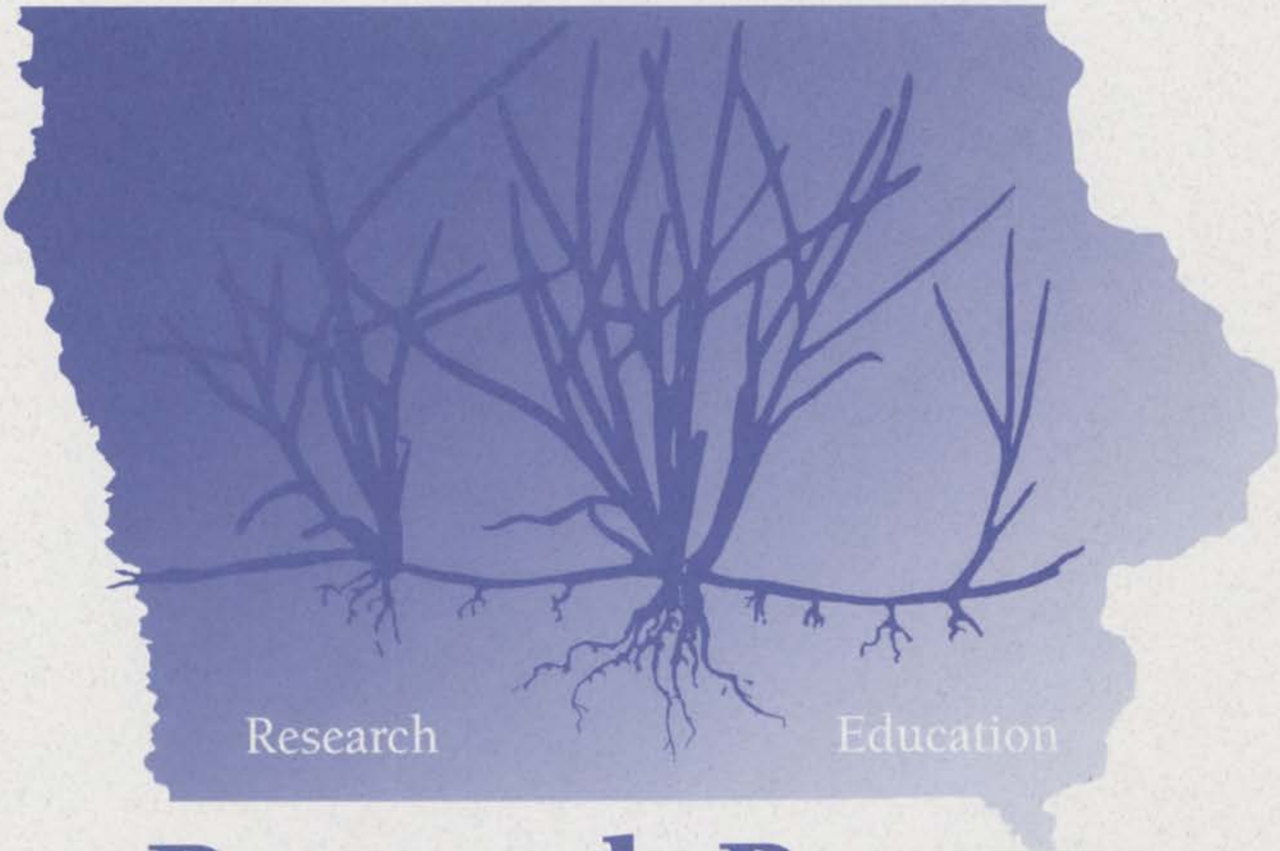
1996

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

University Extension

Ames, Iowa

FG-464 | July 1996

Introduction

Nick E. Christians and David D. Minner

The following research report is the 17th 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 1995 season will be remembered as a very wet spring followed by record heat from mid- to late summer. Summer rainfall was spotty, and some local areas experienced drought conditions. The winter of 95-96 was very cold and some areas experienced severe winter desiccation problems.

For the sixth 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 environmental issues that face our turf industry.

With assistance from the ISU Turf Club, several new sand based golf and athletic field research plots have been constructed on the south end of the Turf Facility at the Horticulture Research Station. Various products and technologies associated with sand based systems will be evaluated such as: SportGrass - a combination of natural grass and synthetic turf, Heatway - a water circulated soil heating system, SubAir - a subsurface forced air system, several organic and inorganic sand amendments, and a sloped area to study temperature and moisture stress on putting greens. Many of the grant and product contributions for conducting the research are recognized at the end of this report. Three contributors were especially crucial to the construction and installation of this new research area. Thanks to Dwayne McAninch (McAninch Corporation) for earth moving, Tim Johnson (Glen Oaks Country Club) for trenching, Mark Creighton (Reams Sprinkler Supply) and Bruce Morgan (Hunter Industries) for irrigation supplies.

We would like to acknowledge Richard Moore, superintendent of the ISU Horticulture Research Station and Jim Dickson, manager of the turf research area; Bryan Unruh, Ph.D. graduate student; Dave Gardener, MS graduate research assistant; Dianna Liu, Postdoctoral researcher; Barbara Bingaman, Postdoctoral 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 Lois Benning for her work in typing and helping to edit this publication.

Edited by Nick Christians and David Minner, Iowa State University, Department of Horticulture, Ames, IA 50011-1100.

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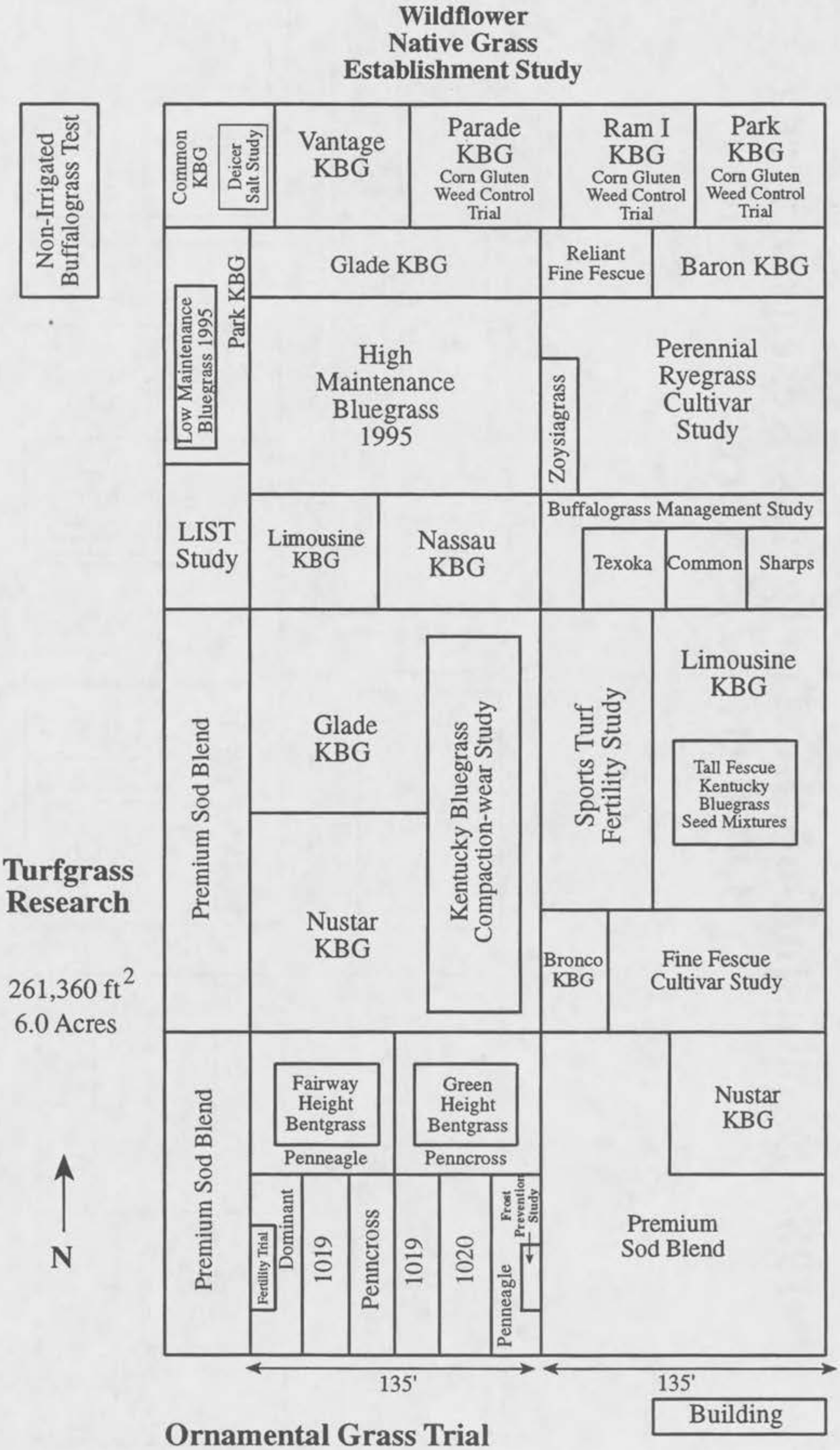
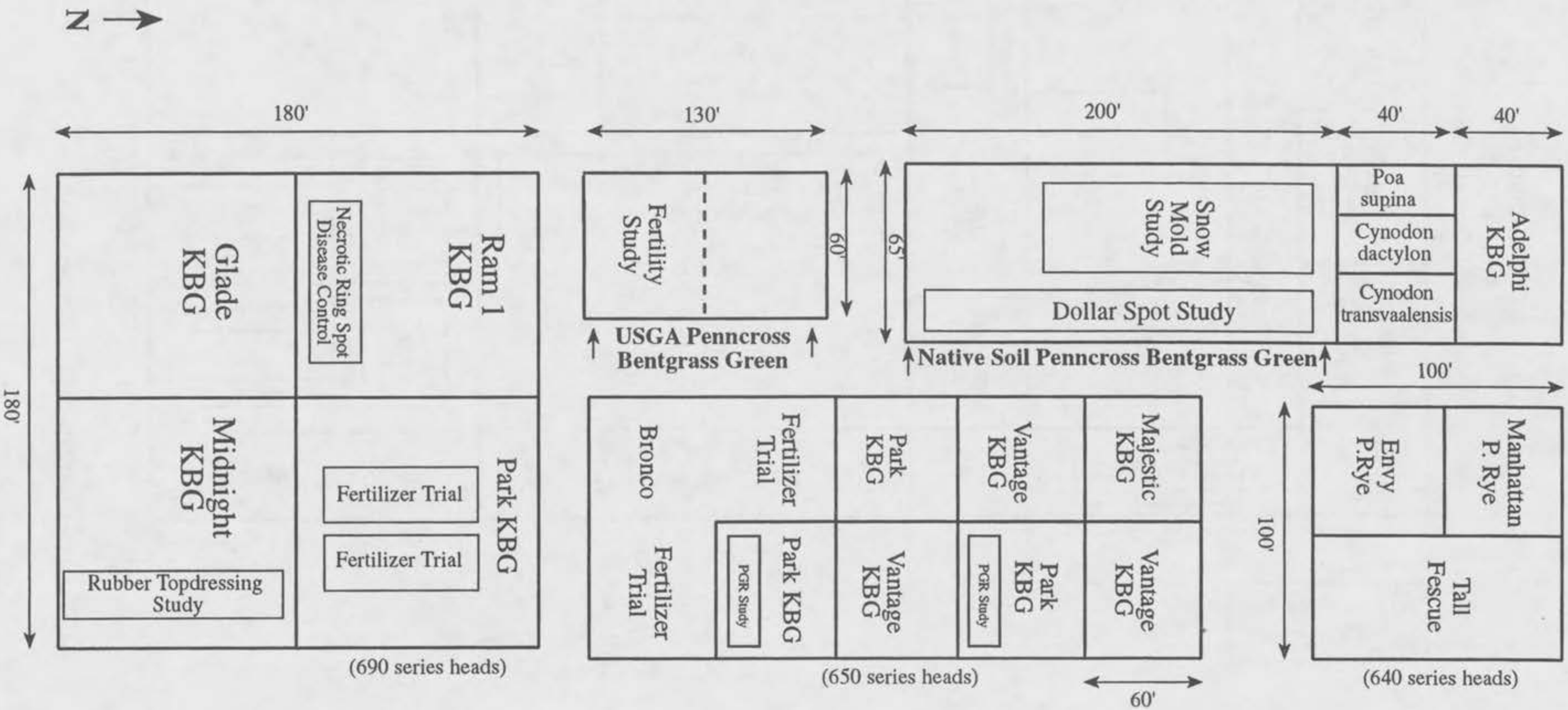


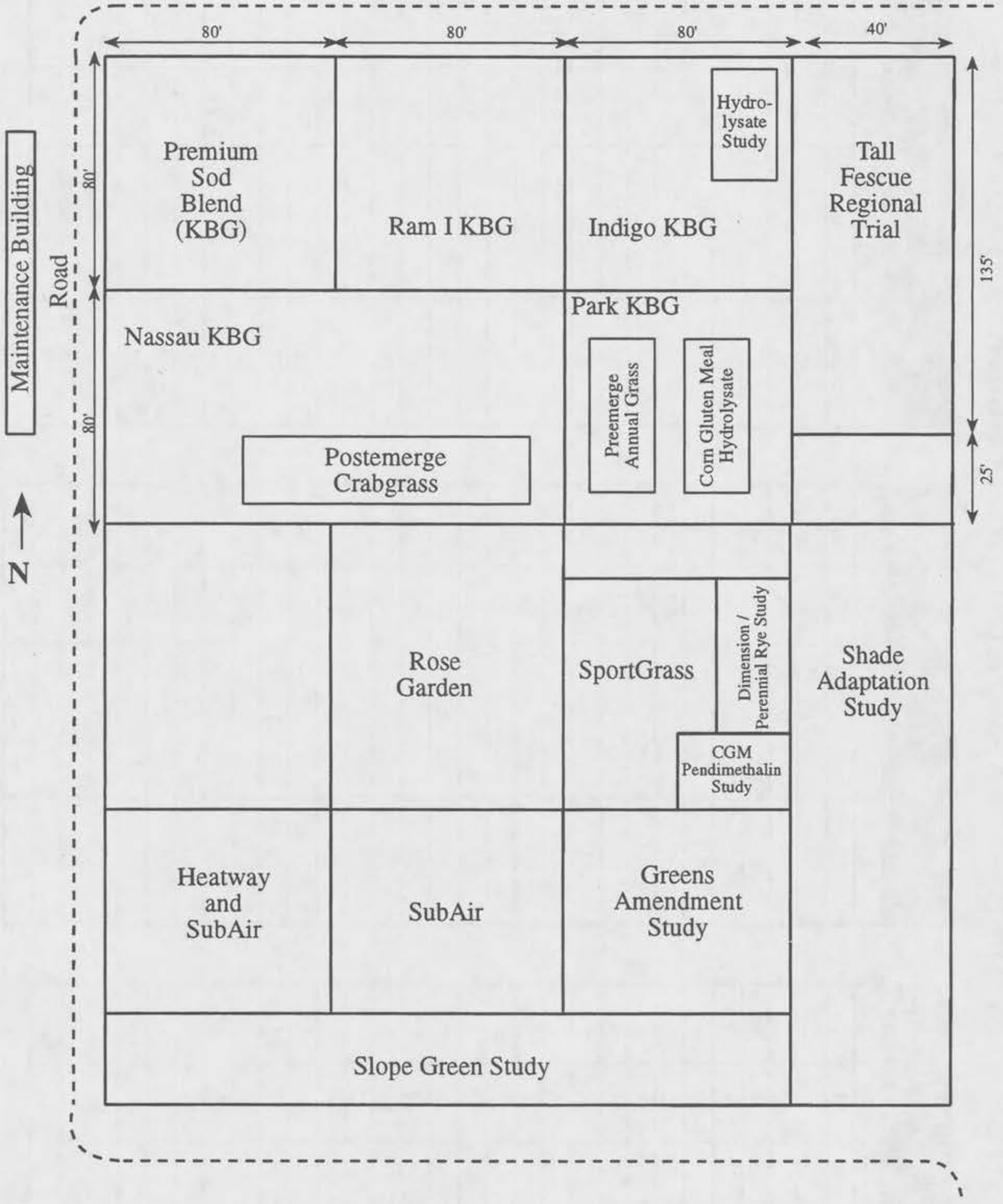
Wildflower
Native Grass
Establishment Study
Non-Irrigated Buffalograss Test
Common KBG
Deicer Salt Study
Vantage KBG
Parade KBG
Corn Gluten Weed Control Trial
Ram I KBG
Corn Gluten Weed Control Trial
Park KBG
Corn Gluten Weed Control Trial
Park KBG
Low Maintenance Bluegrass 1995
Glade KBG
Reliant Fine Fescue
Baron KBG
High Maintenance Bluegrass 1995
Zoysiagrass
Perennial Ryegrass Cultivar Study
LIST Study
Limousine KBG
Nassau KBG
Buffalograss Management Study
Texoka
Common
Sharps
170'
Premium Sod Blend
Glade KBG
Nustar KBG
Kentucky Bluegrass Compaction-wear Study
Sports Turf Fertility Study
Limousine KBG
Tall Fescue Kentucky Bluegrass Seed Mixtures
170'
Bronco KBG
Fine Fescue Cultivar Study
Turfgrass Research
261,360 ft²
6.0 Acres
Premium Sod Blend
Fairway Height Bentgrass
Penneagle
Green Height Bentgrass
Penncross
Nustar KBG
Fertility Trial
Dominant
1019
Penncross
1019
1020
Frost Prevention Study
Penneagle
Premium Sod Blend
170'
N
135'
135'
Building
Ornamental Grass Trial

