	9.072	150
10. Gluten Hydrolysate A	30	13.608	150
11. Gluten Hydrolysate A	40	18.144	150
12. Gluten Hydrolysate B	5	2.268	150
13. Gluten Hydrolysate B	10	4.536	150
14. Gluten Hydrolysate B	20	9.072	150
15. Gluten Hydrolysate B	30	13.608	150
16. Gluten Hydrolysate B	40	18.144	15

*Treatments 2-6 were applied as granular materials. Treatments 7-16 were applied as liquids.

Table 57. The effect of corn gluten meal (CGM) and two corn gluten hydrolysates (CGH-A and CGH-B) on Kentucky bluegrass quality*.

Treatment		Turf Quality**									
		Number of Weeks After Treatment Application									
Sample	Rate lb/1000 ft²	3	4	5	6	7	8	9	10	11	12
Control	0	8	7	6	7	7	6	7	7	7	6
CGM	5	9	7	7	7	7	7	7	8	7	7
	10	9	7	7	7	7	7	8	7	7	7
	20	8	7	7	8	8	7	7	8	8	8
	30	9	8	8	8	9	8	9	8	8	8
	40	8	8	8	9	9	9	9	9	9	9
CGH-A	5	8	7	7	7	7	6	7	7	8	7
	10	9	8	7	8	8	7	7	7	8	7
	20	9	7	8	8	7	8	8	8	8	8
	30	9	9	9	8	8	8	8	8	8	8
	40	9	8	9	8	8	8	9	8	9	8
CGH-B	5	8	7	7	7	7	7	7	7	8	7
	10	9	7	7	7	7	7	7	7	7	7
	20	9	8	7	7	8	7	8	8	8	8
	30	9	8	8	8	8	8	8	7	8	8
	40	9	9	8	8	8	8	8	8	9	8
$LSD_{(0.05)}$		1	1	1	1	1	1	1	1	1	1

*Plots were evaluated on a 1-9 scale, 9= best quality, 6= acceptable quality, and 1= dead turf.

**Values are means of scores of 3 replicates compared against control.

Table 58. The effect of corn gluten meal (CGM) and two corn gluten hydrolysates (CGH-A and CGH-B) on crabgrass control in Kentucky bluegrass field plots.

Treatment			Percent of Crabgrass Reduction (%)*		
Sample	Rate (lb/1000 ft²)	Rate (g/m²)	Week 12	Week 14	Week 16
CGM	5	24.4	30	25	18
	10	48.8	68	65	60
	20	97.7	38	30	53
	30	146.5	30	70	70
	40	195.9	87	70	83
CGH-A	5	24.4	57	35	53
	10	48.8	76	60	60
	20	97.7	87	83	77
	30	146.5	87	83	83
	40	195.9	81	83	83
CGH-B	5	24.4	25	30	25
	10	48.8	81	77	70
	20	97.7	87	83	77
	30	146.5	81	77	65
	40	195.9	68	65	70
$LSD_{(0.05)}$			36	30	28

*Values are means of 3 replicates as compared with the untreated control.

Determining Effective Rates of Different Products of Corn Gluten Meal For Weed Control

J. T. Gates, D. L. Liu, and N. E. Christians

With pesticides constantly coming under close public scrutiny, a shift can be noted from synthetic to natural organic pesticides. Corn gluten meal, a byproduct of the wet milling process, has been found to possess root inhibiting activity on grass and broadleaf species. Corn gluten meal can be made into a pelletized form for easy application on a turfgrass area. Along with its ability to provide herbicidal activity it has an analysis of 10% nitrogen. While corn gluten meal is relatively insoluble in water, a enzymatically hydrolyzed corn gluten meal is quite water soluble. This water soluble corn gluten hydrolysate product would allow for easier application and a possibly more active herbicide. In this study, we looked at different rates of four corn gluten meal products and four hydrolysate products. The objective of this study was to compare the herbicidal activity of these different corn gluten meal related products in the greenhouse.

The four sampes of corn gluten meal and four samples of corn gluten hydrolysate used in this study are listed in Table 59. Four inch pots (Belden Plastics, St. Paul, MN) were filled with Nicollet soil to the surface of 54 cm^2. The soil was sifted for consistency and placed into the pots. Creeping Bentgrass (*Agrostis Palustris*) was sewed on the soil at a rate of 5 $g/1000ft^2$ (0.029 g/pot). On April 6, 1995 each of the eight materials were applied as a dry application to the surface of the soil at the rates of 0, 0.5, 1, 2, 3 g/dm^2, which is equal to 0, 10, 20, 40, and 60 $lbs./1000ft^2$. The total of 102 pots were then placed on a mist bed for one week to provide ample moisture for germination. After germination was complete, the pots were moved to a bench where they were hand watered twice a day. This study was arranged as a randomized block design with 3 replications. Initial data on percent cover and plant number per pot were taken two weeks after the application. Three weeks after the initiation of the study, all pots were allowed to dry for five days before the final data were taken. The data were analyzed by using the General Linear Models Procedure in the SAS system (6.07 version).

The preliminary data that were taken at week two, had already begun to show reductions in percent cover and plant number. While there was a significant difference in data, effects were not as dramatic as week three data, which are presented in this report, after the plants had experienced water stress.

Week three data were taken on percent cover, plant number, clipping weight and root length. The averages of all three replicates are presented as percent reductions from the control in Tables 59, 60, 61, and 62, respectively.

To determine plant survival rate, percent cover (Table 59) and number of live plants per pot (Table 61) were asessed. Both of these parameters show little reduction at the two lower rates and large reductions at the two higher rates. Clipping weights were measured to determine how healthy the plants were. More growth is seen in the first two rates in response to the nitrogen in the materials, while the higher rates suppressed the growth (Table 62).

Since the corn gluten meal products have the greatest affect on the root system, the root lengths were taken to see if they had been suppressed by the products. Within this parameter, a reduction at higher rates and larger differences between products were observed. The higher rates of each product had greater root suppression than the lower rates. The hydrolaste products had a larger affect on the root system than the corn gluten meal products had at the same rate. The greatest reduction was seen in the product GH1 (Table 63).

With little doubt one can see the effects corn gluten meal products have on the plant. It has in most cases reduced the quality of the plant, and caused a reduction in the number of plants that have survived. In some cases the data contradict this general assumption. The percentage cover and clipping weight will almost always decrease with higher application rates. In some of the lower application rates an increase is seen in plant cover and clipping weight (Tables 60 and 62). This is due to a nitrogen response. These treatments were not at lethal rates in the greenhouse conditions and the plants that lived were able to increase growth from the nitrogen present in the products.

Consideration must also be given to the weather conditions at the time. A five day dry down has given ample time to show stress in earlier greenhouse studies. During the dry down period in this study, it was cloudy and by the time of termination for the study some pots still had ample moisture for plants to survive. This allowed for plants with very small root systems to survive where death would have occurred with drier soil conditions. Root data confirm that rooting was reduced by the treatments (Table 63). For each product, there is an evident decrease in the plants root system. In an established turfgrass environment these plants will have difficulty in competing with healthy plants with established root systems. The root data in this study gives the primary evidence that the hydrolosate forms are more effective then the corn gluten meal products. In particular GH1 suppressed root growth dramatically (Table 63).

Table 59. List of eight samples used in this study.

Sample	Description
GM1	Grain Processing Corporation (GPC)1995 Corn Gluten Meal
GM2	GPC Thick gluten residue #1
GM3	GPC Thick gluten residue #2
GM4	Gardens Alive! Corn Gluten Meal
GH1	GPC 1995 Corn Gluten Hydrolysate
GH2	GPC Corn Gluten Hydrolysate (CGH-A)
GH3	GPC Corn Gluten Hydrolysate (CGH-B)
GH4	Sigma Chemical Company Corn Gluten Hydrolysate

Table 60. The effect on the plant coverage of the creeping bentgrass. Data are expressed as percent reduction from the control.