05/20/96

1984 Expansion of the Turfgrass Research Area
108,900 ft. - 2.5 Acres^2



East Research Area



1995 WEATHER DATA FOR THE IOWA STATE UNIVERSITY HORTICULTURE FARM

April	Precipitation (inches)	Temperature High	Temperature Low
1		35	25
2		54	24
3		77	27
4		68	20
5	.02	34	14
6		73	27
7	.10	62	41
8	.50	50	36
9	.02	54	37
10	.89	41	33
11	.44	34	31
12	.01	46	33
13		41	33
14		65	31
15		62	42
16	.04	65	40
17	.35	53	35
18	.17	51	39
19		62	37
20	.29	56	32
21		45	39
22		48	32
23		60	31
24		62	35
25	.99	58	34
26	.36	61	30
27		48	39
28	.05	56	32
29	.25	59	39
30		56	46

May	Precipitation (inches)	Temperature High	Temperature Low
1		55	43
2		56	42
3	.18	59	42
4	.07	54	46
5	.01	54	39
6		68	35
7	.51	67	46
8	.38	65	54
9	1.35	66	54
10	.72	69	52
11		53	49
12	.21	64	42
13		64	40
14		77	54
15		66	44
16	.03	72	39
17		78	51
18		64	45
19		65	32
20		75	38
21		71	49
22	.15	73	38
23		74	52
24	.10	60	47
25	.03	65	47
26		72	43
27	.01	68	46
28	.42	68	54
29	.06	65	49
30		75	46
31		79	47

June	Precipitation (inches)	Temperature High	Temperature Low
1		74	54
2	.41	67	58
3	.35	71	55
4		79	52
5		77	60
6	.30	76	63
7	.01	83	63
8		86	54
9		59	48
10	.01	67	53
11	.16	66	54
12		74	49
13		77	48
14	.01	81	49
15	.45	78	60
16		84	62
17		86	68
18		88	69
19		86	70
20		88	66
21		90	61
22		92	64
23		92	69
24		91	64
25	.06	83	67
26	.59	72	65
27	.23	75	65
28	1.01	75	64
29	.29	75	62
30		76	61

July	Precipitation (inches)	Temperature High	Temperature Low
1		71	51
2		71	47
3		76	50
4		79	60
5	.98	78	61
6		78	59
7		78	56
8		78	54
9	.23	84	60
10	.01	82	64
11		89	62
12		90	70
13		98	74
14		99	76
15		94	78
16	1.30	86	68
17		82	68
18		81	62
19		82	58
20	.48	85	63
21		81	62
22		83	58
23	.07	83	66
24	.03	84	61
25		88	61
26		82	62
27		85	62
28		91	66
29		91	61
30		90	65
31		91	71

August	Precipitation (inches)	Temperature High	Temperature Low
1	.45	88	60
2		75	59
3		77	65
4		84	69
5	.19	87	66
6	.01	87	66
7	.03	83	67
8		86	69
9		92	75
10		86	75
11	1.10	86	67
12		91	71
13		92	74
14		92	77
15	.44	79	67
16	.27	79	64
17	.13	83	71
18		91	71
19		92	75
20		80	57
21		81	54
22		87	57
23		80	57
24		85	69
25		87	67
26		88	63
27		91	63
28		91	66
29		93	71
30		89	68
31		95	69

September	Precipitation (inches)	Temperature High	Temperature Low
1		78	60
2		81	53
3	.09	80	58
4		86	62
5		86	59
6		84	60
7	.03	82	67
8	.01	67	52
9		68	39
10		70	38
11		72	39
12		75	50
13	.03	76	60
14		89	56
15		78	45
16		83	48
17	.06	83	52
18		72	42
19	.33	70	51
20	.37	62	47
21	.24	51	39
22		52	32
23		54	29
24		59	34
25	.39	59	42
26		69	35
27		79	45
28		81	46
29		79	52
30	.52	66	61

October	Precipitation (inches)	Temperature High	Temperature Low
1		79	55
2		73	48
3		68	51
4		67	41
5		73	42
6	.53	57	48
7	.11	54	46
8		60	40
9	.02	62	37
10		66	42
11		77	41
12		83	51
13		84	59
14		67	46
15	.01	56	39
16		62	31
17		64	29
18		78	48
19		69	34
20		64	44
21	.01	44	37
22		53	29
23		59	25
24	.15	62	37
25		55	32
26		67	33
27		59	31
28	.04	49	42
29		54	32
30	.05	45	30
31	.10	41	32

November	Precipitation (inches)	Temperature High	Temperature Low
1	.35	37	32
2	.88	43	35
3		36	22
4		31	15
5		39	9
6	.02	48	31
7		55	33
8		35	20
9		33	14
10		60	28
11		51	21
12		27	12
13		37	17
14		31	18
15		39	25
16		42	27
17		39	27
18		41	27
19		47	25
20		57	32
21		48	29
22		39	16
23		46	17
24		27	8
25		39	8
26		43	27
27		48	29
28	.03	35	8
29		20	3
30	.02	28	4

Results of Regional Kentucky Bluegrass Cultivar Trials
1995 Progress Report

Nick E. Christians and James R. 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 either 62, 80, or 128 cultivars; the number depending on the year of establishment and the type of trial. Each cultivar was replicated three times. These studies were terminated in August, 1995 and were replaced with two new Kentucky bluegrass cultivar trials. Data from the new trials will be included in next year's report.

Three trials were underway at Iowa State University during the 1995 season. The first, a high-maintenance study, was established in 1990, and received 4 lb N/1000 ft^2/yr, and is irrigated as needed. The second trial was established in 1985 and received 4 lb N/1000 ft^2/yr but was non-irrigated. They are mowed at two inches. The third trial was established in the fall of 1991 and was a low-maintenance study that received 1 lb of N/1000 ft^2/yr in September and was non-irrigated. The objective of the high-maintenance study was to investigate cultivar performance under a cultural regime similar to that used on irrigated home lawns in Iowa. The objective of the second study was 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 was 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 1995 season. The cultivars are listed in descending order of average quality.

The 1995 season began with high rainfall and ended hot and dry. Apex (Summit), Blacksburg, and Midnight were the three highest rated cultivars in the high-maintenance trial. There were no statistically significant differences, however, in the first 35 cultivars. Notice that Kenblue is ranked number 3 in the low-maintenance trial and 128th in the high-maintenance trial. Park and South Dakota Certified were also in the top nine cultivars in the low-maintenance trial, even though these varieties usually do not perform well in high-maintenance conditions.

The high-maintenance, non-irrigated trial that is similar to many lawns in Iowa had a number of experimental (numbered) cultivars near the top. The number 1 cultivar was 239. The NE 80-88 and HV 97 were also highly ranked. Because of the stress in mid-summer, the August ratings are quite low. The study was terminated before the fall recovery period. Data from several years for each of these studies can be found in turfgrass research reports from previous years.

Table 1. The 1995 ratings for the high-maintenance, irrigated Kentucky bluegrass trial.

	Cultivar	May	June	July	Aug	Mean
1	Apex (Summit)	7.0	8.3	8.0	7.0	7.6
2	Blacksburg	7.3	7.7	7.7	7.7	7.6
3	Midnight	7.0	7.7	8.0	7.7	7.6
4	BAR VB 852	6.7	7.3	7.7	7.3	7.3
5	Cardiff	7.3	7.0	8.0	6.7	7.3
6	Eagleton	6.7	7.0	8.3	7.3	7.3
7	RAM-1	7.3	7.7	7.7	6.7	7.3
8	A-34	7.0	7.0	7.3	7.3	7.2

	Cultivar	May	June	July	Aug	Mean
9	Ascot (BA 77-279)	7.3	7.7	7.3	6.3	7.2
10	Barsweet	6.7	7.0	7.7	7.3	7.2
11	Kelly	7.0	7.7	7.3	6.7	7.2
12	Miracle	6.7	7.3	7.3	7.3	7.2
13	Pennpro (PR-1)	7.0	7.3	7.7	6.7	7.2
14	Platini	6.7	7.3	7.3	7.3	7.2
15	BA 77-292	6.7	7.3	7.3	7.0	7.1
16	Eclipse	7.3	7.0	7.3	6.7	7.1
17	Estate	7.3	7.0	7.0	7.0	7.1
18	J-333	7.3	7.3	7.0	6.7	7.1
19	Julia	7.3	7.0	7.3	6.7	7.1
20	Livingston	7.0	7.0	7.7	6.7	7.1
21	Melba	6.7	7.0	7.7	7.0	7.1
22	PST-1DW	6.3	7.7	7.3	7.0	7.1
23	Viva (BA 73-366)	7.3	7.0	7.0	7.0	7.1
24	Able I	7.3	7.3	6.7	6.7	7.0
25	BA 70-131	7.0	7.0	7.3	6.7	7.0
26	BAR VB 1169	7.0	7.0	7.0	7.0	7.0
27	Glade	7.0	7.0	7.7	6.3	7.0
28	Indigo	6.7	7.0	7.7	6.7	7.0
29	Miranda	7.0	7.3	7.3	6.3	7.0
30	Preakness (602)	7.3	7.0	7.0	6.7	7.0
31	Princeton 104	7.0	7.0	7.0	7.0	7.0
32	PST-A7-1877	7.7	7.0	6.7	6.7	7.0
33	PST-A7-341	6.7	7.0	7.3	7.0	7.0
34	PST-C-224	7.3	6.7	7.0	7.0	7.0
35	Raven (BA 78-258)	7.0	7.3	7.3	6.3	7.0
36	Barcelona (BAR VB 1184)	7.3	6.7	6.7	7.0	6.9
37	Belmont (798)	7.0	7.0	7.3	6.3	6.9
38	Classic	7.0	7.0	7.3	6.3	6.9
39	Coventry	7.0	7.0	7.3	6.3	6.9
40	Crest	7.0	7.0	7.3	6.3	6.9
41	Gnome	7.0	7.3	7.0	6.3	6.9
42	HV 125	7.0	6.7	7.3	6.7	6.9
43	J13-152	6.7	7.0	7.0	7.0	6.9
44	Opti-Green (PST-B8-106)	7.0	7.0	7.3	6.3	6.9
45	PST-A84-803	7.7	7.0	7.0	6.0	6.9
46	PSU-151	7.0	6.7	7.3	6.7	6.9
47	SR2000	6.7	6.7	7.7	6.7	6.9
48	4 Aces (PST-RE-88)	7.0	7.0	7.3	6.0	6.8
49	Abbey	7.0	7.0	7.0	6.3	6.8
50	Alpine	7.0	6.7	6.7	6.7	6.8
51	Aspen	7.0	7.0	7.3	6.0	6.8
52	BA 73-382	7.0	6.7	7.0	6.3	6.8
53	Baron	7.0	6.7	7.0	6.3	6.8
54	Broadway	7.0	7.3	6.7	6.3	6.8
55	Caliber (J-335)	6.7	7.0	7.0	6.3	6.8
56	Challenger	7.0	7.0	7.3	6.0	6.8
57	Cobalt	7.3	6.7	7.0	6.0	6.8
58	Conni	6.7	7.3	7.3	6.0	6.8
59	Destiny	7.0	7.0	7.0	6.3	6.8
60	EVA (WW AG 508)	5.7	7.3	7.3	6.7	6.8

	Cultivar	May	June	July	Aug	Mean
61	EVB 13.703	6.7	6.7	7.3	6.3	6.8
62	Freedom	7.3	6.7	6.7	6.7	6.8
63	Haga	6.7	7.0	7.0	6.3	6.8
64	Limousine	7.3	7.0	6.3	6.3	6.8
65	Merion	7.0	6.3	7.3	6.3	6.8
66	Merit	7.0	7.0	7.0	6.3	6.8
67	Nublue (J-229)	7.0	7.0	7.0	6.3	6.8
68	Opal	6.7	7.3	7.0	6.3	6.8
69	PST-0514	7.0	7.0	6.7	6.7	6.8
70	PST-UD-10	7.0	7.3	7.0	6.0	6.8
71	R751A	6.3	6.7	7.7	6.7	6.8
72	Trampas	6.7	7.0	7.7	6.0	6.8
73	Trenton	7.3	7.0	6.7	6.0	6.8
74	WW AG 505	6.3	7.0	7.0	7.0	6.8
75	1757	7.0	6.7	6.7	6.3	6.7
76	BA 77-700	6.7	6.7	7.0	6.3	6.7
77	Bartitia	6.3	7.0	7.0	6.3	6.7
78	Barzan	6.0	7.0	7.3	6.3	6.7
79	Blue Star (PST-B8-13)	6.3	7.0	7.0	6.3	6.7
80	Cannon (BA 73-381)	6.3	7.0	7.0	6.3	6.7
81	Dawn	7.0	6.7	7.0	6.0	6.7
82	J11-94	6.7	6.7	7.0	6.3	6.7
83	Liberty	7.0	6.7	6.7	6.3	6.7
84	Monopoly	6.7	7.0	6.7	6.3	6.7
85	PST-A84-928	6.7	7.0	6.7	6.3	6.7
86	PST-HV-116	6.7	7.0	6.7	6.3	6.7
87	Shamrock (H86-712)	6.3	7.0	7.0	6.3	6.7
88	Silvia	6.7	7.0	6.7	6.3	6.7
89	Unique (PST-C-76)	7.7	6.7	6.7	5.7	6.7
90	Washington	5.7	7.0	7.3	6.7	6.7
91	Allure (BA 73-540)	7.0	6.7	6.7	6.0	6.6
92	Barblue	7.0	7.0	7.0	5.3	6.6
93	Barmax (BAR VB 7037)	6.3	6.7	7.0	6.3	6.6
94	Baronie (BAR VB 985)	7.0	6.3	6.7	6.3	6.6
95	Georgetown	7.0	6.7	6.7	6.0	6.6
96	Minstrel	6.7	7.0	6.3	6.3	6.6
97	Noblesse	6.7	6.7	7.0	6.0	6.6
98	Nustar	6.7	6.3	7.0	6.3	6.6
99	PST-UD-12	7.0	6.7	6.7	6.0	6.6
100	Suffolk	7.0	7.0	6.7	5.7	6.6
101	Ampellia	6.7	6.7	6.7	6.0	6.5
102	Cynthia	6.3	6.7	7.0	6.0	6.5
103	Donna	6.3	7.0	6.7	6.0	6.5
104	Fairfax (BA 69-82)	6.7	7.0	6.3	6.0	6.5
105	Fortuna	6.0	7.0	7.0	6.0	6.5
106	J-386	5.7	6.7	7.3	6.3	6.5
107	J34-99	7.0	6.7	6.7	5.7	6.5
108	Marquis	6.7	7.0	6.7	5.7	6.5
109	PST-A84-405	6.3	6.3	7.0	6.3	6.5
110	PST-R-740	6.7	6.3	7.0	6.0	6.5
111	South Dakota Cert.	5.7	6.7	7.0	6.7	6.5
112	SR2100	6.7	6.7	6.7	6.0	6.5

	Cultivar	May	June	July	Aug	Mean
113	Touchdown	5.7	7.0	7.0	6.3	6.5
114	Chelsea	6.3	6.7	6.7	6.0	6.4
115	Nassau	6.7	7.0	6.3	5.7	6.4
116	BA 76-305	5.0	6.7	7.0	6.7	6.3
117	Banff	7.0	6.3	6.3	5.7	6.3
118	Buckingham (BA 74-114)	5.7	6.7	6.7	6.3	6.3
119	NE 80-47	6.0	6.7	6.7	6.0	6.3
120	EVB 13.863	5.7	6.3	6.3	6.3	6.2
121	KWS PP 13-2	6.0	6.0	6.7	5.7	6.1
122	Ronde	5.3	6.0	6.7	6.0	6.0
123	Ginger	4.7	6.0	6.7	6.0	5.8
124	Greenley	4.7	6.3	6.0	6.0	5.8
125	Kenblue	5.3	5.3	5.7	5.7	5.5
	$LSD_{(0.05)}$	1.1	1.0	1.3	1.8	0.6

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

Table 2. The 1995 ratings for the low-maintenance, non-irrigated Kentucky bluegrass trial.

	Cultivar	May	June	July	Aug	Mean
1	BAR VB 852	6.3	6.3	4.3	4.7	5.4
2	Minnfine (MN 2405)	5.3	4.7	6.0	5.3	5.3
3	Kenblue	4.3	4.7	6.3	5.3	5.2
4	Park	5.7	4.7	5.7	4.7	5.2
5	Alene	6.7	5.3	4.7	3.3	5.0
6	Voyager	5.7	5.0	4.7	4.3	4.9
7	BA 78-376	4.7	4.3	5.3	4.3	4.7
8	GEN-RSP	6.3	4.0	3.7	4.0	4.5
9	South Dakota Cert.	5.7	4.3	5.0	3.0	4.5
10	Baron	4.7	4.7	3.7	4.7	4.4
11	PST-C-391	5.7	5.0	4.0	3.0	4.4
12	Banjo (H76-1034)	6.3	4.3	3.3	3.0	4.3
13	Bronco	4.3	4.7	4.3	3.7	4.3
14	Monopoly	5.0	5.0	3.7	3.7	4.3
15	ZPS-84-749	4.3	4.7	4.7	3.3	4.3
16	Barmax (BAR VB 7037)	3.7	5.3	4.7	3.0	4.2
17	PST-YQ	6.0	4.7	3.0	3.0	4.2
18	Washington	4.3	4.7	4.3	3.3	4.2
19	Cynthia	4.7	3.3	4.0	4.3	4.1
20	EVB 13.703	5.0	4.0	3.7	3.7	4.1
21	Haga	5.0	4.7	3.7	3.0	4.1
22	Nublue (J-229)	5.0	4.3	4.0	3.0	4.1
23	PST-A7-111	5.3	4.0	3.3	3.7	4.1
24	Amazon	4.7	4.3	3.3	3.7	4.0
25	Miracle	4.0	4.3	4.0	3.7	4.0
26	NJIC	5.7	3.7	3.3	3.3	4.0
27	BAR VB 1169	5.0	4.3	3.0	3.0	3.8
28	Gnome	4.7	3.7	3.3	3.3	3.8
29	ISI-21	5.7	4.0	2.3	3.3	3.8
30	Liberty	5.3	4.7	2.7	2.3	3.8
31	Merion	5.0	4.0	3.0	3.0	3.8
32	Nustar	4.7	3.3	4.0	3.0	3.8
33	Suffolk	4.7	4.0	3.7	2.7	3.8
34	Livingston	5.0	4.0	3.3	2.3	3.7

	Cultivar	May	June	July	Aug	Mean
35	Barzan	4.3	4.3	2.7	3.0	3.6
36	Chelsea	4.3	3.7	3.3	3.0	3.6
37	Kyosti	3.7	4.0	4.0	2.7	3.6
38	Merit	4.3	3.7	3.3	2.7	3.5
39	PST-C-303	4.7	3.3	3.0	3.0	3.5
40	Sophia	4.3	4.3	3.0	2.3	3.5
41	SR 2000	5.0	3.3	3.0	2.7	3.5
42	Baronie (BAR VB 985)	4.7	3.7	2.7	2.7	3.4
43	Destiny	4.0	3.0	3.0	3.7	3.4
44	BA 74-017	4.0	3.3	3.0	3.0	3.3
45	Belmont (798)	3.7	4.0	2.7	2.7	3.3
46	Caliber (J-335)	4.7	3.7	2.7	2.3	3.3
47	Freedom	4.7	4.0	2.3	2.3	3.3
48	J-386	4.0	3.3	2.7	3.0	3.3
49	KWS PP 13-2	4.3	3.3	3.0	2.3	3.3
50	NE 80-47	4.3	3.3	3.0	2.3	3.3
51	Opal	3.7	3.3	3.0	3.3	3.3
52	Unique (PST-C-76)	3.7	3.7	3.0	3.0	3.3
53	Cobalt	4.0	3.0	2.7	3.0	3.2
54	EVB 13.863	3.3	3.7	3.0	2.7	3.2
55	RAM-1	4.0	3.3	3.0	2.3	3.2
56	Barcelona (BAR VB 118)	3.7	4.0	2.7	2.0	3.1
57	Crest	4.0	3.0	2.7	2.3	3.0
58	Fortuna	3.7	3.0	2.7	2.7	3.0
59	Barsweet	3.0	3.0	2.7	2.7	2.8
60	Bartitia	2.7	3.3	2.7	2.3	2.8
61	Midnight	4.0	3.0	2.3	2.0	2.8
62	Unknown	3.0	2.3	2.7	2.0	2.5
	$LSD_{(0.05)}$	1.6	2.2	1.5	2.8	1.3

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

Table 3. The 1995 quality ratings for the high-maintenance, non-irrigated regional Kentucky bluegrass test.

	Cultivar	May	June	July	August	Mean
1	239	7.0	6.0	5.7	4.0	5.7
2	Tendos	5.7	5.0	6.0	5.3	5.5
3	Annika	6.3	5.7	5.3	4.7	5.5
4	Destiny	4.7	5.0	6.7	5.7	5.5
5	NE 80-88	5.0	6.3	5.0	5.3	5.4
6	HV 97	5.3	5.3	5.7	5.3	5.4
7	Liberty	6.3	6.7	4.7	4.0	5.4
8	Monopoly	5.7	5.7	5.3	4.7	5.3
9	Georgetown	4.7	6.0	5.7	4.7	5.3
10	Mystic	5.7	4.7	6.0	5.0	5.3
11	A-34	6.0	4.7	5.3	5.0	5.3
12	BA 69-82	5.3	6.3	5.0	4.7	5.3
13	Lofts 1757	5.0	5.7	5.7	4.7	5.3
14	Nassau	6.3	5.0	5.3	4.7	5.3
15	F-1872	5.3	5.3	5.3	5.3	5.3
16	Aspen	6.3	4.3	5.7	5.0	5.3
17	NE 80-14	6.0	5.7	5.0	4.3	5.3
18	BA 70-139	5.3	5.7	5.7	4.0	5.2
19	Julia	6.3	5.3	5.3	3.7	5.2
20	Welcome	6.0	5.3	5.3	4.0	5.2
21	Challenger	6.0	4.7	5.0	5.0	5.2
22	NE 80-47	5.7	4.7	5.0	5.3	5.2
23	P-104	4.7	5.0	5.7	5.0	5.1

	Cultivar	May	June	July	August	Mean
24	Cheri	4.3	5.3	5.7	5.0	5.1
25	NE 80-50	6.0	3.7	5.7	5.0	5.1
26	Compact	6.0	5.3	5.0	3.7	5.0
27	K3-178	5.0	4.7	5.3	5.0	5.0
28	Classic	4.7	5.0	5.7	4.3	4.9
29	Ram-I	6.0	4.0	5.0	4.7	4.9
30	Victa	5.3	4.0	5.0	5.3	4.9
31	BAR VB 534	5.3	4.0	5.3	5.0	4.9
32	Parade	5.3	5.0	5.0	4.3	4.9
33	Wabash	5.0	4.3	5.3	5.0	4.9
34	Ikone	5.3	4.3	6.0	4.0	4.9
35	Joy	5.7	4.7	5.0	3.7	4.8
36	Sydsport	5.0	4.7	5.0	4.3	4.8
37	Somerset	4.7	4.7	5.7	4.0	4.8
38	Baron	5.7	4.3	4.7	4.3	4.8
39	Conni	4.7	5.3	4.7	4.3	4.8
40	BA 70-242	5.0	5.7	4.3	4.0	4.8
41	BA 72-492	5.3	4.7	5.0	4.0	4.8
42	BA 73-540	5.0	4.7	5.3	4.3	4.8
43	Eclipse	5.3	5.0	4.7	4.3	4.8
44	Merion	4.0	5.0	5.3	4.7	4.8
45	Glade	4.7	5.0	5.0	4.3	4.8
46	Aquila	4.3	5.0	5.0	4.7	4.8
47	Rugby	4.7	4.3	5.7	4.3	4.8
48	Midnight	4.7	5.3	4.7	4.3	4.8
49	Blacksburg	5.7	4.7	5.0	4.0	4.8
50	WW AG 496	4.3	4.7	5.3	4.7	4.8
51	NE 80-48	4.3	5.0	5.3	4.7	4.8
52	NE 80-55	5.3	4.0	5.0	5.0	4.8
53	Gnome	5.3	5.0	4.3	4.0	4.7
54	Able I	5.0	4.3	5.3	4.0	4.7
55	Merit	5.3	3.7	5.3	4.3	4.7
56	Trenton	5.3	5.0	4.0	4.3	4.7
57	NE 80-110	5.0	4.3	5.0	4.3	4.7
58	NE 80-30	6.7	4.0	4.0	4.0	4.7
59	Park	4.7	4.7	5.0	4.3	4.7
60	Kennblue	4.0	4.3	5.3	4.7	4.6
61	BA 72-500	5.7	4.7	4.3	3.7	4.6
62	Cynthia	4.0	4.7	5.7	4.0	4.6
63	PST-CB1	5.0	4.3	4.7	4.3	4.6
64	BAR VB 577	4.3	4.0	5.0	4.7	4.5
65	BA 72-441	4.3	5.0	4.3	4.3	4.5
66	BA 73-626	4.0	3.7	5.3	5.0	4.5
67	America	5.3	4.3	4.7	3.7	4.5
68	South Dakota Cert.	4.7	4.3	4.3	4.7	4.5
69	WW AG 468	5.0	4.7	4.7	3.7	4.5
70	Asset	4.3	4.3	5.0	4.0	4.4
71	Dawn	4.0	4.0	5.0	4.7	4.4
72	Amazon	4.0	4.3	5.0	4.3	4.4
73	Huntsville	5.7	4.0	4.0	4.0	4.4
74	K1-153	4.7	4.3	5.0	3.7	4.4
75	WW AG 491	4.3	4.7	4.3	4.3	4.4
76	WW AG 495	4.3	4.0	4.7	4.7	4.4
77	Barzan	4.3	5.0	4.7	3.3	4.3
78	Haga	4.0	4.0	5.3	3.7	4.3
79	Bristol	4.7	3.7	5.0	3.7	4.3
80	Harmony	4.0	4.0	4.3	4.0	4.1
	$LSD_{(0.05)}$	NS	NS	NS	NS	NS

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

Perennial Ryegrass Study - 1994
1995 Progress Report

James R. Dickson and Nick E. Christians

This trial began in the fall of 1994 with the establishment of 96 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 1994.

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 1 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.

There was little winter damage in the spring of 1995 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 1).

Table 1. The 1995 quality and other ratings for the national perennial ryegrass study established in 1994.

	Cultivar	Gencolor	Leaftex	May	June	July	Aug	Sept	Oct	Mean
1	Accent	6.3	6.0	7.0	6.0	6.7	6.3	7.3	7.3	6.8
2	Koos 93-6	6.7	5.7	7.3	6.3	6.3	6.0	7.3	7.3	6.8
3	Vivid	6.7	5.7	7.0	6.0	6.7	6.3	7.3	7.3	6.8
4	WVPB-93-KFK	6.7	6.0	7.3	6.3	6.3	6.3	7.0	7.7	6.8
5	Express	5.7	5.7	6.7	6.3	6.7	6.3	7.0	7.0	6.7
6	ISI-R2	6.0	6.0	6.7	6.3	6.0	6.0	7.3	7.3	6.6
7	J-1706	6.3	6.0	6.3	6.3	6.3	6.0	7.3	7.3	6.6
8	Pennant II (MB 42)	8.0	5.7	6.3	5.7	5.7	6.3	7.7	7.7	6.6
9	PST-28M	7.0	5.7	6.7	6.0	6.3	6.3	7.0	7.0	6.6
10	RPBD	7.0	6.0	6.3	6.0	6.3	6.0	7.3	7.7	6.6
11	SRX 4400	6.3	5.7	7.0	5.7	6.3	6.0	7.0	7.3	6.6
12	Stallion Select	7.0	5.3	7.0	6.0	7.0	6.3	6.3	6.7	6.6
13	TMI-EXFLP94	6.3	6.0	7.3	6.0	6.7	6.0	6.7	6.7	6.6
14	ZPS-2DR-94	7.0	5.0	7.3	6.3	5.7	5.7	7.3	7.3	6.6
15	APR 106	6.3	6.0	7.0	6.3	6.0	6.0	6.7	7.0	6.5
16	Assure	6.7	5.7	6.0	5.7	6.3	6.3	7.3	7.3	6.5
17	BAR Er 5813	6.3	5.7	7.3	5.7	6.3	6.0	6.3	7.3	6.5
18	DLP 1305	6.7	5.7	6.7	6.7	6.0	6.0	6.7	7.0	6.5
19	Nobility	6.3	6.0	6.7	6.0	6.0	6.0	7.0	7.3	6.5
20	Precision	6.0	6.0	7.3	5.7	6.0	6.7	6.7	6.7	6.5
21	Advantage	7.7	6.0	6.3	6.0	6.0	6.3	6.7	7.0	6.4
22	Cutter	6.3	5.3	6.7	5.7	6.3	6.0	7.0	7.0	6.4

	Cultivar	Gencolor	Leaftex	May	June	July	Aug	Sept	Oct	Mean
23	DSV NA 9402	6.0	5.7	6.7	5.7	6.0	6.0	7.0	7.0	6.4
24	Divine	7.7	5.7	6.3	5.7	6.3	6.0	7.0	7.0	6.4
25	MB 1-5	7.7	6.0	7.0	6.7	6.3	5.7	6.0	6.7	6.4
26	MB 47	7.7	5.3	6.7	5.7	5.3	6.0	7.3	7.3	6.4
27	MVF-4-1	6.7	6.0	6.3	5.7	6.0	6.3	7.0	7.3	6.4
28	PC-93-1	6.0	6.0	6.7	5.3	5.7	6.3	7.3	7.3	6.4
29	SRX 4010	6.0	5.3	7.0	5.7	6.0	5.7	7.0	7.0	6.4
30	ZPS-2NV	6.7	5.7	7.0	5.7	5.7	6.3	7.0	7.0	6.4
31	BAR USA 94-II	7.3	6.0	5.7	6.0	5.7	6.0	7.0	7.3	6.3
32	CAS-LP23	7.3	6.0	6.7	6.3	6.0	6.0	6.3	6.7	6.3
33	Dancer	6.7	6.0	7.0	5.7	5.7	6.0	6.7	6.7	6.3
34	Edge	6.7	6.0	6.7	5.7	6.0	5.7	6.7	7.3	6.3
35	Elf	7.0	5.7	6.7	6.0	5.7	6.0	6.7	6.7	6.3
36	LRF-94-MPRH	7.3	5.3	6.3	5.3	6.0	6.3	7.0	7.0	6.3
37	MED 5071	6.3	5.7	6.3	6.0	6.0	5.3	7.0	7.3	6.3
38	Morning Star	6.0	5.7	7.0	5.3	6.0	6.3	6.7	6.7	6.3
39	PST-2CB	7.3	5.3	6.0	6.0	6.3	6.3	6.3	6.7	6.3
40	PST-2R3	6.7	5.7	5.7	5.7	5.3	6.7	7.0	7.3	6.3
41	PST-GH-94	7.7	5.3	6.7	5.3	5.7	6.3	6.7	7.0	6.3
42	SR 4200	7.0	6.0	6.3	5.7	6.0	6.0	7.0	7.0	6.3
43	WVPB 92-4	6.0	5.7	7.0	5.7	6.3	5.7	6.7	6.7	6.3
44	APR 124	6.3	6.0	6.3	6.0	6.0	5.7	6.3	6.7	6.2
45	Achiever	6.3	5.3	6.3	6.0	6.0	5.7	6.3	6.7	6.2
46	Esquire	7.0	5.7	6.7	6.0	6.0	6.0	6.0	6.3	6.2
47	MB 41	7.7	5.0	6.0	6.0	5.3	6.0	7.0	7.0	6.2
48	PS-D-9	6.3	6.0	6.0	5.3	6.0	6.0	7.0	7.0	6.2
49	Pick 928	6.7	5.3	6.7	5.7	6.0	5.3	6.7	7.0	6.2
50	Williamsburg	6.3	6.0	6.3	5.7	6.3	5.3	6.7	6.7	6.2
51	DSV NA 9401	5.3	6.0	6.7	6.3	5.3	5.7	6.0	6.3	6.1
52	ISI-MHB	6.0	5.7	6.7	5.7	5.7	6.0	6.3	6.3	6.1
53	Koos 93-3	6.3	5.7	6.7	5.7	5.7	5.7	6.3	6.3	6.1
54	Manhattan III	7.0	5.7	6.0	5.3	6.0	5.3	7.0	7.0	6.1
55	WVPB-PR-C-2	6.3	6.0	6.0	6.0	6.0	5.7	6.3	6.3	6.1
56	ZPS-PR1	7.0	6.0	6.0	6.0	5.7	5.0	7.0	7.0	6.1
57	Night Hawk	7.3	6.0	6.3	5.3	6.3	5.7	6.0	6.3	6.0
58	PSI-E-1	6.3	5.3	6.0	5.7	5.7	5.7	6.3	6.7	6.0
59	LESCO-TWF	7.3	6.0	6.3	6.0	5.3	5.7	6.0	6.0	5.9
60	Laredo	6.7	5.7	6.0	5.7	5.3	5.3	6.3	6.7	5.9
61	Omni	6.7	5.7	6.0	5.3	5.3	5.7	6.3	6.7	5.9
62	Quickstart	6.3	6.0	5.7	5.7	5.7	5.7	6.3	6.7	5.9
63	MB 43	7.0	6.0	5.3	5.3	5.3	6.0	6.3	6.7	5.8
64	PST-2DLM	7.3	5.3	6.3	6.0	5.3	5.3	6.0	6.0	5.8