	Percent Reduction in Plant Coverage Per Pot* (%)			
Sample	0.5 g/dm^2	1.0 g/dm^2	2.0 g/dm^2	3.0 g/dm^2
CGM1	6	14	42	65
CGM2	1	14	73	70
CGM3	29	17	67	88
CGM4	36	46	44	42
CGH1	7	17	61	70
CGH2	26	4	48	55
CGH3	16	29	67	95
CGH4	17	14	54	83

*Data were taken three weeks after treatments. Each number is the average percent cover over the 3 replicates (n=3) expressed as percent reduction. The control which did not receive any treatment is considered having 100% coverage (n=6). The LSD(0.05)= 37%.

Table 61. The effect of the samples on the germination of creeping bentgrass. Data are expressed as percent reduction from the control.

	Percent Reduction of Live Plants Per Pot* (%)			
Sample	0.5 g/dm^2	1.0 g/dm^2	2.0 g/dm^2	3.0 g/dm^2
CGM1	33	39	60	75
CGM2	29	39	81	78
CGM3	50	41	76	91
CGM4	55	62	60	59
CGH1	21	41	72	78
CGH2	47	32	63	68
CGH3	40	50	76	96
CGH4	88	83	89	89

*Data were taken three weeks after treatments. Each number is the average number of live plants per pot over the 3 replicates (n=3) expressed as percent reduction. The control which did not receive any treatment is considered having 100% of plant number (n=6). The LSD(0.05)= 34%.

Table 62. The effect of the samples on the growth of the germinating creeping bentgrass. Data are expressed as percent reduction from the control.

	Percent Reduction in Fresh Clipping Weight Per Pot* (%)			
Sample	0.5 g/dm^2	1.0 g/dm^2	2.0 g/dm^2	3.0 g/dm^2
CGM1	-3	-8	47	79
CGM2	-39	-38	71	68
CGM3	-12	-36	57	85
CGM4	-5	5	46	42
CGH1	-25	-87	52	79
CGH2	-40	-95	3	73
CGH3	-10	-35	13	84
CGH4	-35	-62	15	66

*Data were taken three weeks after treatments. Each number is the average fresh clipping weight over the 3 replicates (n=3) expressed as percent reduction. The control which did not receive any treatment is considered having 100% clipping weight (n=6). The LSD(0.05)= 35%.

Table 63. The effect of the samples on the root formation of germinating creeping bentgrass. Data are expressed as percent reduction from the control.

	Percent Reduction in Root Length Per Pot* (%)			
Sample	0.5 g/dm^2	1.0 g/dm^2	2.0 g/dm^2	3.0 g/dm^2
CGM1	12	42	56	71
CGM2	0	30	58	70
CGM3	23	36	58	79
CGM4	21	20	41	55
CGH1	11	47	80	92
CGH2	20	30	65	89
CGH3	27	30	48	85
CGH4	15	52	68	86

*Data were taken three weeks after treatments. Each number is the average root length over the 3 replicates (n=3) expressed as percent reduction. The control which did not receive any treatment is considered having 100% of root length (n=6). The LSD(0.05)= 21%.

The Use of Corn Gluten Meal Hydrolysate as a Natural Product for Weed Control

D. L. Liu, N. E. Christians, and J. T. Garbutt

Some natural plant compounds inhibit growth and development of other plants and may function as herbicides or serve as the starting point for chemical synthesis of biodegradable herbicides. These materials are considered to represent an environmentally sound approach to weed control (Rice, 1984). It has been reported that corn gluten meal, which is a by-product of corn from the wet milling process, is useful as a natural preemergence herbicide and fertilizer for various plant production systems (Christians, 1993). Corn gluten meal is quite water-insoluble. This characteristic limits its use as an herbicide for some applications. It is difficult to apply evenly; as a result, there is a risk that the soil on which it is applied will not be completely covered, thereby reducing its effectiveness. Also, sprayable herbicides are advantageous for application to certain crops (Liu et al., 1994). Therefore, a continuing need exists for potent, natural preemergence herbicides that are also highly water dispersible and/or water soluble. The objective of this study was to compare the bioactivity of corn gluten meal and corn gluten hydrolysate in both petri dish and soil bioassays for weed control.

Description of Samples:

Corn gluten meal is commercially available as a byproduct of corn milling. It is made by drying the liquid gluten stream separated from corn during the corn wet milling process. Conventionally, corn gluten is filtered and dried to produce solid corn gluten meal, which is sold as an animal feed product. It is typically composed of 60 to 70% protein (Dry Basis).

Corn gluten hydrolysate may be prepared by a process that involves treating an aqueous slurry of corn gluten meal with proteases and amylases. The sample of gluten hydrolysate A (CGH-A) was prepared by treating the proteinaceous slurry with amylases, followed by filtration to remove the solubilized carbohydrates (Christians, 1994). The insoluble residue is then treated with one or more proteases to solubilize the protein components. After pH adjustment with acid, the slurry is filtered and centrifued. The effluent is dried in a conventional manner to yield CGH-A, which properties are listed in Table 64.

Corn gluten hydrolysate B was prepared by a simplified procedure which did not include amylase in the treatment but still yields a water-soluble form of lower protein content (about 70% protein, DB).

Growth Chamber Study:

A study was conducted in a controlled environment to investigate the effect of corn gluten hydrolysate A on creeping bentgrass and crabgrass. An aqueous dilution of the sample in 7 mL water was applied to a blotter paper measuring 42.3 cm^2 at levels of 0, 0.12, 0.24, 0.36, and 0.48 g/dm^2. Eighteen seeds were placed on the blotter papers which were then put into petri dishes, and placed into a controlled environmental chamber. The chamber was set at a 16h photoperiod and maintained at a constant 25°C. Table 65 illustrates the percentage of germination of the creeping bentgrass and crabgrass with varying application levels of the corn gluten hydrolysate A, which completely stopped germination of creeping bentgrass at application levels above 0.24 g/dm^2, and germination of crabgrass at application levels above 0.12 g/dm^2.

In the first greenhouse study, a comparison was made regrading the effects of corn gluten meal and the corn gluten hydrolysate (CGM-A) on the establishment of perennial ryegras (*Lolium perenne* L.). Application levels of the dry hydrolysate to the surface of soil pots seeded with L. perenne ranged from 0 to 7.8 g/dm^2. The pots were allowed to stay on the mist bench for a 24-hour period in order to moisten the soil with leaching of the water soluble corn gluten hydrolysate. Table 66 demonstrates the increased effectiveness of the corn gluten hydrolysate as compared with corn gluten meal. Treatment with 5.2 g/dm^2 of corn gluten hydrolysate resulted in 97% control. The same level of corn gluten meal, however, resulted in only 3% control.

In the second greenhouse study, the effect of two corn gluten hydrolysates materials (CGH-A and CGH-B) on crabgrass was compared. The crabgrass was seeded at a rate of 0.19 g/dm^2 onto 58 cm2 pots filled with a clay loam soil. The hydrolysates were applied to the surface of the pots at levels of 0, 0.86, 1.72, 3.44, and 6.88 g/dm^2. The pots were then placed on a mist bench for 6 days. After seed germination, the pots were moved to a greenhouse bench and maintained for 15 days. Data were collected on the number of live shoots from each pot. The study was repeated three times. Table 67 illustrates the results of this study. The CGH-A reduced the establishment of crabgrass by 76%, 96%, 100%, and 100% at application levels of 0.86, 1.72, 3.44, and 6.88 g/dm^2, respectively. The CGH-B reduced the establishment of crabgrass by 40%, 78%, 98%, and 100% at the same application levels. Thus, while CGH-B is somewhat less effective than CGH-A, it is still highly active.