	Cultivar	Gencolor	Leaftex	May	June	July	Aug	Sept	Oct	Mean
65	PST-2FF	7.0	5.7	5.0	4.7	5.7	6.0	6.7	7.0	5.8
66	Saturn	6.3	6.0	6.3	5.0	5.7	5.7	6.0	6.3	5.8
67	ZPS-2ST	7.0	5.7	5.7	5.3	5.7	5.7	6.3	6.3	5.8
68	APR 066	6.0	5.7	5.7	5.0	5.7	5.3	6.0	6.3	5.7
69	Calypso II	7.0	5.3	5.7	5.3	5.3	5.3	6.3	6.3	5.7
70	Figaro	6.7	5.0	6.0	5.0	5.7	5.0	6.0	6.3	5.7
71	Pennfine	6.3	4.3	6.3	5.3	6.3	5.0	5.7	5.7	5.7
72	Pick Lp 102-92	7.7	5.3	5.7	5.7	5.7	5.3	5.7	6.0	5.7
73	Riviera II	6.7	6.0	6.7	5.7	6.0	5.3	5.3	5.3	5.7
74	WX3-93	6.7	5.7	5.7	5.7	5.3	5.3	6.0	6.0	5.7
75	MB 45	8.0	5.3	6.0	5.0	5.3	5.3	5.7	6.0	5.6
76	Prizm	6.7	6.0	5.3	5.0	5.7	5.0	6.3	6.3	5.6
77	Brightstar	7.3	6.0	5.3	5.3	5.0	5.3	6.0	6.0	5.5
78	PST-2FE	6.7	5.3	5.7	5.0	5.3	5.3	5.7	6.0	5.5
79	Pegasus	6.3	6.0	6.0	5.3	5.7	5.0	5.0	5.3	5.4
80	MB 44	8.0	5.0	5.7	5.0	4.7	5.0	5.7	6.0	5.3
81	Pick PR 84-91	7.0	5.7	6.0	5.0	5.0	5.0	5.3	5.7	5.3
82	Top Hat	7.3	5.3	4.7	5.3	5.7	6.0	5.0	5.3	5.3
83	Navajo	7.0	6.0	4.7	4.3	5.7	5.3	5.7	5.7	5.2
84	PST-2DGR	7.3	5.3	5.0	4.3	4.3	5.0	6.0	6.7	5.2
85	PST-2ET	7.3	5.7	5.7	4.7	5.0	4.7	5.7	5.7	5.2
86	APR 131	6.7	5.7	4.7	4.7	5.7	5.0	5.3	5.3	5.1
87	LRF-94-C8	8.0	4.3	5.0	4.7	4.3	5.0	5.7	5.7	5.1
88	Nine-O-One	8.0	5.7	5.3	4.7	5.0	4.7	5.3	5.3	5.1
89	J-1703	7.3	6.0	5.0	4.3	4.3	5.3	5.0	5.3	4.9
90	Imagine	7.0	5.7	4.7	5.3	5.3	4.3	4.7	4.7	4.8
91	LRF-94-B6	7.3	5.0	4.7	4.3	4.3	4.3	5.3	5.7	4.8
92	WX3-91	6.3	5.7	4.7	4.0	4.3	4.7	5.3	5.3	4.7
93	LRF-94-C7	8.0	4.7	5.3	4.3	4.7	4.3	4.3	4.3	4.6
94	PST-2M3	7.3	4.3	4.3	4.3	4.0	4.7	4.7	5.3	4.6
95	MB 46	8.0	5.3	4.3	4.3	4.7	4.0	4.3	4.7	4.4
96	Linn	4.0	3.0	4.7	4.0	4.3	3.3	4.3	4.3	4.2
	$LSD_{(0.05)}$	1.0	1.2	2.4	2.5	1.7	2.0	1.8	1.9	1.4

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

Shade Adaptation Study - 1995

Nick E. Christians, Barbara R. Bingaman, and Gary M. Peterson

The first shade adaptation study was established in the fall of 1987 to evaluate the performance of 35 species and cultivars of grasses. The species include chewings fescue (C.F.), 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 are mowed at a 2-inch height and receive 2 lb N/1000 ft^2/year. No weed control has been required on the area, but the grass was irrigated during extended droughts.

Monthly quality data are collected from May through October (Table 1). 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 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 1995 season started cool and very wet and then became very warm and dry in August. The chewings and hard fescues were among the best quality turf under these conditions. The Kentucky bluegrass varieties exhibited the worst quality.

A new shade trial was added in the fall of 1994 to evaluate the performance of cultivars of chewings fescue (C.F.), creeping red fescue (C.R.F.), hard fescue (H.F.), tall fescue (T.F.), Kentucky bluegrass (K.B.), rough bluegrass (*Poa trivialis*), and *Poa supina*.

The *Poa trivialis* cultivars had the best quality for the 1995 season. Some of the chewings, hard and tall fescues also exhibited fairly good quality (Table 2). Some of the Kentucky bluegrass cultivars and the *Poa supina* had the worst quality.

In 1994, Gary Peterson compiled six years of data from the older of the two trials. The data were averaged and ranked (Table 3).

Table 1. The 1995 quality ratings for grasses in the 1987 shade trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Mary (C.F.)	7.7	6.7	6.0	5.7	6.3	7.7	6.7
2	Victor (C.F.)	6.3	6.7	6.0	6.3	6.3	8.0	6.6
3	Bar Fo 81-225 (H.F.)	6.0	6.7	6.0	6.7	6.3	7.3	6.5
4	Jamestown (C.F.)	7.0	5.0	5.7	6.3	5.7	7.3	6.2
5	St-2 (SR3000) (H.F.)	5.7	5.7	6.0	5.7	6.3	7.0	6.1
6	Shadow(C.F.)	6.3	5.7	5.3	5.0	6.0	7.3	5.9
7	Waldina (H.F.)	4.3	5.7	5.3	5.7	6.3	7.7	5.8
8	Waldorf (C.F.)	6.0	5.7	5.0	5.3	6.0	6.7	5.8
9	Rebel (T.F.)	5.0	7.0	5.0	6.0	5.7	5.3	5.7
10	Estica (C.R.F.)	4.3	6.7	5.0	5.0	5.7	6.7	5.6
11	Pennlawn (C.R.F.)	5.0	5.3	5.3	5.0	5.7	6.7	5.5
12	Atlanta (C.F.)	6.3	4.7	4.3	5.0	5.7	7.0	5.5
13	Banner (C.F.)	4.7	5.3	4.7	5.0	5.7	6.7	5.3

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
14	Apache (T.F.)	4.3	6.7	5.7	5.3	5.0	5.0	5.3
15	Bonanza (T.F.)	5.3	7.0	4.7	4.7	5.0	4.7	5.2
16	Falcon (T.F.)	4.7	6.7	5.7	5.0	4.7	4.7	5.2
17	Biljart (H.F.)	4.3	5.0	5.0	5.0	5.3	6.0	5.1
18	Agram (C.F.)	4.7	4.3	5.0	4.7	5.3	6.7	5.1
19	Rebel II (T.F.)	4.7	6.0	4.7	5.0	4.7	5.7	5.1
20	Wintergreen (C.F.)	5.0	4.3	4.3	5.0	4.7	6.7	5.0
21	Spartan (H.F.)	3.3	5.0	4.7	4.7	5.3	6.7	4.9
22	Scaldis (H.F.)	4.0	4.0	4.0	5.0	5.3	6.3	4.8
23	Sabre (*Poa trivialis*)	5.0	6.3	4.3	3.7	3.0	6.3	4.8
24	Reliant (H.F.)	4.0	4.3	4.3	4.7	5.3	6.0	4.8
25	Highlight (C.F.)	4.3	4.3	4.0	4.0	5.0	6.3	4.7
26	Arid (T.F.)	4.3	6.0	4.3	4.0	5.0	4.7	4.7
27	Koket (C.F.)	5.0	5.0	4.3	4.0	4.3	4.7	4.6
28	Ensylva (C.R.F.)	4.7	4.7	3.7	3.7	4.3	5.7	4.4
29	Midnight (K.B.)	2.3	4.7	4.0	5.0	4.7	5.7	4.4
30	Coventry (K.B.)	3.3	5.0	3.7	4.0	3.3	3.7	3.8
31	Bristol (K.B.)	2.7	4.0	3.3	3.7	3.7	4.0	3.6
32	Ram I (K.B.)	2.3	3.7	3.3	3.0	3.7	4.0	3.3
33	Chateau (K.B.)	2.3	3.7	3.3	3.0	2.3	3.3	3.0
34	Glade (K.B.)	1.7	3.0	3.0	2.7	3.0	3.3	2.8
35	Nassau (K.B.)	2.0	2.7	2.7	2.0	2.7	2.3	2.4
	$LSD_{(0.05)}$	2.1	1.7	1.7	1.9	1.9	2.1	1.5

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

Table 2. The 1995 quality ratings for grasses in the 1994 shade trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Polder (*Poa trivialis*)	6.3	7.7	7.0	7.0	6.3	8.0	7.1
2	Cypress (*Poa trivialis*)	6.0	7.3	6.7	6.7	6.0	8.0	6.8
3	Saber (*Poa trivialis*)	6.7	7.7	6.7	6.3	5.7	7.7	6.8
4	SR5100 (C.F.)	6.0	6.0	5.0	5.3	6.7	7.0	6.0
5	Silvana (H.F.)	5.0	5.7	5.0	5.7	6.7	7.0	5.8
6	Banner (C.F.)	6.0	5.0	4.3	5.3	6.3	7.3	5.7
7	Nordic (H.F.)	5.0	5.7	5.3	5.0	5.7	7.0	5.6
8	Arid (T.F.)	5.3	5.3	5.3	4.7	4.7	5.7	5.2
9	Spartan (H.F.)	5.3	5.0	4.7	4.3	5.3	6.0	5.1
10	Waldina (H.F.)	4.3	4.3	5.7	4.7	5.7	6.0	5.1
11	Bonanza (T.F.)	4.0	4.7	5.3	5.0	4.7	6.3	5.0
12	Brigade (H.F.)	4.7	5.7	4.0	4.3	5.3	5.7	4.9
13	Southport (C.F.)	5.3	5.7	4.3	3.3	5.0	5.7	4.9
14	Shenandoah (T.F.)	5.0	5.0	5.3	4.3	4.7	5.3	4.9
15	Rebel II (T.F.)	5.0	5.3	5.3	4.0	4.7	5.0	4.9
16	Banner II (C.F.)	6.0	4.0	3.7	3.7	5.3	6.3	4.8
17	Mirage (T.F.)	4.7	5.0	5.0	4.7	4.3	5.0	4.8
18	Bridgeport (C.F.)	5.7	5.7	4.3	2.0	4.0	6.3	4.7
19	Ascot (K.B.)	2.0	3.7	4.7	5.3	5.7	6.0	4.6
20	Rebel (T.F.)	5.7	5.3	4.7	3.7	4.0	4.3	4.6
21	Bonanza II (T.F.)	4.0	5.0	5.0	5.0	4.3	4.3	4.6
22	Aztec (T.F.)	4.3	5.0	5.0	5.0	3.7	4.7	4.6
23	Adobe (T.F.)	3.7	5.0	5.0	4.0	5.0	5.0	4.6
24	Coventry (K.B.)	2.7	4.7	5.0	5.3	4.3	5.0	4.5
25	Flyer (C.R.F.)	5.0	4.0	3.7	3.3	4.7	6.0	4.4
26	Midnight (K.B.)	2.7	2.7	4.3	5.3	4.7	6.3	4.3

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
27	Shadow (C.F.)	6.0	5.0	4.0	3.7	3.0	4.3	4.3
28	Victory (C.F.)	7.0	4.7	3.3	2.0	3.0	4.7	4.1
29	Molinda (C.F.)	5.0	5.0	4.0	2.0	3.7	5.0	4.1
30	Bonsai (T.F.)	4.3	6.0	5.0	2.3	2.7	3.7	4.0
31	Buckingham (K.B.)	2.7	3.3	3.7	4.0	4.3	5.7	3.9
32	Bristol (K.B.)	2.3	3.0	4.0	4.7	4.0	5.0	3.8
33	Falcon II (T.F.)	3.0	3.7	3.3	4.3	3.7	5.0	3.8
34	Glade (K.B.)	2.0	3.0	3.3	4.0	4.3	5.0	3.6
35	Supranova (*Poa supina*)	5.7	3.3	3.0	2.0	1.7	2.7	3.1
	$LSD_{(0.05)}$	1.3	1.4	1.5	2.1	1.8	1.7	1.2

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

Table 3. The Average quality ratings for grasses in the 1987 Shade Trial: 1988 - 1994.

	Cultivar	1988	1989	1990	1991	1992	1993	1994	Average
1	ST-2 (SR 3000) (H.F.)	7.3	7.3	7.3	5.1	6.3	5.7	6.1	6.44
2	Bonanza (T.F.)	5.8	6.3	6.4	6.5	6.9	6.3	6.2	6.34
3	Victor (C.F.)	7.3	6.3	6.1	4.3	5.9	7.2	7.1	6.31
4	Estica (C.R.F.)	7.7	7.0	7.0	4.1	5.6	6.6	6.1	6.30
5	Rebel (T.F.)	6.7	6.6	6.6	5.3	6.0	6.9	5.9	6.29
6	Arid (T.F.)	5.8	6.3	6.3	6.0	7.1	6.7	5.6	6.26
7	Apache (T.F.)	6.7	6.6	6.8	6.0	6.0	6.3	5.4	6.26
8	Sabre (*Poa trivialis*)	6.4	5.4	5.0	6.9	6.4	7.4	6.2	6.24
9	Falcon (T.F.)	6.6	6.4	6.3	5.3	6.0	6.5	6.3	6.20
10	Waldorf (C.F.)	6.1	6.2	6.2	5.5	7.3	5.9	6.2	6.20
11	BAR FO 81-225 (H.F.)	5.7	6.9	7.1	4.9	6.5	5.5	6.1	6.10
12	Rebel II (T.F.)	6.0	6.6	6.8	5.3	5.6	6.1	6.2	6.09
13	Biljar (H.F.)	6.7	7.5	7.0	5.1	6.1	5.0	5.1	6.07
14	Mary (C.F.)	6.3	6.2	6.3	3.9	6.4	6.7	6.6	6.06
15	Jamestown (C.F.)	6.7	6.0	6.0	4.2	6.0	6.5	6.6	6.00
16	Waldina (H.F.)	7.1	6.8	6.8	4.1	5.5	5.5	5.8	5.94
17	Shadow (C.F.)	6.9	5.5	5.2	4.7	6.0	6.6	6.6	5.93
18	Pennlawn (C.R.F.)	6.7	5.8	5.6	4.7	6.2	6.3	5.5	5.83
19	Atlanta (C.F.)	6.6	5.7	5.7	4.9	6.1	5.8	5.7	5.79
20	Banner (C.F.)	6.9	5.6	6.0	4.5	5.0	6.0	5.6	5.66
21	Spartan (H.F.)	7.6	6.9	7.2	3.5	4.2	4.7	5.1	5.60
22	Ensylva (C.R.F.)	7.1	5.4	5.2	4.0	5.1	5.9	5.4	5.44
23	Agram (C.F.)	6.7	5.6	5.3	3.9	5.9	5.4	5.3	5.44
24	Wintergreen (C.F.)	6.1	5.6	5.5	4.6	5.9	5.0	5.0	5.39
25	RAM I (K.B.)	6.2	6.1	5.2	5.0	5.0	5.9	4.3	5.39
26	Chateau (K.B.)	5.4	5.8	5.5	6.2	5.5	5.2	4.1	5.39
27	Coventry (K.B.)	4.9	5.3	5.3	5.7	5.4	6.0	4.7	5.33
28	Koket (C.F.)	6.3	5.4	4.9	4.2	5.2	5.2	5.7	5.27
29	Scaldis (H.F.)	6.5	6.5	5.8	3.7	5.2	4.6	4.4	5.24
30	Glade (K.B.)	5.1	5.3	5.4	5.5	4.8	5.3	3.3	4.96
31	Midnight (K.B.)	2.4	3.8	4.7	5.9	5.5	6.4	4.6	4.76
32	Highlight (C.F.)	5.1	4.9	4.8	3.5	4.6	5.0	4.8	4.67
33	Bristol (K.B.)	4.8	4.7	4.3	3.9	3.9	5.0	4.1	4.39
34	Reliant (H.F.)	5.3	3.7	3.9	3.1	3.5	4.2	4.9	4.09
35	Nassau (K.B.)	4.3	4.1	3.7	3.4	3.8	4.3	3.3	3.84

Quality Based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
Table 3 compiled by Gary Peterson, Commercial Horticulture Field Specialist

Regional Fine Fescue Cultivar Evaluation - 1993
1995 Progress Report

Nick. E. Christians and James R. Dickson

This was the second 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 3 x 5 ft (15 ft^2) plots were established for each cultivar in September of 1993. The trial is maintained at a 2-inch mowing height, 3.5 lbs 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. Data on genetic color (Gencolor), and leaf texture (leaftex) are also included. The highest rated cultivars in 1995 were three experimental chewings fescues: PST-44D, ISI-FC-62, and MB-64-93. Several of the hard fescues developed Dollar Spot following the wet conditions of spring. Drier years tend to favor the hard fescues; whereas they often deteriorate in quality in the wetter years.

Table 1. The 1995 quality ratings for the fine fescue regional cultivar trial.

					Quality						
	Cultivar	Species	Gencolor	Leaftex	May	June	July	Aug	Sept	Oct	Mean
1	PST-44D	CF	8.3	8.3	7.0	5.0	7.0	6.3	6.3	6.7	6.4
2	ISI-FC-62	CF	7.3	6.7	6.0	4.7	7.3	6.3	7.0	5.7	6.2
3	MB 64-93	CF	7.0	7.3	6.0	5.3	7.7	6.0	6.3	6.0	6.2
4	PST-4ST	STC	8.0	7.7	5.0	4.7	7.7	6.0	7.3	6.7	6.2
5	Discovery	HF	7.3	7.0	6.3	6.7	5.3	5.0	6.7	6.3	6.1
6	Pick 4-91W	CF	7.7	7.7	6.3	6.0	5.7	5.3	6.0	7.3	6.1
7	Treazure (ZPS-MG)	CF	7.0	7.3	6.7	4.7	6.3	6.0	6.0	6.7	6.1
8	Victory (E)	CF	8.0	7.0	6.3	4.7	7.0	5.7	6.3	6.3	6.1
9	Brittany	CF	7.7	8.0	6.0	4.0	6.3	5.7	7.0	7.0	6.0
10	Jamestown II	CF	7.7	7.0	7.7	5.3	6.7	5.3	5.0	6.0	6.0
11	MB 63-93	CF	7.0	6.7	5.7	5.0	6.3	6.0	6.3	6.7	6.0
12	MB 82-93	HF	7.0	7.3	5.7	5.7	5.3	5.0	7.0	7.3	6.0
13	PRO 92/24	HF	7.3	7.0	5.7	6.0	5.7	5.3	6.7	6.7	6.0
14	Shademaster II	STC	6.0	5.3	4.3	5.0	7.3	5.3	6.3	7.7	6.0
15	TMI-3CE	CF	7.0	6.3	6.3	4.7	6.3	5.7	6.3	6.3	5.9
16	WX3-FF54	CF	6.3	7.0	6.3	5.0	6.0	5.7	5.7	6.7	5.9
17	WX3-FFG6	STC	6.7	7.0	6.0	5.3	7.3	6.0	5.3	5.7	5.9
18	Jasper (E)	STC	7.3	7.3	4.0	4.7	6.7	5.0	7.0	7.3	5.8
19	MB 61-93	CF	7.3	7.3	6.7	4.3	6.0	6.0	6.0	6.0	5.8
20	PST-4VB Endo.	STC	6.3	6.0	5.3	6.0	6.3	5.7	5.7	6.0	5.8
21	Quatro (FO 143)	SF	7.7	6.3	5.3	5.7	5.7	6.0	6.3	6.0	5.8
22	MB 65-93	CF	6.7	7.3	6.0	4.7	6.3	5.3	5.3	6.3	5.7
23	PST-4DT	STC	6.3	6.7	4.3	4.3	7.0	5.7	6.3	6.3	5.7
24	Banner II	CF	7.3	6.7	6.3	3.7	5.7	5.3	6.3	6.0	5.6
25	Ecostar	HF	6.0	6.3	5.7	6.0	4.0	4.7	6.3	6.7	5.6
26	SR 5100	CF	7.0	6.0	5.3	5.0	7.3	6.0	4.3	5.7	5.6

	Cultivar	Species	Gencolor	Leaftex	Quality							
					May	June	July	Aug	Sept	Oct	Mean
27	Aruba	STC	5.3	5.7	4.7	4.3	6.7	5.7	5.7	6.0	5.5
28	MB 81-93	HF	6.7	6.7	6.0	6.3	4.7	4.0	5.3	6.7	5.5
29	Medina	CF	5.3	6.0	7.3	4.7	5.3	4.7	4.7	6.3	5.5
30	Shadow (E)	CF	7.0	7.0	5.7	5.3	5.3	5.3	5.7	5.7	5.5
31	BAR FRR 4ZBD	STC	7.0	6.7	5.0	4.3	7.0	5.3	5.3	5.3	5.4
32	BAR UR 204	STC	6.3	5.3	4.3	5.0	6.0	6.3	4.7	6.0	5.4
33	Bridgeport	CF	7.0	6.7	5.0	4.7	6.7	5.0	5.7	5.7	5.4
34	Brigade	HF	6.7	5.7	5.3	6.7	4.3	4.3	6.0	6.0	5.4
35	MB 83-93	HF	6.3	6.3	5.0	6.0	4.3	4.7	6.3	6.3	5.4
36	SR 3100	HF	6.7	6.3	6.7	6.3	4.7	4.3	4.7	5.7	5.4
37	ZPS-4BN	STC	6.0	5.7	4.7	4.0	6.3	6.0	5.3	6.0	5.4
38	Molinda	CF	6.0	6.0	5.3	4.0	5.3	5.7	5.3	6.0	5.3
39	Scaldis	HF	6.3	6.3	6.0	5.3	4.3	4.7	5.7	5.7	5.3
40	MB 66-93	CF	6.0	5.7	5.7	5.0	5.7	5.0	4.3	5.3	5.2
41	Tiffany	CF	7.3	6.3	6.0	4.3	6.0	4.7	5.0	5.3	5.2
42	Flyer	STC	6.3	5.7	5.3	4.0	5.7	4.7	5.7	5.0	5.1
43	Jamestown	CF	5.7	5.7	6.0	5.0	6.0	5.3	4.0	4.3	5.1
44	NJ F-93	CF	5.0	5.0	6.3	5.0	5.3	4.3	4.3	5.0	5.1
45	PRO 92/20	CF	6.7	6.0	5.0	4.7	6.3	5.7	3.7	5.3	5.1
46	Reliant II	HF	6.7	6.3	5.7	5.3	4.0	4.0	5.7	6.0	5.1
47	Seabreeze	SLC	5.0	4.7	5.0	4.3	5.7	5.7	4.3	5.0	5.0
48	CAS-FR13	STC	5.7	5.3	4.0	3.7	5.7	5.3	5.0	5.7	4.9
49	Nordic	HF	5.7	5.0	6.0	5.7	4.0	4.0	4.3	5.3	4.9
50	Rondo	STC	5.0	6.0	4.7	5.0	6.0	4.7	3.3	5.0	4.8
51	Spartan	HF	5.3	5.3	6.0	5.7	3.7	3.0	5.0	5.7	4.8
52	Aurora W/Endo.	HF	6.0	5.0	6.0	5.7	3.7	3.7	4.3	5.0	4.7
53	Darwin	CF	4.7	5.0	6.3	4.7	4.7	4.7	3.3	4.3	4.7
54	Cascade	CF	4.3	4.0	5.7	4.7	6.0	3.7	3.0	4.0	4.5
55	Pamela	HF	5.7	4.7	5.0	5.0	3.7	3.3	4.3	5.0	4.4
56	Common Creeping	STC	4.3	3.7	4.3	4.0	5.0	4.0	3.7	5.0	4.3
57	WVPB-STCR-101	STC	5.3	5.3	4.7	3.7	4.7	4.3	4.0	4.7	4.3
58	Dawson	SLC	3.3	3.7	5.0	4.3	4.7	3.7	2.3	3.0	3.8
59	67135	SF	5.7	4.0	3.7	2.7	2.0	2.7	3.3	3.7	3.0
	$LSD_{(0.05)}$	—	1.7	1.8	1.6	1.4	1.5	1.6	1.8	1.6	0.9

Species: CF = Chewings Fescue
HF = Hard Fescue
SF = Sheep Fescue
SLC = Slender Creeping Fescue
STC = Strong Creeping Fescue

Gencolor (Genetic color): 9 = dark green and 1 = light green.

Leaftex (Leaf texture): 9 = fine and 1 = coarse.

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 (Native Soil) - 1993
1995 Progress Report

Nick E. Christians and James R. Dickson

This is the second year of data from the Green Height Bentgrass Cultivar trial established in the fall of 1993. The area was maintained at a 3/16-inch mowing height. This is a National Turfgrass Evaluation Program (NTEP) trial and is being conducted at several research stations in the U.S. It contains 28 seeded cultivars, including a number of experimentals.

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

G-2 was the highest rated cultivar in 1995 (Table 1). The first 10 cultivars are statistically the same. Data on genetic color (Gencolor), leaf texture (Leaftex), and Brown patch ratings (Brownpat) are also included in Table 1. This was the first full year of data. 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. Reports from previous years contain information from several seasons data on older bentgrass studies.

Table 1. The 1995 ratings for the green height bentgrass trial.

					Quality						
	Cultivar	Gencolor	Leaftex	Brownpat	May	June	July	Aug	Sept	Oct	Mean
1	G-2	8.0	8.3	6.3	5.3	7.0	6.3	6.7	8.0	7.0	6.7
2	Crenshaw	6.3	8.0	6.7	4.7	5.3	6.0	6.0	8.0	7.0	6.2
3	SR 1020	7.3	8.0	7.7	3.7	5.3	6.0	6.7	7.7	7.0	6.1
4	Cato	7.0	7.0	7.7	5.3	5.7	5.7	5.7	7.0	6.7	6.0
5	Providence	6.3	7.0	9.0	4.3	6.0	5.3	7.0	7.0	6.3	6.0
6	18th Green	7.0	7.0	8.3	5.7	5.0	5.7	7.0	6.7	5.3	5.9
7	SYN 92-5	7.7	7.3	6.3	5.0	5.7	5.7	6.0	6.3	6.7	5.9
8	BAR WS 42102	6.3	8.0	5.7	5.3	6.3	5.0	5.7	5.7	6.7	5.8
9	ISI-AP-89150	8.0	8.3	6.0	5.0	6.3	5.0	6.3	6.3	6.0	5.8
10	L-93	7.0	7.0	9.0	4.7	5.7	5.3	6.3	6.3	6.3	5.8
11	SYN 92-1	7.0	7.7	7.7	4.3	4.3	5.0	5.7	6.7	7.0	5.5
12	G-6	6.7	7.0	7.3	5.0	4.0	4.7	4.7	6.7	7.3	5.4
13	Penncross	6.3	6.7	8.3	4.3	4.7	4.7	6.0	7.0	5.7	5.4
14	Pro/Cup	6.0	6.0	7.7	5.0	4.7	5.0	5.7	5.7	6.3	5.4
15	A-1	7.0	7.0	7.0	4.3	5.0	5.0	5.0	6.3	6.3	5.3
16	DG-P	6.3	6.7	7.7	4.3	4.7	5.3	5.0	6.3	6.0	5.3
17	MSUEB	6.3	6.7	5.3	4.7	5.3	4.7	5.3	6.3	5.7	5.3
18	Regent	6.0	6.7	7.0	4.0	5.0	5.0	5.7	6.0	6.0	5.3
19	Lopez	6.3	6.0	8.3	4.3	4.7	4.7	5.3	6.0	6.0	5.2
20	Pennlinks	6.7	6.3	6.7	4.3	5.0	4.7	5.7	5.7	6.0	5.2
21	Southshore	6.7	7.0	7.7	4.0	4.3	4.3	5.7	6.7	6.0	5.2
22	Trueline	6.7	7.0	7.7	4.0	4.7	4.7	5.3	7.0	5.7	5.2
23	SYN 92-2	6.7	7.3	7.7	3.7	4.0	4.3	5.3	6.7	6.0	5.0
24	SYN-1-88	5.7	5.7	4.7	4.3	4.0	4.3	5.0	6.0	5.7	4.9
25	A-4	6.7	7.0	6.3	4.0	3.3	4.0	4.7	5.7	7.0	4.8
26	BAR AS 492	5.7	5.3	4.3	4.3	3.3	3.3	4.0	5.0	4.3	4.1
27	Seaside	5.3	4.3	5.0	3.7	2.7	3.0	4.3	4.7	4.7	3.8
28	Tendenz	4.7	4.3	3.3	5.3	3.0	3.0	3.0	4.3	3.7	3.7
	$LSD_{(0.05)}$	1.4	1.3	2.0	NS	1.7	1.3	1.6	1.9	1.6	1.0

Gencolor (Genetic color): 9 = dark green and 1 = light green.
Leaftex (Leaf texture): 9 = fine and 1 = coarse.
Brownpat (Brown patch): 9 = no damage and 1 = maximum damage.
Quality 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.

Fairway Height Bentgrass Study - 1993
1995 Progress Report

Nick E. Christians and James R. Dickson

This is the second 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, 1994. The area is maintained at a 0.5 in. mowing height. This is a National Turfgrass Evaluation (NTEP) trial and is being conducted at several research stations in the U.S. It contains 21 of the newest seeded cultivars and a number of experimentals.

The cultivars are maintained with 4 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 1 contains monthly visual quality ratings for the 1995 season. Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Data on genetic color (Gencolor), leaf texture (Leaftex), and Brown patch ratings (Brownpat) are also included.

Southshore was the highest rated cultivar in 1995, followed by Cato and Crenshaw. The first nine cultivars are statistically the same.

Table 1. The 1995 quality ratings for the fairway height bentgrass study.

					Quality						
	Cultivar	Gencolor	Leaftex	Brownpat	May	June	July	Aug	Sept	Oct	Mean
1	Southshore	8.3	7.7	8.7	6.3	7.7	7.7	8.0	8.3	8.3	7.7
2	Cato	8.0	7.3	8.7	6.0	6.0	6.7	7.0	9.0	9.0	7.3
3	Crenshaw	7.7	7.7	8.7	5.3	6.7	6.7	8.3	8.7	8.0	7.3
4	Penneagle	8.0	7.3	9.0	5.0	6.3	6.0	9.0	8.7	8.0	7.2
5	Providence	8.0	7.3	8.7	5.7	6.7	6.3	8.3	7.7	8.3	7.2
6	BAR WS 42102	8.3	7.7	8.0	5.7	7.0	7.0	7.0	7.3	7.3	6.9
7	G-2	8.0	7.0	8.3	6.3	6.7	6.3	6.3	7.7	6.7	6.7
8	G-6	6.7	7.0	9.0	4.7	5.7	6.0	7.7	7.7	8.3	6.7
9	Pro/Cup	7.7	6.0	8.0	5.7	5.7	6.7	7.0	7.7	7.3	6.7
10	Trueline	8.0	7.3	8.7	5.3	5.7	7.0	7.7	6.3	6.3	6.4
11	18th Green	8.0	7.0	8.7	5.0	4.7	6.0	8.0	6.7	6.0	6.1
12	DF-1	7.7	5.7	7.0	4.3	5.3	5.3	6.7	7.3	7.7	6.1
13	Penncross	7.3	8.3	8.3	6.0	5.3	6.3	6.7	6.7	5.7	6.1
14	Lopez	7.0	5.7	8.3	5.0	4.7	5.3	7.3	6.3	6.3	5.8
15	ISI-AT-90162 (Colonial)*	6.3	6.3	3.3	5.0	5.0	4.7	3.7	5.7	5.3	4.9
16	OM-AT-90163	7.0	5.7	3.7	4.7	4.3	5.0	3.7	6.3	5.7	4.9
17	SR 7100 (Colonial)	6.7	6.3	2.7	4.7	4.3	5.0	3.3	6.0	6.0	4.9
18	BAR AS 492	6.7	5.3	4.7	4.3	4.7	4.7	4.3	5.3	5.7	4.8
19	Seaside	7.3	6.3	6.7	3.7	4.3	4.7	4.7	5.7	5.3	4.7
20	Tendenz (Colonial)	6.3	5.0	3.3	4.3	3.3	4.3	3.7	4.7	4.3	4.1
21	Exeter (Colonial)	6.0	4.7	3.7	2.7	2.7	3.7	3.7	4.7	4.3	3.6
	$LSD_{(0.05)}$	2.0	2.6	1.5	2.2	2.0	2.1	1.5	1.8	1.2	1.0

* Colonial Bentgrass
Gencolor (Genetic color): 9 = dark green and 1 = light green.
Leaftex (Leaf texture): 9 = fine and 1 = coarse.
Brownpat (Brown patch): 9 = no damage and 1 = maximum damage.
Quality based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

1995 Preemergence Annual Weed Control Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Several herbicides were screened for efficacy as preemergence products for crabgrass control in turfgrass. The study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental site was an established area of 'Park' Kentucky bluegrass. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 2.6% organic matter, a pH of 6.7, 5 ppm P, and 90 ppm K. This area was seeded with a mixture of large hairy crabgrass [*Digitaria sanguinalis* (L.) Scop.] and smooth crabgrass [*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl] before the study was begun.

The experimental design was a randomized complete block and three replications were conducted. Individual plots were 5 x 5 ft and there were 28 treatments including 26 herbicides, a fertilized control, and an untreated control (Table 1). Chipco Ronstar 2GR, Barricade 75WG, Penidmethalin 60WDG, and Dimension 1EC were applied in standard formulations. Barricade, Pendimethalin, and Team were applied in granular formulations with fertilizer. Dimension 1EC and granular Dimension plus fertilizer materials also were included and the rates were determined so that an equal amount of N was applied to the plots treated with these materials.

The turf was uniform in color and overall quality prior to treatment. Initial application of materials was April 27, 1995. A carbon dioxide backpack sprayer equipped with #8006 nozzles at a pressure of 25-30 psi was used to apply the liquid formulations. Granular materials were applied using plastic coated containers as 'shaker dispensers'.

Sequential applications of Dimension, Dimension plus fertilizer formulations, and fertilizer were made on June 9, 45 days after the initial treatments. The 8-week postemergence applications of Team plus fertilizer and Pendimethalin plus fertilizer were made on June 21.

Rainfall was sporadic throughout the duration of this study and the temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to keep the grass in good growing condition.

The experimental area was examined for Kentucky bluegrass phytotoxicity on May 1, May 4, and May 19 and no symptoms were detected. Visual quality data were taken from May 4 through August 3. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 2).

Crabgrass germination was detected on May 25. Crabgrass control data were taken on June 28, July 14, July 21, and August 3. Crabgrass control was measured by estimating the percentage of crabgrass cover per plot. (Table 3).

All data were analyzed using the Statistical Analysis System (SAS) version 6.06 (SAS Institute, 1989) and the analysis of variance (ANOVA) procedure. Least Significant Difference tests (LSD's) were used to compare means among the treatments for visual quality and percent crabgrass cover.

On May 25 (four weeks after the initial applications), there were significant visual quality differences (Table 2). Kentucky bluegrass with the best quality (ratings of 8 and 9) had either been treated with herbicide formulations in combination with fertilizer (Treatments 6-8, 12-19, and 26-28) or had received fertilizer and no herbicide (Treatment 20). The best mean visual quality was for grass receiving either herbicide materials with fertilizer or fertilizer alone (Treatments 7, 12-20, 22, and 24).

All herbicide formulations significantly reduced the percentage of crabgrass cover when compared with the untreated and fertilized controls. Reductions in crabgrass cover ≥ 90% were achieved for 14 of the herbicide products when compared to the untreated control.

Table 1. The preemergence herbicides, herbicide plus fertilizer formulations, and fertilizer materials that were screened[1].