This invention provides a selective, non toxic preemergence herbicide for use on soil plots to control weeds. Corn gluten hydrolysate has been found to provide a water-soluble material which is more active than corn gluten meal as preemergence herbicide. It completely stopped root formation of test species at an application level of 0.24 g/dm^2 in controlled environmental chambers and prevented plant establishment by 96% at a level of 1.72 g/dm^2 in greenhouse trials on soil. The corn gluten meal hydrolysate can potentially be used as a natural herbicide. U.S. patent No. 5,290,749, entitled "Preemergence weed control using plant protein hydrolysate" was issued on March 1, 1994. Corn gluten hydrolysate can be used as a growth-regulating material to inhibit root formation of germinating weeds in agricultural settings, and thereby act as natural preemergence herbicides.

References:

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Table 64. Properties of corn gluten hydrolysate A (CGH-A).

Appearance	Cream-tan powder
Dry substance, %	> 90
Solids recovery	> 50
Protein, % DB (% Kjeldahl nitrogen X 6.25)	>90
pH (as 5% solution)	> 6.5
Water solubility (as 10% w/v solution)	Soluble with slight haze
Ash, % DB	< 5
Odor	Characteristic odor

Table 65. The effect of corn gluten hydrolysate on germination of two grass species.

Percentage of Germination of Creeping Bentgrass and Crabgrass Treated with Corn Gluten Hydrolysate		
Level of Hydrolysate	Percent Germination (%)*	
(g/dm²)	C. Bentgrass	Crabgrass
0.00	61	67
0.12	44	6
0.24	11	0
0.36	0	0
0.48	0	0

*Values are means of scores of 3 replicates.

Table 66. The effect of corn gluten meal (CGM) and corn gluten hydrolysate A (C GH-A) on the establishment of perennial ryegrass on soil in the greenhouse.

Application Level of CGM and CGH-A (g/dm^2)	Percent of Inhibition (%)*	
	CGM	CGH-A
0.0	0	0
1.3	0	0
2.6	0	60
3.9	0	87
5.2	3	97
6.4	0	100
7.8	10	97

*Values are means of scores of 3 replicates.

Table67 4. The effect of two corn gluten hydrolysates on the establishment of crabgrass seedling on soil in the greenhouse.

Level of Hydrolysate (g/dm^2)	Crabgrass (% cover/pot)*	
	CGH-A	CGH-B
0.00	95	95
0.86	23	57
1.72	4	21
3.44	0	2
6.88	0	0

*Values are means of scores of 3 replicates.

Bioactivity of a Pentapeptide Isolated from Corn Gluten Hydrolysate on the Germination of Perennial Ryegrass Seeds

D. L. Liu and N. E. Christians

It has been found that hydrolysed corn gluten meal and 5 dipeptides, which could be isolated from corn gluten hydrolysate, have root-inhibiting activity and can be used as natural herbicides (1994 Iowa Research Report, pp 84 and 85). Two patents, numbers 5,290,749 anf 5,290,757, were issued by the U.S. Patent and Trademark Office on March 1, 1994 for use these products as preemergence weed control materials. The objective of this study was to continue to isolate and identify more biological compounds from corn gluten hydrolysate for weed control. On May 8, 1994, another bioactive compound was isolated from corn gluten hydrolysate and identified to be a 5-residue peptide, Leu-Ser-Pro-Ala-Gln. The inhibitory activity of the compound to germinating perennial ryegrass seeds is shown in Table 68. An international patent application entitled "Preemergence weed control using natural herbicides" was submitted in July of 1994.

Table 68. Bioactivity of Leu-Ser-Pro-Ala-Gln by using the perennial ryegrass petri dish bioassay*.

Pentapeptide	Percentage of Control** (%)	
μg/cm²	Root Length	Shoot Length
13	50.1±16.9	14.5±3.2
26	44.2±17.6	15.5±2.7
39	27.7±7.1	11.6±2.7
52	10.2±9.1	13.5±4.4
104	0	0.5±1.3

* Each dish contained a Whatman No. 1 filter paper measuring 38.5 cm^2 in area.

** Control had 1mL deionized distilled water per plate and was considered as 100%. Values are means of measurement of the length of 7 seedlings ± standard deviation.

Cellular Effects of Root Inhibiting Compounds Derived from Corn Gluten Meal

J. B. Unruh and N. E. Christians

In 1985, it was observed that unprocessed corn meal applied in large quantities to soil areas had an inhibitory effect on the establishment of germinating plants. Further studies showed that the protein fraction of corn grain, corn gluten meal, had higher levels of the inhibitor. The work of D.L. Liu and N.E. Christians, Iowa State University, subsequently led to the isolation and identification of five root inhibitory compounds contained in the water soluble protein extract from corn gluten meal. These compounds were identified as the dipeptides alaninyl-asparagine, alaninyl-glutamine, glycinyl-alanine, alaninyl-alanine, and glutaminyl-glutamine.

In an effort to better understand the efficacy of these root inhibiting dipeptides for weed control purposes, investigations are currently underway to determine the effects these compounds have on germinating perennial ryegrass seeds.

Microscopic studies focusing on cellular activity of treated and untreated plants are currently being done. In addition to the structural and morphological observations, studies using a radioactive isotope of the root inhibiting compound, alaninyl-alanine, are being conducted. This isotope is being used to trace the compound's movement through the seedling.

Results of these experiments show profound differences between treated and untreated seedlings. The cellular effects of the root inhibiting compounds appear to be concentration dependent. At low treatment levels, the cell structural integrity of the treated seedlings appears normal. At higher concentrations, however, the cells are greatly disrupted and the cell walls and membranes are not intact. Furthermore, the degree of severity is greatest on the perimeter of the root, and diminishes towards the cortex. Autoradiographs of seedlings treated with a low concentration of radioactive alaninyl-alanine, show uniform labeling throughout the root. As the level of treatment increases, the labeling intensifies and localizes itself only in the outermost layers of cells. At the highest level of treatment, virtually no label is noted on the interior of the root, and the damage appears to be a necrosis of the cells.

In addition to the structural and morphological differences between treated and untreated seedlings, differences in cell processes have been observed. Mitosis, the process by which cells replicate, is drastically altered. Differences in mitosis are seen regardless of the concentration of root inhibiting compound. There also appears to be a peculiar substance between the cells and in vacuole-like structures seen within the cells.

This project is nearing an end, and a comprehensive report detailing all the factors involving the cellular effects of these root inhibiting compounds is being prepared.

Fate of Nitrogen Applied to Turfgrass-Covered Soil Columns

S. K. Starrett, N. E. Christians, and T. A. Austin

Current public concern for the environment has focused attention on the environmental effects of chemical applications to turfgrass areas. Little research has been done concerning the environmental effects of nitrogen (N) applied to turfgrasses. Our objectives were to investigate the hydrology of 50-cm undisturbed soil columns with a Kentucky bluegrass turf intact macropores under a heavy (four 2.54-cm applications) and a light regime (sixteen 0.64-cm applications), and to measure the fate of N, using ^{15}N as a tracer, when applied to an undisturbed soil column. Mean leachate values for columns under heavy irrigation regime totaled about 6 times the amount collected from columns under the light irrigation regime. We found that the heavy irrigation increased N that leached through the 50-cm undisturbed soil columns by 30 times and decreased volatilization of liquid urea compared with the light irrigation.

Fate of ^{15}N Amended Urea in Turfgrass Biosystems

S. K. Starrett, N. E. Christians, and T. A. Austin

The fate of nitrogen (N) has been studied under several agronomic crops and agricultural profiles, but relatively little information has been collected from areas managed as turfgrass. The turfgrass industry has become the focus of environmental concerns in recent years and is often identified as a source of ground water contaminate. The objectives of this study were to investigate the hydrology of (20-cm diameter by 50-cm depth) undisturbed soil columns covered with a Kentucky bluegrass (*Poa pratensis* L.) turf under a heavy (one 2.54-cm application) and a light (four 0.64-cm applications) irrigation regime; and to quantify the fate of ^{15}N-labeled urea when it is applied to an undisturbed soil column having intact macropores. Clipping, verdure, and thatch/mat samples were taken from each column, and the soil was excavated in 10-cm layers at the end of the 7-day test period. A glass collection chamber was used to collect volatilized N and a plastic bag for leachate collection. All samples were analyzed for atom % ^{15}N. Volatilization of N was negligible because irrigation was applied immediately after the application of N. The heavy irrigation regime significantly increased the transport of N below 30-cm by 5 times, compared to the light irrigation regime. Eighty-five percent of the N found in the leachate from the 50-cm columns was in the urea form indicating that macropores may have played a major role in transport of surface applied N through the soil profile.

Comparing Chloride Transport in Undisturbed and Disturbed Soil Columns Under Turfgrass Conditions

S. K. Starrett, S. E. Luke, N. E. Christians, and T. A. Austin

Transport of surface applied chloride in undisturbed soil columns with intact macropores was compared to disturbed, repacked columns of the same soil. The total amount of chloride that leached from 20-cm deep soil columns was 2.0 times higher for the undisturbed columns than for the disturbed columns. Chloride (CL) recovered (mass basis) in layer #2 (6.7 to 13.4-cm) was 1.79 times higher and in layer #3 (13.4 to 20.0-cm) was 2.72 times higher for the disturbed soils than for the undisturbed. For the plant and thatch layer (0.0 to 2.0-cm) the opposite was observed, total CL recovered from the undisturbed columns was 2.4 times higher than the disturbed columns.

Cargill Particle Size Corn Gluten Meal Study - 1994

B. R. Bingaman and N. E. Christians

The objective of this study was to assess the efficacy of different corn gluten meal products on the survival of creeping bentgrass, *Agrostis palustris* Huds. Six samples of various particle mesh sizes were supplied by Cargill and were compared with standard pelletized and nonpelletized (powdered) corn gluten meal produced by Grain Processing (Table 69).

Eight different corn gluten meal material and an untreated control were screened. The Cargill products had particle sizes of >20, <20, >10, 10-20, 20-40, and <40 mesh. The pelletized material from Grain Processing was their standard product consisting of pellets of various sizes. Their nonpelletized material was a very fine, dusty powder.

The materials were applied at 0.0, 0.353, 0.706, and 1.058 g/pot on the basis of weight of product per surface area of the pots. These rates correspond with 0.0, 20.0, 40.0, and 60.0 lbs/1000 ft^2, respectively. The recommended rate for CGM is 20 - 40 lbs/1000 ft^2.

All plants were grown under greenhouse conditions in #3, square, Lockwood green plastic pots with a 7.0 cm top diameter. The planting medium was sifted Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll). Bentgrass seeds were planted at a depth of 0.6 cm.

Soil surface preemergent (PRE) and preplant incorporated (PPI) application methods were used. For the PRE treatments, the pots were filled with soil to the 0.6 cm from full line. The seeds were planted on this surface and were covered with enough soil to fill the pots. The PRE materials were then spread evenly on the soil surface. The PPI treatments were evenly mixed with the volume of soil sufficient to fill the upper 2.5 cm of the pots. Three-quarters of this soil and corn gluten meal mix was placed into the pots and the seeds were planted on this surface. The remaining one-quarter of the mix was used to cover the seeds. By using these methods the seeds in the PRE and PPI treated pots were planted at the same depth.

Supplemental lighting from high-pressure sodium lamps was used to enhance the natural irradiance and to extend the daylength to 16 hours. These lights delivered approximately 70 mmoles m^{-2} s^{-1} of irradiance.

To ensure maximum germination rates, the soil was kept moist for 14 days and was then allowed to dry until the untreated control plants were wilting. Because corn gluten meal inhibits the formation of roots at the time of germination, the efficacy of the various materials was assessed at this time by evaluating the response of treated plants to moisture stress. These plant stress data represent the number plants per pot that were still green and presumed alive. All plants were then thoroughly watered and kept moist for 3 days. The number of he number of green, living plants per pot were again counted. These plant survival data were taken to measure the ability of some plants to recover from severe moisture stress and are another indication of the degree of root inhibition caused by the corn gluten meal.

The lengths of the primary roots also were measured for Replication 1 to obtain a visual estimation of the amount of root inhibition that was present. A representative plant in each pot was carefully extracted and the soil was removed. The length of the longest root was taken and these measurements are included in.

Two sets of three replications were conducted using the same protocol and under the same growing conditions. The first 3 replications were started on November 1 and ended on November 21. The second set was begun on November 7 and terminated on November 29.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) by using the Analysis of Variance (ANOVA) to test the significance of the corn gluten meal products and application methods on bentgrass survival. Least significant difference (LSD) tests were used to compare means among the treatments.

Table 69. Survival after a period of moisture stress of creeping bengtrass receiving soil incorporated (PPI) Cargill and Grain Procesing corn gluten meal materials.

Treatment	$lbs/1000\ ft^2$	Mean Plant Survival	% Reduction in Plant Survival
Untreated control	0	126	---
>20 mesh CARGILL	20	72	43
>20 mesh CARGILL	40	34	73
>20 mesh CARGILL	60	54	57
<20 mesh CARGILL	20	78	38
<20 mesh CARGILL	40	54	57
<20 mesh CARGILL	60	27	79
>10 mesh CARGILL	20	85	33
>10 mesh CARGILL	40	50	60
>10 mesh CARGILL	60	46	63
10-20 mesh CARGILL	20	53	58
10-20 mesh CARGILL	40	36	71
10-20 mesh CARGILL	60	30	76
20-40 mesh CARGILL	20	57	55
20-40 mesh CARGILL	40	31	75
20-40 mesh CARGILL	60	33	74
<40 mesh CARGILL	20	45	64
<40 mesh CARGILL	40	62	51
<40 mesh CARGILL	60	22	83
pelletized GPC	20	68	46
pelletized GPC	40	34	73
pelletized GPC	60	49	61
powdered GPC	20	66	48
powdered GPC	40	42	67
powdered GPC	60	75	40
$LSD_{0.05}$		44	

Table 70. Survival after a period of moisture stress of creeping bentgrass receiving surface applied (PRE) Cargill and Grain Processing corn gluten meal materials.