	Product	Number of Applications	Initial Rate lb a.i./A	Sequential Rate lb a.i./A
1	Untreated Control	NA	NA	NA
2	CHIPCO Ronstar G-2GR[2]	1	4.00	NA
3	Barricade - 65WG[3]	1	0.65	NA
4	Barricade - 65WG[3&4]	1	0.75	NA
5	Barricade - 65WG[2]	1	1.00	NA
6	Barricade 0.5% + Fertilizer (32-3-12)[3]	1	0.65	NA
7	Barricade 0.5% + Fertilizer (32-3-12)[3]	1	0.75	NA
8	Pendimethalin 0.86% + fertilizer[2]	1	3.00	NA
9	Pendimethalin-60WDG[3&4]	1	1.50	NA
10	Pendimethalin-60WDG[4]	2	0.75	0.75
11	Dimension 1 EC[2&3]	1	0.50	NA
12	Dimension - 1EC + fert(39-0-0)[4]	1	0.25	NA
13	Dimension - 1EC + fert(39-0-0)[4]	1	0.50	NA
14	Dimension - 1EC + fert(39-0-0)[4]	2	0.125	0.125
15	Dimension - 1EC + fert(39-0-0)[4]	2	0.25	0.25
16	Dimension - AND444 + fert (39-0-0)[4]	2	0.125	0.125
17	Dimension - AND445 + fert (39-0-0)[4]	1	0.25	NA
18	Dimension - AND447 + fert (39-0-0)[4]	1	0.50	NA
19	Dimension - AND445 + fert (39-0-0)[4]	2	0.25	0.25
20	Fertilizer control (39-0-0)[4]	NA	NA	NA
21	Team 1.15% GR + Fert (27-3-8) PRE [5]	1	1.50	NA
22	Team 1.15% GR + Fert (27-3-8) PRE & POST [5]	2	1.50	1.50
23	Pendimethalin 1.21% GR + fert (28-3-4) PRE5	1	1.50	NA
24	Pendimethalin 1.21% GR + fert (28-3-4) PRE & POST [5]	2	1.50	1.50
25	Dimension 0.172% + fert (24-4-14) PRE[5]	1	0.25	NA
26	Barricade 0.22% + fert (19-4-6) PRE[5]	1	0.50	NA
27	Pendimethalin 0.75% + fertilizer 22-0-6[6]	1	1.50	NA
28	Pendimethalin 1.15% + fertilizer 33-3-10[6]	1	1.50	NA

[1]Application dates: initial on April 27, 45-day on June 9 for Trts 10, 12-20, and 8-week on June 21 for Trts 22 & 24.

These products were screened for Rhone-Poulenc Ag Company[2] ,Sandoz Agro Inc.[3], Rohm and Haas Company[4], DowElanco[5], and O. M. Scott & Sons[6].

Table 2. The visual quality[1] of Kentucky bluegrass treated with preemergence herbicides, herbicide plus fertilizer formulations, and fertilizer alone[2].

	Treatment	Rate lb a.i./A	May 4	May 19	May 25	May 30	June 8	June 21	June 28	July 14	July 21	August 3	Mean Visual Quality
1	Untreated Control	NA	8	7	7	7	7	7	6	6	7	6	7
2	CHIPCO Ronstar G-2GR	4.00	8	7	7	6	7	7	6	7	7	7	7
3	Barricade 65WG	0.65	8	7	6	6	7	7	7	6	6	7	7
4	Barricade 65WG	0.75	8	7	7	6	6	7	6	6	7	6	7
5	Barricade 65WG	1.00	8	7	6	6	6	6	5	6	6	6	6
6	Barricade 0.5% + fertilizer	0.65	8	7	8	8	7	7	7	7	8	7	7
7	Barricade 0.5% + fertilizer	0.75	8	7	8	8	7	7	7	7	8	8	8
8	Pendimethalin 0.86% + fertilizer	3.00	8	7	8	7	7	7	6	7	7	7	7
9	Pendimethalin 60WDG	1.50	8	7	6	6	7	7	6	6	7	7	7
10	Pendimethalin 60WDG	0.75+0.75	8	7	6	6	7	7	6	7	7	7	7
11	Dimension 1EC	0.50	8	7	6	6	6	6	5	6	7	6	6
12	Dimension 1EC+ fertilizer	0.25	8	7	8	8	7	8	9	8	8	9	8
13	Dimension 1EC+ fertilizer	0.50	8	7	9	8	7	9	9	9	9	9	8
14	Dimension 1EC+ fertilizer	0.125+0.125	8	7	8	8	8	9	9	8	8	9	8
15	Dimension 1EC+ fertilizer	0.25+0.25	8	7	8	8	7	9	9	8	9	9	8
16	Dimension (AND444) + fertilizer	0.125+0.125	8	7	8	8	7	9	8	8	9	9	8
17	Dimension (AND445) + fertilizer	0.25	8	7	8	8	8	9	8	8	8	9	8
18	Dimension (AND447) + fertilizer	0.50	8	7	8	7	7	9	8	8	9	9	8
19	Dimension (AND445) + fertilizer	0.25+0.25	8	7	8	8	8	8	8	8	8	9	8
20	Fertilizer control (39-0-0)	NA	8	7	8	8	8	9	8	8	8	9	8
21	Team 1.15% + fert PRE	1.50	8	7	7	7	7	7	6	7	8	8	7
22	Team 1.15% + fert 8-10 wks	1.50+1.50	8	7	7	7	7	7	8	8	8	8	8
23	Pendimethalin + fert PRE	1.50	8	7	7	6	7	7	6	6	7	7	7
24	Pendimethalin + fert 8-10 wks	1.50+1.50	8	7	7	7	7	7	8	8	8	8	8
25	Dimension + fertilizer PRE	0.25	8	7	7	7	6	7	6	6	8	7	7
26	Barricade 0.22%+ fertilizer PRE	0.50	8	7	8	7	7	7	7	6	8	7	7
27	Pendimethalin 0.75% + fertilizer	1.50	8	7	8	8	7	7	7	7	8	8	7
28	Pendimethalin1.15% + fertilizer	1.50	8	7	8	8	7	8	7	7	7	7	7
	$LSD_{(0.05)}$	---	NS	NS	1	1	1	1	1	1	1	1	0.4

[1]Visual quality is based on a scale of 9 to 1: 9 = best, 6 = lowest acceptable quality, and 1 = poorest quality.
[2]Application dates: initial on April 27, 45-day on June 9 for Trts 10, 12-20, and 8-week on June 21 for Trts 22 & 24.
NS = not significantly different at the 0.05 level.

Table 3. Percentage of crabgrass cover in plots of Kentucky bluegrass treated with preemergence herbicides, herbicide plus fertilizer formulations, and fertilizer alone[1].

	Material	Rate lb a.i./A	June 28	July 14	July 21	August 3	Mean % Cover	% Cover Reduction
1	Untreated Control	NA	18	27	42	49	34	0
2	CHIPCO Ronstar G-2GR	4.00	1	2	4	2	2	94
3	Barricade 65WG	0.65	1	2	4	5	3	92
4	Barricade 65WG	0.75	0	4	5	2	3	92
5	Barricade 65WG	1.00	0	2	2	1	1	96
6	Barricade 0.5% + fertilizer	0.65	5	7	13	10	9	74
7	Barricade 0.5% + fertilizer	0.75	2	7	8	7	6	83
8	Pendimethalin 0.86% + fertilizer	3.00	3	5	10	5	6	83
9	Pendimethalin 60WDG	1.50	2	5	12	9	7	79
10	Pendimethalin 60WDG	0.75+0.75	2	4	10	8	6	83
11	Dimension 1EC	0.50	0	1	2	1	1	97
12	Dimension - 1EC+ fertilizer	0.25	2	2	8	5	4	88
13	Dimension - 1EC+ fertilizer	0.50	0	1	1	1	1	98
14	Dimension - 1EC+ fertilizer	0.125+0.125	1	1	5	3	3	93
15	Dimension - 1EC+ fertilizer	0.25+0.25	0	1	2	1	1	97
16	Dimension (AND444) + fertilizer	0.125+0.125	1	1	4	2	2	94
17	Dimension (AND445) + fertilizer	0.25	2	1	1	1	1	97
18	Dimension (AND447) + fertilizer	0.50	1	1	4	2	2	95
19	Dimension (AND445) + fertilizer	0.25+0.25	0	1	1	0	1	99
20	Fertilizer control (39-0-0)	NA	18	38	60	57	43	0
21	Team 1.15% + fertilizer PRE	1.50	3	4	10	5	6	83
22	Team 1.15% + fertilizer 8-10 wks	1.50+1.50	2	1	4	2	2	93
23	Pendimethalin 1.21% + fertilizer PRE	1.50	2	5	10	7	6	82
24	Pendimethalin 1.21% + fert. 8-10 wks	1.50+1.50	5	2	5	4	4	88
25	Dimension 0.172% + fertilizer PRE	0.25	2	1	2	2	2	93
26	Barricade 0.22%+ fertilizer PRE	0.50	2	4	10	7	6	82
27	Pendimethalin 0.75% + fertilizer	1.50	5	5	12	10	8	76
28	Pendimethalin1.15% + fertilizer	1.50	4	5	8	6	6	83
	$LSD_{(0.05)}$	---	4	7	9	11	7	19

[1]Application dates: Initial on April 27, 45-day on June 9 for Trts 10, 12-20, and 8-week on June 21 for Trts 22 & 24.

1995 Postemergence Annual Weed Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Experimental formulations were tested for efficacy as early postemergence materials for crabgrass control in turf areas. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental site was an area of Kentucky bluegrass seeded in the fall of 1994. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.2% organic matter, a pH of 5.9, 3.0 ppm P, and 145 ppm K.

The experimental design was a randomized block split-plot. Thirteen herbicide products were screened at two different application rates. Individual plots were 5 x 10 ft and three replications were run. Herbicide products were randomly assigned to plots as the main plot treatments. Each 5 x 10 ft plot was split and the two application rates were randomly assigned to the two 5 x 5 ft subplots. AgrEvo USA products AGR 40500, 10 PRECLAIM formulations, PRECLAIM 2.06 EW, and PRECLAIM 2.09 EW were screened. Each product was applied at two different rates. An untreated control was included.

Early postemergence application was made on June 12 when the crabgrass plants were in the 2-4 leaf stage of the first tiller. Pre-treatment assessment of the experimental area indicated that turf quality was uniform. Application was with a carbon dioxide backpack sprayer equipped with #8006 nozzles using a spray pressure of 25-30 psi.

Rainfall was sporadic for the duration of this study and the temperatures were unusually high. Irrigation was used to provide supplemental moisture to maintain the turf in good growing condition.

A post-treatment survey of the area on June 16 showed that all treated Kentucky bluegrass had a uniform yellow discoloration. Symptoms ranged from yellow discoloration to severe necrosis and dead plants. Damage was assessed with a scale from 9 to 1: 9 = healthy grass, 7 = plants discolored (yellowed) with some damage, 5 = severe damage with intermittent necrosis, and 3 = uniform necrosis (Table 1).

The grass in most plots had recovered adequately to take visual quality data on July 27 and August 10. The ratings were assigned using a 9 to 1 scale: 9 = best quality , 6 = lowest acceptable quality, and poorest quality turf. (Table 2).

Crabgrass control was measured by estimating the percentage of crabgrass cover. Crabgrass germination was detected on May 25 and percent cover data were taken on July 27 and August 10 (Table 3).

The Statistical Analysis System version 6.06 (SAS Institute, 1989) and Analysis of Variance (ANOVA) were used to analyze the data. Least Significant Difference (LSD) means comparisons were made to test for main plot (among herbicides) and subplot (between application rates) effects on phytotoxicity, visual quality, and crabgrass control.

On June 19 (7 DAT), the bluegrass in plots treated with the herbicide formulations was still tinted yellow. By June 30, phytotoxic symptoms were evident. All of the herbicides damaged the bluegrass when compared to the grass in the untreated control plots (Table 1). The degree of damage differed among the herbicides. Application rate also affected bluegrass phytotoxicity. In general, the higher rate of the products caused more severe damage than the lower rate. By July 21, the bluegrass in most of the treated plots had begun to recover.

Visual quality data were taken after the bluegrass had sufficiently recovered from the herbicide treatments. Turf quality was similar in treated plots and was not different from the untreated controls (Table 2). All herbicide formulations significantly reduced crabgrass cover when compared with the untreated controls. There were no differences in control between the high and low application rates (Table 3).

Table 1. Kentucky bluegrass phytotoxicity[1] in plots treated with AGR and PRECLAIM early postemergent annual weed materials on June 12, 1995.

	Material	Rate lb a.i./A	June 30 17 DAT	July 7 25 DAT	July 14 32 DAT	July 21 39 DAT	Mean Phyto
1.	Untreated control	NA	9	9	8	8	9
2.	AGR 40500	2.06	7	7	7	7	7
3.	PRECLAIM #1150	2.08	6	6	6	7	6
4.	PRECLAIM #1151	2.06	8	6	7	7	7
5.	PRECLAIM #1152	2.08	7	6	7	7	7
6.	PRECLAIM #1153	2.06	7	6	7	7	7
7.	PRECLAIM #1154	2.08	6	6	7	7	7
8.	PRECLAIM #1155	2.06	7	6	6	7	7
9.	PRECLAIM #1156	2.08	6	6	7	7	7
10.	PRECLAIM #1157	2.06	7	7	6	7	7
11.	PRECLAIM #1158	2.08	7	6	7	7	7
12.	PRECLAIM #1159	2.06	7	7	8	7	7
13.	PRECLAIM 2.06 EW	2.02	7	6	8	8	7
14.	PRECLAIM 2.09 EW	1.86	6	6	7	7	6
15.	Untreated control	NA	9	9	8	8	9
16.	AGR 40500	3.09	6	5	5	6	6
17.	PRECLAIM #1150	3.12	6	5	5	6	6
18.	PRECLAIM #1151	3.09	6	5	6	7	6
19.	PRECLAIM #1152	3.12	4	4	5	6	5
20.	PRECLAIM #1153	3.09	6	5	5	7	6
21.	PRECLAIM #1154	3.12	5	4	5	6	5
22.	PRECLAIM #1155	3.09	7	5	5	6	6
23.	PRECLAIM #1156	3.12	5	5	6	6	5
24.	PRECLAIM #1157	3.09	6	5	5	6	5
25.	PRECLAIM #1158	3.12	5	6	5	6	6
26.	PRECLAIM #1159	3.09	7	6	6	7	6
27.	PRECLAIM 2.06 EW	3.03	7	6	7	7	7
28.	PRECLAIM 2.09 EW	2.78	7	5	6	6	6
	$LSD_{0.05}$ among herbicides		1	1	1	1	1
	$LSD_{0.05}$ between rates		1	1	1	1	1

[1] Visual quality was based on a 9 to 1 scale: 9 = healthy, 7 = discolored (yellowed) with some damage, 5 = intermittent necrosis, 3 = uniform necrosis, 1 = all plants dead.

Table 2. Visual quality[1] of Kentucky bluegrass 46 and 60 days after treatment with AGR and PRECLAIM early postemergence annual weed herbicides.

Material	Rate lb a.i./A	July 27 46 DAT	August 10 60 DAT	Mean Quality
1. Untreated control	NA	8	7	8
2. AGR 40500	2.06	7	7	7
3. PRECLAIM #1150	2.08	8	7	7
4. PRECLAIM #1151	2.06	8	7	7
5. PRECLAIM #1152	2.08	8	7	7
6. PRECLAIM #1153	2.06	7	7	7
7. PRECLAIM #1154	2.08	7	7	7
8. PRECLAIM #1155	2.06	7	7	7
9. PRECLAIM #1156	2.08	7	7	7
10. PRECLAIM #1157	2.06	7	7	7
11. PRECLAIM #1158	2.08	8	7	7
12. PRECLAIM #1159	2.06	7	7	7
13. PRECLAIM 2.06 EW	2.02	8	7	8
14. PRECLAIM 2.09 EW	1.86	8	7	7
15. Untreated control	NA	8	7	8
16. AGR 40500	3.09	7	7	7
17. PRECLAIM #1150	3.12	7	7	7
18. PRECLAIM #1151	3.09	7	7	7
19. PRECLAIM #1152	3.12	6	7	6
20. PRECLAIM #1153	3.09	7	7	7
21. PRECLAIM #1154	3.12	6	7	6
22. PRECLAIM #1155	3.09	7	7	7
23. PRECLAIM #1156	3.12	7	7	7
24. PRECLAIM #1157	3.09	6	6	6
25. PRECLAIM #1158	3.12	7	7	7
26. PRECLAIM #1159	3.09	7	7	7
27. PRECLAIM 2.06 EW	3.03	8	7	7
28. PRECLAIM 2.09 EW	2.78	7	7	7
$LSD_{(0.05)}$ among herbicides		NS	NS	NS
$LSD_{(0.05)}$ between rates		1	NS	1

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

Table 3. The percentage of crabgrass cover in plots of Kentucky bluegrass treated with AGR and PRECLAIM early postemergence annual weed herbicides.