Treatment	lbs/1000 ft^2	Mean Plant Survival	% Reduction in Plant Survival
Untreated control	0	148	---
>20 mesh CARGILL	20	29	80
>20 mesh CARGILL	40	36	76
>20 mesh CARGILL	60	27	82
<20 mesh CARGILL	20	52	65
<20 mesh CARGILL	40	34	83
<20 mesh CARGILL	60	24	84
>10 mesh CARGILL	20	77	48
>10 mesh CARGILL	40	54	64
>10 mesh CARGILL	60	31	79
10-20 mesh CARGILL	20	48	68
10-20 mesh CARGILL	40	28	81
10-20 mesh CARGILL	60	26	82
20-40 mesh CARGILL	20	74	50
20-40 mesh CARGILL	40	32	78
20-40 mesh CARGILL	60	24	84
<40 mesh CARGILL	20	76	49
<40 mesh CARGILL	40	55	72
<40 mesh CARGILL	60	21	86
pelletized GPC	20	38	74
pelletized GPC	40	33	78
pelletized GPC	60	33	78
powdered GPC	20	62	58
powdered GPC	40	55	63
powdered GPC	60	32	78
$LSD_{0.05}$		33	

A Greenhouse Study on the Environmental Requirements for Forecasting Pythium Blight on Golf Courses

J. Livingston, F.W. Nutter, and N.E. Christians

Pythium blight, caused by *Pythium aphanidermatum* (7), is a warm weather turfgrass disease that can destroy extensive turf areas very quickly. In the aftermath of a severe outbreak of Pythium blight, it is usually necessary to re-establish the turfgrass species (2).

Pythium aphanidermatum is a foliar pathogen, and is first seen on turf as irregular water-soaked spots. Later, leaves fade to a light brown color and senesce. Patches of diseased areas then combine to form streaks of diseased turf which can be as large as ten feet in diameter. Diseased plants often have a greasy appearance and may be covered with white, cobweb-like mycelium.

P. aphanidermatum belongs to the Oomycetes family of fungi. Oomycetes are water-loving organisms which spread rapidly in saturated soils. This is why blighting frequently coincides with surface water drainage patterns (2). The fungus sexually produces a resistant, overwintering structure called an oospore. When conditions are favorable, oospores (located mostly in the thatch layer) may germinate and infect healthy turfgrass. The newly formed mycelia then actively spreads from plant to plant, as well as by surface drainage and mowing (3).

Little is known about the factors affecting oospore germination in soil, but according to Adams (1971), a soil temperature of 30°C, and a pH of 7.5 was needed for optimum *P. aphanidermatum* oospore germination(1). The disease is also more severe on high alkaline soils combined with high fertility. Plants grown under low calcium conditions are also more susceptible to Pythium blight(2).

Pythium blight has been widely known by superintendents to be dependent on two important environmental factors: temperature and moisture. Disease is most likely to occur when the maximum daily temperature is higher than 30°C, followed by at least 14 hours of high relative humidity (at least 90%). If the minimum temperature during the high relative humidity time period does not drop below 20°C, then conditions are considered favorable for Pythium blight development. Below 20°C, there is little or no risk of the disease (7).

Golf course superintendents can make use of these environmental requirements to determine when to apply fungicides to prevent damage from the disease. By limiting fungicide applications to only those periods of time which are favorable for Pythium development, a superintendent can be both environmentally safe and more cost efficient(5). Management practices such as fertilization, mowing, irrigation, and syringing can also be altered to make conditions less favorable for the pathogen, thereby reducing the need for fungicide applications.

The above forecasting system is based on work done by F.W. Nutter (7). The system was developed by placing hygrothermographs, instruments that monitor temperature and relative humidity, on golf courses in areas that represented different levels of disease risk. Hygrothermographs were placed where Pythium blight frequently occurred, where the disease had occurred in some years, and in areas where disease seldom occurred. Each hygrothermograph was housed and placed about 15 cm above the soil line. Pythium outbreaks were visually monitored daily for disease presence in relation to the temperature and relative humidity data collected from earlier studies. When the hygrothermographs recorded maximum temperatures at greater than 30°C, along with 90% relative humidity for at least 14 hours, and the minimum night time temperature above 20°C, Pythium blight was correctly forecast with 96% accuracy (7). Testing in Iowa during 1991 to 1994 has demonstrated that the forecasting model works very well in this region.

Although much of the research to date has been conducted in the field, controlled environment experiments are needed to verify the model and to improve on the forecasting system in its present form. Controlled environment studies on Pythium blight have not been widely reported. Therefore the purpose of this study was to determine the environmental conditions necessary for Pythium blight development on creeping bentgrass (*Agrostis palustris*) using controlled environmental chambers.

First, it was necessary to use a Pythium inoculum that could be distributed evenly over a potted area. An air-dried corn cob medium infested with *Pythium aphanidermatum* as developed by Nutter and Cole(8) was used for the greenhouse study. When properly dried, the inoculum contains only oospores(8).

The medium was prepared by placing 250 grams of number 4 corn cob pellets into a 2 Liter flask and adding 100 mls of distilled water. The pellets were then allowed to expand (5 min.) before 4 grams of calcium carbonate dissolved in another 100 mls of water was again added to the flask. Two flasks were prepared in this way; one to be inoculated and one to be used as the control. The flasks were capped and autoclaved twice for 45 minutes(121°C at 15 psi). One flask was then aseptically inoculated by placing 5 discs from each of three isolates of *Pythium aphanidermatum* grown on corn meal agar into the flask. The flasks were then placed in an incubator at 27°C for 14 days. After 14 days, the inoculum was placed into sterile pans covered with 4 layers of cheesecloth, and then air dried in the pans for 8 days. Once dry, the inoculum (which contains oospores) was stored in air tight containers until the time of inoculation (8).

Five maximum temperature treatments were randomly assigned to separate temperature controlled chambers. The five temperatures were as follows: 21, 24, 27, 30, and 33°C.

For each temperature treatment, two 4" pots of Penncross creeping bentgrass seedlings (14 day growth), seeded at a rate of 0.05 g/dm^2, were put into each temperature chamber. One pot contained about 2.5 grams of corn cob inoculum placed about 2 cm under the seed at the time of seeding, and the other contained the same amount of the non-inoculated control. The bentgrass was seeded into a sterile mixture of soil, sand, peat, and perlite (1:1:1:1, v:v). Each temperature treatment was replicated four times. After each replication, the temperature chambers were again randomly assigned the five temperatures to be tested.

The seedlings were left in the temperature chambers for 8 hours, and were then placed into a high humidity dew chamber set at 24°C until Pythium blight was observed. The treatments were checked at two hour intervals after the first 12 hours of incubation.

Appearance of Pythium blight did not occur on any treatment during the initial experiment. The study was concluded after 20 hours incubation. Only after the treatments were again placed in very high temperature stress for over 10 hours, and then placed in a dew chamber for approximately 48 hours, did any sign of Pythium blight appear. It was not possible in this study to determine if the disease had actually originated from oospores in the corn cob inoculum.

Growth inhibition of the seedlings was observed early in the experiment, which was probably due to the effects of the corn gluten material in the inoculum. Also, many soil saprophytes were observed on the soil media during seedling germination. What affect the saprophytes had on the Pythium inoculum is unknown.

In a subsequent experiment, bentgrass plants were inoculated with new CCI amended with V-8 juice to increase oospore formation. The inoculum was mixed 1:1 with the greenhouse mix and was added to the upper layer of the treated pots.

After about 10 hours of high temperature stress at 33°C, the 6 week old treatments were then placed in a dew chamber until Pythium blight was observed. Pythium infection was noticed as early as 36 hours after the treatments were placed in the dew chamber. When treatments using both the non-amended inoculum and the V-8 amended inoculum were run side by side, only the V-8 inoculated treatments became infected with Pythium blight. The number of hours until Pythium blight was observed varied from 36 to 60 hours for each of three replications.

There are a few possibilities that can be discussed as to why Pythium blight was not observed during the initial experiment. For instance, the inoculum being placed 2 cm below the soil mixture could have inhibited oospore germination. It is also possible that the pH of the soil was not at an optimum for disease development. A new experiment has been started which tests Pythium blight development using inoculum mixed 1:1 with the soil mixture, and with the inoculum placed on the soil surface.