Material	Rate lb a.i./A	July 27 46 DAT	August 10 60 DAT	Mean Crabgrass Cover
1. Untreated control	NA	4	7	5
2. AGR 40500	2.06	0	1	1
3. PRECLAIM #1150	2.08	0	0	0
4. PRECLAIM #1151	2.06	0	2	1
5. PRECLAIM #1152	2.08	0	2	1
6. PRECLAIM #1153	2.06	0	1	1
7. PRECLAIM #1154	2.08	0	1	1
8. PRECLAIM #1155	2.06	0	1	1
9. PRECLAIM #1156	2.08	0	0	0
10. PRECLAIM #1157	2.06	0	0	0
11. PRECLAIM #1158	2.08	0	0	0
12. PRECLAIM #1159	2.06	0	0	0
13. PRECLAIM 2.06 EW	2.02	0	1	1
14. PRECLAIM 2.09 EW	1.86	0	0	0
15. Untreated control	NA	5	12	8
16. AGR 40500	3.09	0	1	1
17. PRECLAIM #1150	3.12	0	0	0
18. PRECLAIM #1151	3.09	0	1	1
19. PRECLAIM #1152	3.12	0	1	1
20. PRECLAIM #1153	3.09	0	0	0
21. PRECLAIM #1154	3.12	0	1	1
22. PRECLAIM #1155	3.09	0	1	1
23. PRECLAIM #1156	3.12	0	0	0
24. PRECLAIM #1157	3.09	0	1	1
25. PRECLAIM #1158	3.12	0	0	0
26. PRECLAIM #1159	3.09	0	1	1
27. PRECLAIM 2.06 EW	3.03	0	0	0
28. PRECLAIM 2.09 EW	2.78	0	1	1
$LSD_{(0.05)}$ among herbicides		1	1	1
$LSD_{(0.05)}$ between rates		NS	NS	NS

NS = not significantly different at the 0.05 level.

1995 Postemergence Broadleaf Weed Control Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Confront, Vanquish, Garlon and other herbicides in different formulations and tank mixes were screened for efficacy as postemergence broadleaf weed control products in turfgrass (Table 1). This trial was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was comprised of strips of common Kentucky bluegrass and partially bare areas that were previously used as planting beds. Both areas were heavily infested with clover and dandelion. The soil in this experimental area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.3%, a pH of 6.00, 23 ppm P, and 151 ppm K.

The experimental design was a randomized complete block. Individual experimental plots were 5 x 10 ft and there were 18 treatments with three replications. The study was arranged so each individual plot was approximately 1/2 bluegrass and 1/2 planting bed.

Vanquish 4SL (Dicamba DGA) and three different rates of Vanquish 4SL plus Garlon 3SL (Triclopyr amine) were screened. Two Confront plus fertilizer formulations and Turf builder + 2 with MCPP were applied to both wet and dry foliage. To accomplish this, the plots receiving these products were split to make 2 - 2 1/2 x 10 ft plots. Trimec Classic was included for comparisons (Table 1).

The herbicides were applied May 25, 1995. A pre-treatment survey of the plot confirmed that dandelion and clover were present in all individual plots and the bluegrass quality was uniform. The liquid formulations were applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles and a spray pressure of 25-30 psi. The granular herbicides were applied using plastic coated containers as 'shaker dispensers'. Treatments on wet foliage were made immediately following the application of sufficient water to moisten the foliage.

Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Kentucky bluegrass phytotoxicity was observed on May 30 and by June 8 symptoms were no longer present (Table 1). Evaluations were made using a scale from 9 to 1: 9 = healthy turf, 7 = intermittent yellowing, 5 = uniform yellowing, 3 = intermittent dead turf, and 1 = uniform dead turf.

Estimations of broadleaf weed infestations were taken on June 28, July 7, and July 14 (Table 2). Assessments were made according to percentage of broadleaf weed cover per plot. Dandelion and clover were the predominate broadleaf species and were considered together with all other broadleaf species for these data.

Weed control data also were taken for dandelion and clover individually. The number of dandelions per plot was counted and clover infestations were estimated as percent cover per plot (Table 3).

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) tests were used to compare means for herbicide effects on bluegrass phytotoxicity, percent weed cover, and weed numbers.

On May 30, bluegrass treated with the Vanquish plus Garlon tank mixes and Confront 3SL exhibited phytotoxic symptoms and had significant reductions in quality when compared with the other treated and untreated plots (Table 1). None of the other herbicide materials reduced the turf quality when compared with the untreated controls.

In turf treated with the herbicide materials, the percentage of broadleaf weed cover was significantly lower than in untreated turf. Applications on dry versus wet foliage did not significantly affect the level of control provided by the Confront plus fertilizer formulations and Turf builder + 2 with MCPP (Table 2). Broadleaf cover reductions ≥ 90% were achieved with some of the herbicide products.

When dandelion and clover populations were considered separately, all herbicide products significantly reduced the number of dandelion and the percent clover cover when compared with the untreated controls (Table 3). The Confront plus fertilizer formulations and Turfbuilder + 2 with MCPP provided the same level of control when applied to dry versus wet foliage. Reductions of ≥ 90% in dandelion and clover cover were recorded for some of the herbicide materials.

Table 1. Kentucky bluegrass phytotoxicity[1] in plots treated with postemergence broadleaf herbicide products on May 25, 1995

Material	Foliage Condition at Application	Rate (lb a.i./A)	Phytotoxicity on May 30 (5 DAT)
1. Untreated Control	dry	NA	9
2. Vanquish 4 SL[2]	dry	0.250	8
3. Vanquish 4 SL + Garlon 3 SL[2]	dry	0.125 + 1.000	5
4. Vanquish 4 SL + Garlon 3 SL[2]	dry	0.250 + 0.500	7
5. Vanquish 4 SL + Garlon 3 SL[2]	dry	0.250 + 1.000	6
6. Trimec Classic 3.32 SL[2]	dry	1.350	8
7. Confront (3SL)[2]	dry	0.750	5
8. Confront S-6271 @ (1X)[3]	dry	0.650	9
9. Confront S-6271 @ (1X)[3]	wet	0.650	9
10. Confront S-6271 @ (1.15X)[3]	dry	0.750	8
11. Confront S-6271 @ (1.15X)[3]	wet	0.750	8
12. Confront S-6272 @(1X)[3]	dry	0.650	9
13. Confront S-6272 @ (1X)[3]	wet	0.650	9
14. Confront S-6272 @ (1.15X)[3]	dry	0.750	9
15. Confront S-6272 @ (1.15X)[3]	wet	0.750	9
16. Turf builder+2 with MCPP 1.21%[3]	dry	1.500	9
17. Turf builder+2 with MCPP 1.21%[3]	wet	1.500	9
$LSD_{(0.05)}$		—	2

[1] Phytotoxicity was assessed using a scale from 9 to 1: 9 = healthy turf, 7 = intermittent yellowing, 5 = uniform yellowing, 3 = intermittent dead turf, 1 = uniform dead turf.
These products were screened for Sandoz Agro Inc.[2] and The Scotts Company[3].

Table 2. Percentage of broadleaf weed cover[1] in Kentucky bluegrass treated with postemergence broadleaf herbicide products on May 25, 1995.

Material	Rate (lb a.i./A)	June 28 (33 DAT)	July 7 (42 DAT)	July 14 (49 DAT)	Mean % Cover	Mean % Reduction
1. Untreated Control	NA	58	53	45	52	0
2. Vanquish 4 SL[2]	0.250	6	7	4	5	90
3. Vanquish 4 SL + Garlon 3 SL[2]	0.125 + 1.000	8	4	1	4	91
4. Vanquish 4 SL + Garlon 3 SL[2]	0.250 + 0.500	6	4	4	5	91
5. Vanquish 4 SL + Garlon 3 SL[2]	0.250 + 1.000	9	2	2	5	91
6. Trimec Classic 3.32 SL[2]	1.350	15	7	8	10	81
7. Confront (3SL)[2]	0.750	4	2	4	3	94
8. Confront S-6271 @ (1X)[3] (dry)	0.650	2	2	2	2	96
9. Confront S-6271 @ (1X)[3] (wet)	0.650	1	1	1	1	98
10. Confront S-6271 @ (1.15X)[3] (dry)	0.750	4	4	1	3	95
11. Confront S-6271 @ (1.15X)[3] (wet)	0.750	1	1	2	1	97
12. Confront S-6272 @(1X)[3] (dry)	0.650	4	4	2	3	94
13. Confront S-6272 @ (1X)[3] (wet)	0.650	8	5	5	6	88
14. Confront S-6272 @ (1.15X)[3] (dry)	0.750	5	4	8	6	88
15. Confront S-6272 @ (1.15X)[3] (wet)	0.750	2	2	2	2	96
16. Turf builder+2 with MCPP 1.21%[3] (dry)	1.500	20	15	10	15	71
17. Turf builder+2 with MCPP 1.21%[3] (wet)	1.500	13	15	8	12	77
$LSD_{(0.05)}$	---	12	10	11	10	20

[1] Dandelion and clover were considered in estimating these percentages.
These products are being screened for Sandoz Agro Inc.[2] and The Scotts Company[3].

Table 3. Dandelion and clover populations[1] on July 21 in Kentucky bluegrass treated with postemergence broadleaf herbicide products on May 25, 1995.

Material	Rate (lb a.i./A)	Dandelions per plot	% Dandelion reduction	% Clover cover	% Clover reduction
1. Untreated Control	NA	96	0	42	0
2. Vanquish 4 SL[2]	0.250	4	95	4	91
3. Vanquish 4 SL + Garlon 3 SL[2]	0.125 + 1.000	5	95	3	92
4. Vanquish 4 SL + Garlon 3 SL[2]	0.250 + 0.500	23	76	0	100
5. Vanquish 4 SL + Garlon 3 SL[2]	0.250 + 1.000	2	98	0	99
6. Trimec Classic 3.32 SL[2]	1.350	2	98	5	88
7. Confront (3SL)[2]	0.750	2	98	1	98
8. Confront S-6271 @ (1X)[3] (dry)	0.650	1	99	1	99
9. Confront S-6271 @ (1X)[3] (wet)	0.650	1	99	2	96
10. Confront S-6271 @ (1.15X)[3] (dry)	0.750	9	91	4	91
11. Confront S-6271 @ (1.15X)[3] (wet)	0.750	1	99	1	98
12. Confront S-6272 @(1X)[3] (dry)	0.650	3	97	1	98
13. Confront S-6272 @ (1X)[3] (wet)	0.650	3	97	2	94
14. Confront S-6272 @ (1.15X)[3] (dry)	0.750	11	88	1	98
15. Confront S-6272 @ (1.15X)[3] (wet)	0.750	7	92	2	96
16. Turf builder+2 with MCPP 1.21%[3] (dry)	1.500	5	94	5	88
17. Turf builder+2 with MCPP 1.21%[3] (wet)	1.500	2	98	10	76
$LSD_{(0.05)}$	---	26	27	8	19

[1] The clover and data consititue the percentage of cover per plot.
These products were screened for Sandoz Agro Inc.[2] and The Scotts Company[3].
NS = not significantly different at the 0.05 level.

1995 Non-Kerosene, Triclopyr Bee Postemergence Broadleaf Weed Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Non-kerosene based Triclopyr Bee formulations were evaluated for efficacy as postemergence broadleaf herbicides in turfgrass. This trial was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was comprised of strips of common Kentucky bluegrass and partially bare soil that were previously used as planting beds. The grass and planting bed areas were heavily infested with clover and dandelion. The soil in this experimental area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 2.2%, a pH of 5.7, 21 ppm P, and 85 ppm K.

The study was arranged in a split-plot randomized block design with three replications. Individual experimental plots were 5 x 10 ft and the study was arranged so each individual plot was approximately 1/2 bluegrass and 1/2 planting bed. The two application rates, 0.50 and 1.00 lb a.i./A, were the main plot treatments in each block. Each subplot contained seven treatments: an untreated control, Turflon ester 4EC, 4 Triclopyr Bee formulations (NAF-99, 100, 101, and 102), and Turflon ester 4EC + Mecomec (MCPP) 4SL tank mix (Table 1).

The herbicides were applied on May 25. A pre-treatment survey of the experimental area showed that dandelion and clover were present in each individual plot and bluegrass quality was uniform. All formulations were applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles and a spray pressure of 25-30 psi.

Rainfall was sporadic throughout the duration of this study and temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Kentucky bluegrass phytotoxicity was observed on May 30 and data were taken May 30, June 8, and June 16 (Table 1). Evaluations were made using a scale from 9 to 1: 9 = best quality, 7 = some yellowing, 5 = severe yellowing, and 1 = dead turf. By June 16, no bluegrass phytotoxicity was present.

Broadleaf weed damage was measured with a scale from 9 to 1: 9 = healthy weeds, 5 = severe and uniform symptoms, and 1 = dead weeds. Symptoms ranged from slight to severe discoloration (red, yellow, and brown foliage) and leaf curling (Table 2).

Broadleaf weed control was measured by estimating percentage of cover per plot (Table 3). Dandelion and clover were the predominate broadleaf species and were considered together with all other broadleaf species for these data.

Weed control also was assessed by determining the number of broadleaf weeds per plot for each species present (Table 4). Dandelion plants were counted in each plot but because of the difficulty in separating individual plants, clover infestations were estimated as the percentage of cover.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) tests were used to compare means for main plot effects (differences between application rates for each herbicide) and subplot effects (differences among the various herbicide products).

On May 30, all Kentucky bluegrass treated with herbicide materials showed some degree of yellowing. Differences in phytotoxicity were indicated among the herbicide products but differences were not significant between the application rates for each herbicide (Table 1).

Broadleaf weed damage was observed on May 30, June 8, and June 16 in all plots treated with herbicide materials. Significant differences in the severity of weed damage were found among herbicides (Table 2).

All herbicide materials reduced broadleaf weed cover when compared with the untreated controls. The level of reduction varied among herbicide products but was similar for rates of the same product (Table 3).

The number of dandelions per plot significantly differed among the herbicides. All plots treated with herbicide products had less dandelions than the untreated controls. Larger reductions in dandelion populations were recorded for the higher application rates of most products (Table 4).

The percentage of clover cover per plot was lower in herbicide treated plots than in the untreated controls. There were differences among the herbicide products in the level of control but there were no differences among the rates for each product (Table 4).

Table 1. Kentucky bluegrass phytotoxicity[1] in plots treated with Non-Kerosene, Triclopyr Bee formulations and other herbicides on May 25, 1995.

Material	Rate (lb a.i./A)	May 30	June 8	June 16	Mean Phytotoxicity May 30 & June 8
1. Untreated Control	NA	8	8	8	8
2. Turflon ester - 4EC	0.50	5	7	8	6
3. Turflon ester - 4EC	1.00	5	7	8	6
4. Triclopyr Bee NAF-99 - 4EC (Aliphatic)	0.50	7	7	8	7
5. Triclopyr Bee NAF-99 - 4EC (Aliphatic)	1.00	6	7	8	7
6. Triclopyr Bee NAF-100 - 4EC (Aliphatic)	0.50	7	7	8	7
7. Triclopyr Bee NAF-100 - 4EC (Aliphatic)	1.00	6	7	8	7
8. Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	0.50	7	7	8	7
9. Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	1.00	6	7	8	7
10. Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	0.50	7	7	8	7
11. Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	1.00	6	7	8	7
12. Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	5	7	8	6
13. Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	5	7	8	6
14. Untreated Control	NA	8	8	8	8
$LSD_{(0.05)}$ (Differences among products)	—	0.6	0.3	NS	0.4
$LSD_{(0.05)}$ (Differences between rates for the same product)	—	NS	NS	NS	NS

[1] Phytotoxicity was assessed using a 9 to 1 scale: 9 = best quality, 7 = some yellowing, 5 = severe yellowing, and 1 = dead turf.
NS = not significantly different at the 0.05 level.

Table 2. Damage[1] on broadleaf weeds in plots treated with Non-Kerosene, Triclopyr Bee formulations and other herbicides on May 25, 1995.

Material	Rate (lb a.i./A)	May 30	June 8	June 16	Mean weed damage
1. Untreated Control	NA	8	9	9	9
2. Turflon ester - 4EC	0.50	5	7	6	6
3. Turflon ester - 4EC	1.00	6	7	6	6
4. Triclopyr Bee NAF-99 - 4EC (Aliphatic)	0.50	6	7	7	7
5. Triclopyr Bee NAF-99 - 4EC (Aliphatic)	1.00	6	6	5	6
6. Triclopyr Bee NAF-100 - 4EC (Aliphatic)	0.50	6	8	6	7
7. Triclopyr Bee NAF-100 - 4EC (Aliphatic)	1.00	5	7	6	6
8. Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	0.50	6	6	5	6
9. Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	1.00	6	7	6	6
10. Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	0.50	6	7	7	7
11. Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	1.00	6	6	4	5
12. Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	5	6	5	5
13. Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	5	7	6	6
14. Untreated Control	NA	9	8	9	9
$LSD_{(0.05)}$ (Differences among products)	—	1	1	1	1
$LSD_{(0.05)}$ (Differences between rates for the same product)	—	NS	NS	NS	1

[1] Damage was assessed on a scale of 9 to 1: 9 = healthy weeds, 5 = severe and uniform discoloration and leaf curling, and 1=dead weeds.
NS = not significantly different at the 0.05 level.

Table 3. The percentage of cover[1] of broadleaf weeds in plots treated with Non-Kerosene, Triclopyr Bee formulations and other herbicides on May 25, 1995.

Material	Rate (# a.i./A)	June 28	July 7	July 14	Mean % weed cover	% Reduction in weed cover
1. Untreated Control	NA	43	53	50	49	0
2. Turflon ester - 4EC	0.50	8	10	15	11	81
3. Turflon ester - 4EC	1.00	7	4	5	5	90
4. Triclopyr Bee NAF-99 - 4EC (Aliphatic)	0.50	10	10	15	12	80
5. Triclopyr Bee NAF-99 - 4EC (Aliphatic)	1.00	5	5	4	5	92
6. Triclopyr Bee NAF-100 - 4EC (Aliphatic)	0.50	13	20	20	18	69
7. Triclopyr Bee NAF-100 - 4EC (Aliphatic)	1.00	2	2	1	2	97
8. Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	0.50	8	10	17	12	80
9. Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	1.00	5	5	5	5	91
10. Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	0.50	13	15	20	16	72
11. Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	1.00	4	5	4	4	93
12. Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	2	1	2	2	97
13. Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	5	2	1	3	95
14. Untreated Control	NA	60	65	70	65	0
$LSD_{(0.05)}$ (Differences among products)	—	8	7	7	5	9
$LSD_{(0.05)}$ (Differences between rates for the same product)	—	NS	NS	NS	NS	NS

[1] Percentages include the area per plot occupied by dandelion, clover, spotted spurge, knotweed, and black medic plants.
NS = not significantly different at the 0.05 level.