Another reason for the lack of disease development could be with the inoculum itself. Only a few oospores were visible in the corn cob pellets, not as many as was desired. V-8 juice was later tried, and the juice seemed to help stimulate oospore formation. There is also research which suggests that lecithins, phospholipids obtained from egg yolk, stimulate and induce oospore formation in *Pythium aphanidermatum*(4). In future experimentation, careful cultures of the dry inoculum will be used to try to ensure a large population of oospores in the inoculum. The possible use of other types of inoculum, such as infested rye grain, is also being evaluated.

The data obtained on the environmental requirements of Pythium blight in controlled environments to date is not conclusive. Obviously, some requirement was not met during the study. Important knowledge on the methodology necessary to produce Pythium blight on turfgrass in the greenhouse was obtained for use in further research.

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Managing Dry Spots on Bentgrass Putting Greens

D. D. Minner, S. Bughrara and J. H. Dunn

Preliminary results from our topdressing trials with calcined clay indicated that there may be some inhanced cooling and moisture retention properties associated with calcined clay topdressing. Instead of just topdressing with calcined clay, our goal was to incorporate some of the material by topdressing following hollow tine coring. The study was situated on an area of the green that had a history of dry spot and was difficult to manage.

Year 1 - 1993

A localized dry spot study was developed in the southwest corner of the small USGA Green located at the University of Missouri Turf Research Center, Columbia, MO. The green was constructed in the spring of 1992 and sodded with creeping bentgrass from Rohoza Sod Farm in Pennsylvania. This 25 ft x 25 ft area of the green has approximately a 3% slope and required daily hand syringing. On 30 July the dry spot trial was divided into two areas for treatment. The highest location had the most severe dry spot injury and the lower location had only moderate dry spot injury. Two treatments consisted of topdressing with sand or Profile. There were six replications of each 2 ft x 12 ft treated plot per location. A 3/32-inch topdressig was applied for each treatment immediately following hollow core aerification with 3/8-inch tines on two-inch centers. The three-inch cores were removed before topdressing and the topdressing was lightly broomed into the holes. On 14 October topdressing treatments were applied at 1/32 inch without core aerification. Plots were watered with overhead irrigation and by hand to promote recovery of the dry spot areas. Data collected on 1 September represents the level of injury that typically occurs after our highest summer stress period. Data collected on 14 October represents the amount of turf recovery that occurred when cooler temperatures promoted better growing conditions.

On 1 September, following the summer stress period, Profile topdressing significantly improved turf quality and reduced dry spot injury (Table 71). In the severe dry spot location, turf quality was 5.0 for Profile and 3.3 for the sand. Profile also had 23% less dry spot injury. On 14 October, after the fall recovery period, Profile topdressed plots had a turf quality of 5.7 compared with just 4.0 for sand. The net result is that there was 25% more turf cover with Profile-treated plots compared to sand. This trend for improved turf with Profile was also evident in the "moderate dry spot" location.

Core aerification and topdressing of sand-based greens with Profile significantly improves turf quality and reduces the amount of turf injury from localized dry spots.

Year 2 - 1994

The same localized dry spot areas of 1993 were again core aerified and topdressed with either Profile or sand in 1994. Plots were cored on 9 May, 25 June and 17 September of 1994. After each coring, topdressing materials were applied at 5/16 inch, broomed into holes and watered. From 12 to 18 July, water was restricted to allow dry spot symptoms to appear. From 19 to 22 July, all plots were hand syringed once daily to simulate a golf course superintendent's practice of "cooling greens". After 23 July all plots received sufficient irrigation to promote turf recovery. On 18 September six more replications of each 2 ft x 12 ft treatment were constructed for drying in 1995. A 3/32-inch topdressing was applied for each treatment immediately following hollow core aerification with 3/8-inch tines on two-inch centers. The three-inch cores were removed and topdressing treatments were lightly broomed into the holes.

The overwhelming observation was that the Profile-topdressed plots never developed severe localized dry spot. Profile-treated plots also recovered faster and with better turf cover than the sand-topdressed plots (Table 72). Turf plots topdressed with Profile have better quality and color than the sand-topdressed plots (Table 72). The percent of area wilted in the Profile-treated plots was significantly lower than the area wilted in the sand-treated plots. Dew was less visible on the Profile-treated plots than the sand-treated plots (Table 72).

Canopy temperatures taken with an infrared thermometer on 20 and 30 July of 1994 were 24.4 and 18°F cooler on the Profile plots (105 and 105°F, respectively) compared to the sand plots (128.4 and 123.4°F, respectively). In general, the Profile plots were 6.5 to 9°F cooler during the period from 10 to 29 July. Soil temperatures at one and three inches below the surface were 1 to 1.4°F cooler in the Profile-treated plots (Table 72). Profile-treated plots had significantly less topdressing material visible 3 days after treatment (Table 72).

Turf injury from localized dry spot may be reduced by mid summer coring of problem areas followed by topdressing with Profile. Irrigation, syringing and green cooling practices will be required to get the maximum effect from treatment with Profile.

Table 71. Quality and % turf cover of creeping bentgrass on severe and moderate localized dry spot areas topdressed with sand or Profile.

Topdress treatment	Severe dry spot location				Moderate dry spot location			
	9/1/93 After stress		10/14/93 After recovery		9/1/93 After stress		10/14/93 After recovery	
	Quality	Dry Spot % Area	Quality	% Turf Cover	Quality	Dry Spot % Area	Quality	% Turf Cover
Sand	3.3	63.3	4.0	50.8	4.5	32.5	5.3	79.2
Profile	5.0*	40.0*	5.7	75.8*	5.5	17.5*	6.7	94.2*

* Significant at 0.05 probability level.

Table 72. Several parameter measurements for localized dry spot areas. Core aerified and topdressed with Profile and sand on the USGA green at the MU Turf Research Center in 1994.

		1994											
	Treatment	6/1	6/13	6/29	7/4	7/10	7/11	7/20†	7/23	7/28	7/29	7/30	8/30
Quality 1 - 9; 9 = best	Profile	8.3**		7.5**		8.0**		8.2**					8.2**
	Sand	7.3		5.8		7.2		5.2					6.7
Temp Surface °F	Profile		90.3^{NS}	87.7*		91.3^{NS}			97.5**		86.0**		
	Sand		90.7	91.2		91.2			103.8		94.7		
Temp 1" Depth °F	Profile		86.8*	82.2^{NS}		90.7^{NS}			90.2^{NS}		79.1**		
	Sand		87.8	83.5		90.5			89.7		87.2		
Temp 3" Depth °F	Profile		83.8	79.2		89.5			85.7		75.5		
	Sand		85.2	80.0		89.5			86.7		82.7		
Topdress Visible %	Profile			60.8**									
	Sand			72.5									
Canopy Temp Tc	Profile						94.0**	104.0**	96.8**		106.4**	105.4**	
	Sand						100.5	128.4	104.6		115.4	123.4	
Canopy Temp Decrease by Profile							6.5°F	24.4°F	7.8°F		9.0°F	18.0°F	
Dew 1 - 9; 9 = most dew	Profile				1.8**								
	Sand				4.0								
Color 1 - 9; 9 = greenest	Profile					8.8**							
	Sand					7.8							
Area wilted %	Profile							20.8**					
	Sand							80.8					
Recovery after drying %	Profile												85.8*
	Sand												55.0

Tc = Canopy temperature measured by infrared thermometer.

*, ** Significantly different at the 0.05 and 0.01 probability level.

^{NS} Non-significant.

$^{+}$ Very hot day.

Ornamental Studies

Evaluation of Deciduous Azaleas for Iowa

J. K. Iles

The Northern Lights series of deciduous azaleas, resulting from crosses between Mollis hybrids (*Rhododendron* × *kosteranum*) and rose-shell azaleas (*Rhododendron prinophyllum*), is the only group of azaleas that dependably withstand harsh Midwestern winters and annually produce spectacular blooms. Flower buds on these hybrids have proven to be hardy to -45°F. Northern Lights azaleas can be seen flowering in late May or early June in a number of vibrant colors. Many other types of deciduous azaleas are available in the nursery trade today, but we have very little information about their adaptability to the Iowa climate. Therefore, in the spring of 1994 a deciduous azalea trial was initiated at the Iowa State University Horticulture Research Station, to evaluate several promising azalea selections for use in Iowa. Deciduous azaleas were obtained from Roslyn Nursery, Dix Hills, New York, and are briefly described below.

Plant Materials

Rhododendron **`Jane Abbott´** - A hardy, upright plant with fragrant pink flowers that appear in late May.

Rhododendron **`July Jewel´** - Maturing at about 3 feet, this David Leach introduction blooms in early July with salmon flowers.

Rhododendron **`July Joy´** - Salmon-pink flowers appear in early July on this upright growing David Leach selection.

Rhododendron **`July Jubilation´** - This well-branched, low-growing David Leach hybrid has fragrant, bright red flowers with a light orange blotch in mid July.

Rhododendron **`Lemon Drop´** - A Weston Nurseries introduction with yellow flowers in early July. Flowers have a lemony fragrance and autumn foliage is red.

Rhododendron **`Pink and Sweet´** - A Weston Nurseries introduction with fragrant, pink flowers that appear in July.

Rhododendron **`Vinecourt Troubadour´** - This dense, upright plant has double red flowers in mid May.

Rhododendron **`Vineland Delight´** - This selection bears deep pink flowers on an upright, dense plant.

Rhododendron **`Vineland Dream´** - An extremely floriferous plant producing bright pink flowers with a slight orange flare.

Crabapples for Iowa Landscapes

J.K. Iles

TAXA	FLR[1]	FRT[2]	HT/WD	FORM[3]	COMMENTS
`Adams´	R	DR	20/20	Round	Dense; one of best reds
`Adirondack´	W	R	20/10	Upright	Good for parkway use
`Amberina´	W	OR	12/12	UpOval	Yellow fall leaf color
`Anne E.´	W	R	10/10	Weeping	Birds attracted to fruit
`Autumn Glory´	W	OR	15/15	Spreading	Birds attracted to fruit
baccata `Walters´	W	YO	15/15	Round	Yellow fall leaf color
`Bob White´	W	Y	20/25	Horizontal	Birds attracted to fruit
`Candied Apple´	P	DR	15/15	Weeping	Good for espalier
`Centurion´	R	R	20/15	UpSpreading	Parkway use if pruned
`David´	W	R	15/15	Round	Post-frost fruit color
`Donald Wyman´	W	R	20/20	Round	Post-frost fruit color
`Doubloons´	W	Y	12/10	UpSpreading	Heavy bloomer
floribunda	P/W	Y	20/25	Horizontal	Birds attracted to fruit
Golden Raindrops™	W	Y	20/15	UpSpreading	Fine-textured
Harvest Gold®	W	Y	20/15	UpSpreading	Post-frost fruit color
`Indian Magic´	P	OR	15/15	Round	Excellent fruit display
`Indian Summer´	R	R	20/20	UpSpreading	Red-orange fall leaf color
`Jewelberry´	W	R	12/15	Spreading	Birds attracted to fruit
`Louisa´	P	Y	15/15	Weeping	Fine-textured
Madonna™	W	R	20/15	UpSpreading	Double flowers
Molten Lava®	W	OR	15/15	Horizontal	Birds attracted to fruit
`Pink Satin´	P	DR	15/15	Rounded	Clear pink flowers
`Prairifire´	R	DR	20/20	UpSpreading	Orange-red fall leaf color
`Professor Sprenger´	W	OR	25/25	Round	Persistent fruit
`Profusion´	R	DR	20/20	UpSpreading	Orange fall leaf color
`Red Barron´	R	R	18/10	Columnar	Red-orange fall leaf color
`Red Jade´	W	R	15/15	Weeping	Needs space to develop
`Red Jewel´	W	R	18/12	UpOval	Post-frost fruit color
`Red Splendor´	P	R	25/25	UpSpreading	Red-purple fall leaf color
`Red Swan´	W	R	15/15	Weeping	Improved `Red Jade´
sargentii	W	R	6/12	Horizontal	Birds attracted to fruit
`Sentinel´	W	R	15/10	Upright	Parkway use if pruned
`Serenade´	W	O	12/12	Semi-weeping	Excellent fruit display
`Silver Moon´	W	DR	25/15	UpOval	Blooms late in the season
`Sinai Fire´	W	OR	15/15	Weeping	Persistent fruit
`Snowdrift´	W	O	20/20	Round	Birds attracted to fruit
Sugar Tyme®	W	R	20/20	Round	Persistent fruit
`Winter Gold´	W	Y	25/20	Vase-shaped	Excellent yellow fruit
× *zumi* `Calocarpa´	W	R	15/20	Horizontal	Birds attracted to fruit
× *zumi* `Winter Gem´	W	R	15/12	UpSpreading	Small persistent fruit
× *zumi* `Wooster´	W	OR	12/15	Horizontal	Good winter fruit color

[1]FLR=flower color: R=red; P=pink; W=white; P/W=pink and white
[2]FRT=fruit color: R=red; DR=dark red; O=orange; Y=yellow; OR=orange-red; YO=yellow-orange
[3]FORM: UpSpreading = upright-spreading; UpOval = upright-oval

Shade and Ornamental Tree Trials

J. K. Iles

The Shade and Ornamental Tree Trial project is sponsored by the Iowa Nurserymen's Research Corporation in cooperation with the Department of Horticulture at Iowa State University. The project was initiated in 1986, and grows larger each year as new trees are added to the collection. A significant number of trees in the trial were purchased with funds donated by the Research Corporation, however, in recent years trees have been donated by several institutions as part of annual "trial packs". In 1995, J. Frank Schmidt & Son Co. and the Landscape Plant Development Center shipped trees to ISU for evaluation at the Horticulture Station trial site (USDA hardiness zone 5a). The goal of this project is to provide reliable plant performance information to industry professionals and to the citizens of Iowa. Trees that have routinely excelled, or those showing promise are described below.

Acer platanoides **Crystal™** (Norway maple) - A Bailey Nurseries introduction made in Oregon by Max Lamis. Expected to grow 50 to 60 feet tall, Crystal is noted for a vigorous, straight trunk. It reportedly has better branching than Emerald Lustre™ with a lighter colored leaf tip.

Acer platanoides **Emerald Lustre™** (Norway maple) - Selected in Minnesota and introduced in 1980, Emerald Lustre™ grows vigorously and develops excellent branching when young. The tree demonstrates greater winter hardiness than most other Norway maples and its leaves show outstanding scorch resistance. Trees are expected to grow about 60 feet tall and 50 feet wide.

Acer rubrum **Fairview Flame®** (red maple) - Although the tree is sold as *Acer rubrum*, the leaves of Fairview Flame® are similar to those of many *Acer × freemanii* cultivars in the trade today. The exact origin of Fairview Flame® is unknown, however, some think it was a chance selection from a population of 'Armstrong' seedlings (an *Acer × freemanii* type). The handsome scarlet to reddish-orange fall leaf color develops relatively late in central Iowa (late October), yet trees have not suffered winter die-back or sunscald injury. The tree develops a very uniform canopy, but its growth rate could be characterized as slow to moderate (6 to 8 inches/year). McGill & Son Nurseries introduced Fairview Flame® and propagate it on its own roots.

Acer saccharum **'Legacy'** (sugar maple) - If you're looking for a sugar maple with a dense, full crown, leathery dark green leaves that resist scorch and tatter, and excellent long-lasting yellow-orange fall leaf color, then your choice should be 'Legacy'. 'Legacy' is a Bill Wandell introduction (Discov-Tree Research) and is expected to grow 50 feet tall and about 35 feet wide. Some growers and retailers in northern Iowa describe a lack of winter hardiness with 'Legacy', however, this selection is reportedly thriving in Chanhassen, Minnesota (USDA hardiness zone 4a).

Aesculus × **'Homestead'** (buckeye) - 'Homestead' is a buckeye of hybrid origin (*Aesculus glabra* × *Aesculus flava* or possibly *Aesculus* × *sylvatica*) introduced by researchers from Brookings, South Dakota. The original tree was planted in the early 1900's, however, the seed came from a tree near Des Moines, Iowa. 'Homestead' has performed admirably throughout the upper Midwest earning it a USDA hardiness zone rating of 4 (some actually say zone 3). It is a vigorous, strong-growing tree, eventually developing a broad, rounded form with slightly pendulous lower branches. 'Homestead' begins producing its characteristic yellowish-white flowers as early as 3 to 4 years of age, but most are sterile and therefore only a few seeds are produced each year. Summer foliage is dark green and has proven resistant to leaf-blotch and powdery mildew. Fall color, usually occurring in mid-October, is spectacular with leaves turning shade of carmine-red and pumpkin-orange.

Fraxinus pennsylvanica **Prairie Spire™** (green ash) - This male green ash selection from North Dakota State University is characterized by a striking, narrowly erect growth habit, accented by a strong central leader and dense lateral branching. Unlike `Summit′ which tends to broaden with age, Prairie Spire™ stays relatively slim, becoming narrowly pyramidal-elliptical as it matures. Summer leaves are dark green and semi-glossy, but fall color has not lived up to its advance billing. Instead of intense golden-yellow as promised by the introducers, we see uninteresting shades of yellow-brown. Nevertheless, Prairie Spire™ seems well-suited to street-side or parking lot planter use. The tree is hardy to USDA hardiness zone 3.

Liquidambar styraciflua **Moraine™** (sweetgum) - Sweetgum are not reliably hardy in many parts of Iowa, however, Moraine™ sweetgum has survived two winters at the ISU Horticulture Research Station without a hint of branch die-back. Expected to grow 60 feet tall and 40 feet wide, Moraine™ should be spring-planted in full sun with adequate space for root growth. Dark glossy-green leaves turn brilliant red and burgundy in fall. Golf course managers should be aware, however, the large woody fruits of Moraine™ may create a nuisance when they fall from the tree.

Prunus maackii (Amur chokecherry) - Hardy at least to -35° F, Amur chokecherry should thrive in just about any landscape in Iowa. The common name, Amur chokecherry refers to the species's native habitat along the Amur River in northeastern China. Though Amur chokecherry produces small racemes of white spring flowers and pea-size dark-purple fruit, the main ornamental feature is its bark. Golden brown and glossy, it peels off in thin strips when mature. Lit by afternoon sun or seen against a backdrop of snow, the beautiful bark of *Prunus maackii* is an unforgettable sight.

Sorbus alnifolia (Korean mountain ash) - Korean mountain ash produces flat-topped clusters of white flowers in mid-May. Highly ornamental small, pea-sized fruits ripen in September and vary in color from bright reddish-pink to reddish-purple. As the fruit ripens, leaves change from dark green to a stunning blend of oranges and browns. Trees will grow 30 to 40 feet tall and about as wide. *Sorbus alnifolia* adapts to alkaline soils and prefers good drainage. Its fibrous roots contribute to ease of transplanting and rapid establishment in the landscape.

Evaluating a Gravel Bed System to Improve Survival and Growth of Bare-Root Trees Transplanted in Mid-Summer

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C. Starbuck, University of Missouri

Significance to Nursery/Landscape Industry

Increasing freight costs, price depression due to competition from mass-market outlets, and labor shortages are creating pressure on all segments of the nursery/landscape industry to invent and develop more efficient methods of producing and handling nursery stock. Our proposed research will evaluate the performance of a gravel bed system that permits the planting of bare-root nursery stock throughout the growing season. If the performance of gravel bed trees harvested and transplanted in mid-summer is comparable to the performance of transplanted container-grown and dormant-planted bare-root trees, then retailers and landscape nurseries will have the option of selling and planting less expensive and lighter weight bare-root stock all summer. Because this production method does not require the use of containers, carefully prepared media, and other expenditures typical of container culture, substantial cost savings might be realized which could be passed on to the retail customer.

Objective and Justification

The objective of this research is to compare the growth of bare-root trees held in a gravel bed and field-planted in mid-summer with growth of dormant bare-root trees field-planted in early spring, and growth of container-grown trees field-planted in mid-summer. Bare-root nursery stock is less expensive to produce and ship than container-grown or balled and burlapped (B&B) stock. Historically, the use of bare-root stock has been restricted by the perception that it must either be planted in early spring or potted. But preliminary studies indicate the bare-root planting season might be safely extended into mid-summer using a novel technique in which bare-root nursery stock is held in a bed of irrigated gravel (see NM-PRO, March 1995). Results show trees and shrubs held in a gravel bed can be planted in mid-summer with survival rates equal to, or greater than those expected for container-grown or B&B plants. As promising as these early results are, additional work is required to better characterize the performance of gravel bed plants after planting in the field.

Present Status of Research

The initial research on the gravel bed technique was conducted in 1987 at the University of Missouri. `Hopa´ crabapples and `Whitehouse´ callery pears taken from a gravel bed and field-planted in July showed 100% survival. Subsequent studies using `Aristocrat´ and `Redspire´ callery pear, redbud, flowering dogwood, maples, lindens, and hybrid tea roses confirmed that trees and shrubs can be planted bare-root in full leaf in mid-summer with essentially 100% survival if held in a bed of irrigated pea gravel. In 1994, Sherman Nursery Co. (Charles City, IA) held 500 dormant trees (approximately 30 species) in gravel beds until August 25 before they were field planted. And again, the results were very encouraging.

Research Methodology

Trees of Washington hawthorn (*Crataegus phaenopyrum*), Eastern American redbud (*Cercis canadensis*), green ash (*Fraxinus pennsylvanica*), and red maple (*Acer rubrum*) were removed from cold storage at Sherman Nursery Co. (Charles City, IA) in early May 1995, and randomly assigned to three treatments. Controls (bare-root trees for immediate field planting) and trees to be potted, were packed in boxes for transport to the Iowa State University Horticulture Research Station (Ames, IA). Container-grown trees were planted in appropriately-sized containers (7-10 gal.) in a bark/sand medium, and grown until July. Gravel bed trees were placed upright in 18-inch-deep pea gravel at Sherman Nursery, fertilized with a granular slow-release fertilizer applied to the gravel surface, and drip irrigated with an automatic system as needed. In late July, gravel bed trees will be harvested from the gravel, sprayed with water, and transported to the field planting site in Ames where they and the container-grown trees will be randomly planted among the early spring-planted controls. A slow-release fertilizer will be applied to gravel bed and container-grown trees after field planting. Trunk caliper and length of the longest four shoots will be measured at the end of the first, second, and third growing season.

Introducing

Introducing

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or Supplied Products to

the Iowa State University Turfgrass Research Program

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