Table 4. The percentage of cover and number of broadleaf weeds[1] in plots treated with Non-Kerosene, Triclopyr Bee formulations and other herbicides on May 25, 1995.

	Material	Rate (# a.i./A)	Number of dandelion	% Reduction in dandelion	% Clover cover	% Reduction in clover
1.	Untreated Control	NA	121	0	35	0
2.	Turflon ester - 4EC	0.50	60	50	8	82
3.	Turflon ester - 4EC	1.00	9	93	3	93
4.	Triclopyr Bee NAF-99 - 4EC (Aliphatic)	0.50	55	55	7	86
5.	Triclopyr Bee NAF-99 - 4EC (Aliphatic)	1.00	13	90	3	93
6.	Triclopyr Bee NAF-100 - 4EC (Aliphatic)	0.50	55	54	18	61
7.	Triclopyr Bee NAF-100 - 4EC (Aliphatic)	1.00	6	95	2	96
8.	Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	0.50	67	45	7	86
9.	Triclopyr Bee NAF-101 - 4EC (Veg Oil A)	1.00	14	88	4	92
10.	Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	0.50	89	26	15	68
11.	Triclopyr Bee NAF-102 - 4EC (Veg Oil B)	1.00	13	89	1	99
12.	Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	17	86	2	96
13.	Turflon ester - 4EC + MCPP (Mecomec)- 4SL	0.50+1.25	7	94	2	96
14.	Untreated Control	NA	120	0	58	0
	$LSD_{(0.05)}$ (Differences among products)	—	20	17	7	15
	$LSD_{(0.05)}$ (Differences between rates for the same product)	—	27	12	NS	NS

[1] Percentage of cover/plot is recorded for clover plants. The number of plants/plot is listed for dandelion.
NS = not significantly different at the 0.05 level.

1995 Fairway Height Turfgrass *Poa annua* and Crabgrass Control Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Dithiopyr (Dimension) turf herbicide and Trinexapac-ethyl (Primo) are being screened for efficacy as herbicides on a Kentucky bluegrass and perennial ryegrass fairway. The objectives of this study are to determine if split applications of Dithiopyr will provide control of *Poa annua* and crabgrass, to determine optimum application rates, and to document any turfgrass phytotoxicity. Another objective is to evaluate the effects of Primo on *Poa annua* populations and turf quality.

This study was established on the 14th fairway at Veenker Memorial Golf Course north of the ISU campus in Ames, Iowa. The experimental area consists of Kentucky bluegrass and perennial ryegrass mowed at 3/4" height that was overseeded in September with perennial ryegrass. The experimental design was a randomized complete block with individual plots 5 x 5 ft and three replications.

There were a total of nine Dithiopyr treatments. The rate of all initial treatments in the fall of 1995 was 0.50 lb a.i./A. Three different rates of Dithiopyr were applied sequentially in the fall (0.25, 0.38, and 0.50 lb a.i./A) and in the spring of 1996, the plots received another application at these rates. Primo was applied in the fall of 1995 and was applied in the spring of 1996 at the recommended rate for perennial ryegrass (0.50 fl oz/1000 ft^2). An untreated control also was included for comparisons (Table 1).

The initial applications of Dithiopyr and the fall application of Primo were made on September 26, 1995. The materials were watered-in with the irrigation system. The 45-60 day sequential applications of Dithiopyr were made on October 26, 1995. These materials were also watered-in with the irrigation system. These applications were made 30 days after initial treatment because of the early onset of cold temperatures and winter-like conditions.

The plot was evaluated for turf phytotoxicity and visual turf quality on September 27, October 4, 11, and 18, and November 3. No phytotoxic symptoms were observed and there were no differences in turf quality among the treated plots and the untreated controls. *Poa annua* and other weed control data will be taken in early spring.

Spring preemergence applications of Dithiopyr and Primo will be made after pre-treatment assessments of weed populations and turf quality are taken. Weed control, phytotoxicity, and visual quality data will be taken periodically throughout the spring and summer.

Table 1. Application rates and timing[1] for the 1995 Fairway Height Turfgrass *Poa annua* and Crabgrass Control Study.

	Products	1st Application lbs a.i./Acre	2nd Application lbs a.i./Acre	Spring 1996 Application lbs a.i./Acre
1	Untreated control	NA	NA	NA
2	Dimension 1EC[2]	0.50	0.00	0.00
3	Dimension 1EC[2]	0.50	0.00	0.38
4	Dimension 1EC[2]	0.50	0.00	0.50
5	Dimension 1EC[2]	0.50	0.25	0.00
6	Dimension 1EC[2]	0.50	0.38	0.00
7	Dimension 1EC[2]	0.50	0.50	0.00
8	Dimension 1EC[2]	0.50	0.25	0.25
9	Dimension 1EC[2]	0.50	0.38	0.38
10	Dimension 1EC[2]	0.50	0.50	0.50
11	Primo 1E[3]	0.50[4]	NA	0.50[4]

[1]Initial applications were made on September 26 and sequentials on October 26, 1995.
[2]These materials are being screened for Rohm & Haas.
[3]This material is being screened for Ciba-Geigy.
[4]These rates are 0.5 fl oz/1000 ft^2.

1995 Green Height Bentgrass *Poa annua* Control Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Turf Enhancer, Turf Enhancer + fertilizer, Prograss, Prograss + fertilizer, and a growth regulator, Trinexapac-ethyl (Primo) are being screened for their efficacy in controlling *Poa annua* in green height creeping bentgrass and for their effects on bentgrass quality.

This study was established at Veenker Memorial Golf Course north of the ISU campus in Ames, Iowa. The experimental design is a randomized complete block with 5 x 5 ft individual plots and three replications. The experimental area is in a practice green of 'Penncross' creeping bentgrass. The mowing height of the green height bentgrass is 0.155". The practice green was covered on November 17.

Turf Enhancer 2SC and High K fertilizer + Turf Enhancer were applied in September and October, 1995 at 0.125 lb a.i./A. They will be applied in April, May, and June of 1996 at the same rate. Proturf High K fertilizer + Prograss, and Prograss 1.5EC were applied in September, and October, 1995 at 0.380 lb a.i./A and Prograss also was applied at 0.560 lb a.i./A. These products were applied in early spring, 1996 at the same rates. A November application of these materials was planned but there was an early snowstorm. Primo was applied in September, 1995 at 0.30 fl oz/1000 ft^2 and will be applied in the spring, 1996 at 0.25 fl oz/1000 ft^2. An untreated control receiving a 15-0-30 fertilizer also was included for comparisons (Table 1).

A pre-treatment survey of the experimental area showed that the bentgrass turf was uniform in color and density. In addition, *Poa annua* was distributed throughout the experimental plot.

Turf Enhancer 2SC, Prograss 1.5EC, and Primo were applied as liquids using a carbon dioxide backpack sprayer equipped with #8006 nozzles and a pressure of 25-30 psi. Fertilizer formulations with Turf Enhancer and Prograss were applied in granular form using plastic coated containers as 'shaker dispensers'.

Initial applications of the materials were made on September 26, 1995. The 30 day sequential applications were made on October 26, 1995. The materials were watered-in with the irrigation system.

On October 18, the Veenker grounds crew applied a 15-0-30 Nutralene fertilizer to the experimental area at 0.75 lb N/1000 ft^2. As a result, no additional fertilizer was applied to the untreated control plots.

The plot was evaluated for turf phytotoxicity and visual turf quality on September 27, October 4, 11, 18, and November 3. No phytotoxic symptoms were observed. There were no differences in turf quality among the treated and untreated plots, but there were some slight color differences among the plots. *Poa annua* and other weed control data will be taken in early spring.

The early spring applications were made in April after pre-treatment assessments of weed populations and turf quality were taken. Sequential applications will be made as indicated. Weed control, phytotoxicity, and visual quality data will be taken periodically throughout the spring and summer.

Table 1. Application Rates and Timing[1] for Products Screened in the 1995 Greens Height Creeping Bentgrass *Poa Annua* Control Study.

	Material	Application Frequency	lb a.i./A					
			1995			1996		
			Sept	Oct	Nov	April	May	June
1.	Untreated Control	NA	NA	NA	NA	NA	NA	NA
2.	Turf Enhancer 2SC[2]	5	0.125	0.125	none	0.125	0.125	0.125
3.	High K fertilizer (15-0-29) + Prograss (0.516% a.i.)[2]	4	0.380	0.380	0.380	0.380	none	none
4.	High K fertilizer (15-0-29) + Turf Enhancer (0.13% a.i.)[2]	5	0.125	0.125	none	0.125	0.125	0.125
5.	Prograss 1.5 EC[2]	4	0.380	0.380	0.380	0.380	none	none
6.	Prograss 1.5 EC[2]	4	0.560	0.560	0.560	0.560	none	none
7.	Primo 1E[3]	2	0.300[4]	none	none	0.250[4]	none	none

[1]Initial applications were made September 26 and sequentials on October 26, 1995. No November applications were made.
[2]These products are being screened for The Scotts Company.
[3]This product is being screened for Ciba-Geigy.
[4]These rates are 0.30 fl oz product/1000 ft^2 and 0.25 fl oz product/1000 ft^2.

1995 Herbicide Demonstration Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Finale from AgrEvo, Roundup, and an experimental herbicide from Monsanto (#65005) were screened in a non-replicated study for efficacy in creating even border areas. This trial was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa as a demonstration plot for the 1995 Turfgrass Field Day.

The experimental area consisted of established Kentucky bluegrass edge areas surrounding permanent ornamental grass beds. Finale, Roundup, and Monsanto #65005 were applied to approximately 6" wide border strips around individual ornamental plantings. Finale and Monsanto #65005 were applied at a rate of 4.0 oz a.i./A and Roundup at 2.7 oz a.i./A (Table 1). Finale and Roundup were applied 14, 5, and 2 days before the field day which was held on July 20, 1995. Monsanto #65005 was applied 5 and 2 days before the field day.

The 14-day applications were made on July 7. The 5-day applications were made on July 14. The treatments were applied at 9:00 a.m. and the plot was watered by mistake at 11:00 a.m. On July 18, the 2-day applications were made. The materials were applied with a backpack carbon dioxide sprayer equipped with #8006 nozzles and a pressure of 25-30 psi.

Phytotoxicity data were taken on July 13, 18, 21, and 28. Assessments were made on overall condition of the turf and the straightness of the border areas edges (Table 1).

All materials worked satisfactorily and produced even border strips with brown, dead grass in approximately 10 days (Table 1). Treatment, however, resulted in different phytotoxic symptoms. Finale treated bluegrass exhibited severe chlorosis a few days after treatment before turning brown and dying. Grass treated with either Roundup or Monsanto #65005 turned from healthy green to shades of brown. By July 18, the grass in plots treated with either Finale or Roundup on July 7 was uniformly brown and dead.

Table 1. Phytotoxic symptoms on Kentucky bluegrass in ornamental border areas sprayed with Finale, Roundup, and Monsanto #65005.

Treatment	Days before Field Day	Date applied	Symptoms			
			July 13	July 18	July 21	July 28
Untreated Control	NA	NA	green, healthy	green, healthy	green, healthy	green, healthy
Finale - 120 SC	14	July 7	severe chlorosis, most plants dead, even border	plants brown, all dead, even border	plants brown, all dead, even border	plants brown, all dead, even border
	5	July 14		moderate to severe chlorosis, even border	severe chlorosis, most plants dead, even border	plants brown, all dead, even border
	2	July 18			moderate chlorosis, even border	plants brown, all dead, even border
Roundup - 356 SN	14	July 7	plants brown, most dead, even border	plants brown, all dead, even border	plants brown, all dead, even border	plants brown, all dead, even border
	5	July 14		moderate, uneven browning, even border	severe browning most plants dead, even border	plants brown, all dead, even border
	2	July 18			slight browning, even border	plants brown, all dead, even border
Monsanto #65005	5	July 14		slight browning, even border	plants brown, all dead, even border	plants brown, all dead, even border
	2	July 18			uneven browning, 50% brown, even border	plants brown, all dead, even border

1995 Dimension / Activated Charcoal Perennial Ryegrass Germination Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Activated charcoal was screened for effectiveness in deactivating Dimension 1EC. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental site was in an area of common Kentucky bluegrass and the soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 2.2%, a pH of 6.0, 12 ppm P, and 86 ppm K.

The experiment was designed as a randomized complete block. The individual plots were 5 x 5 ft and three replications were conducted. Dimension was applied at three rates (0.5, 1.0, and 2.0 lbs a.i./A). Each of these rates were screened in combination with activated charcoal applied 1 and 15 days after the Dimension. The charcoal was applied at 100 lbs/A. An untreated control, a plot receiving Dimension 1EC at 0.5 lb a.i./A and no charcoal, and plots treated with charcoal at 1 and 15 days were included for comparisons (Table 1).

Dimension 1EC was applied on May 4 using a carbon dioxide backpack sprayer equipped with #8006 nozzles using a spray pressure of 25-30 psi. A pre-application survey was conducted and the turf quality was uniform throughout the experimental area. Activated charcoal was applied using plastic coated containers that served as 'shaker dispensers'. The one-day treatments were applied on May 5 and the 15-day charcoal was applied on May 19.

Perennial ryegrass overseeding was performed June 2 (14 days after the last charcoal treatments were applied and 29 days after the Dimension 1EC was applied). Prior to overseeding, the bluegrass was mowed to a height of 1". The clippings were removed and the plot was verticut in two directions. The residue was removed and the ryegrass was seeded with a slit seeder in two directions. A drop spreader was used to seed in two diagonal directions. An endophyte enhanced ryegrass seed (#4200 from Seed Research of Oregon, Inc.) was planted at approximately 10 lbs/1000 ft^2. After seeding, the plot was rolled lightly and P was applied at 1 lb/1000 ft^2. Rainfall occurred on June 2 and June 3.

Rainfall was sporadic for the duration of this study and the temperatures were unusually high. Supplemental irrigation was used to provide enough moisture for good turf growth and ryegrass germination.

The plots were checked for Kentucky bluegrass phytotoxicity on May 5, May 19, and May 30. Visual turf quality ratings were taken May 19, May 30, June 16, June 28, July 6, July 21, and July 28. Assessments of turf quality were based on color, texture, and thickness using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1).

Crabgrass cover data were taken to ensure that Dimension was providing crabgrass control and to check for possible decreases in the level of control when activated charcoal was applied. Crabgrass control was assessed by estimating the percentage of crabgrass cover per plot. Crabgrass germination was detected on May 25. Percentage of crabgrass cover data were taken on June 28, July 6, and July 21 (Table 2).

Establishment of perennial ryegrass was measured by counting the number of plants per sample area within each plot. Destructive sampling was employed and 2" diameter plugs were randomly taken from each plot using a soil core sampler. Ryegrass counts were made on July 28 and August 11 and were reported as the number of ryegrass plants/ft^2 (Table 3).

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) tests were used to compare means for Dimension effects on visual quality, on percentage crabgrass cover, and on ryegrass establishment.

There were no symptoms of phytotoxicity on the Kentucky bluegrass treated with Dimension at any rate. On all data collection dates, bluegrass quality was uniform among the plots (Table 1).

Crabgrass cover was maintained at ≤ 5% by Dimension at all application rates (Table 2). The addition of charcoal to Dimension treated plots did not significantly alter the level of crabgrass control. Charcoal with no Dimension did not affect crabgrass cover when compared to the untreated control plots.

The mean number of ryegrass plants/ft^2 in plots receiving Dimension at 0.5 lb a.i./A and charcoal (Treatments 2 and 5) was significantly higher than in plots receiving Dimension at 1.0 and 2.0 lb a.i./A with charcoal added at either 1 or 15 days (Treatments 3, 4, 6, and 7). The number of plants/ft^2 was similar in plots treated with Dimension at 0.5 lb a.i./A and charcoal, Dimension at 0.5 lb a.i./A without charcoal (Treatment 8), no charcoal and no Dimension (Treatment 1), and charcoal only at either 1 or 15 days (Table 3).

Table 1. Visual quality of Kentucky bluegrass plots treated with Dimension and Dimension plus activated charcoal and then overseeded with Perennial ryegrass[1].

	Treatment	lb a.i. /Acre	May 4	May 5	May 19	May 30	June 16	June 28	July 6	July 21
1	Untreated control	NA	9	9	9	9	9	9	9	8
2	Dimension-1 day charcoal	0.5	9	9	9	9	9	9	9	8
3	Dimension-1 day charcoal	1.0	9	9	9	9	9	9	9	8
4	Dimension-1 day charcoal	2.0	9	9	9	9	9	9	9	8
5	Dimension-15 day charcoal	0.5	9	9	9	9	9	9	9	8
6	Dimension-15 day charcoal	1.0	9	9	9	9	9	9	9	8
7	Dimension-15 day charcoal	2.0	9	9	9	9	9	9	9	8
8	Dimension-no charcoal	0.5	9	9	9	9	9	9	9	8
9	Charcoal control-1 day	NA	9	9	9	9	9	9	9	8
10	Charcoal control-15 day	NA	9	9	9	9	9	9	9	8
	$LSD_{(0.05)}$	—	NS	NS	NS	NS	NS	NS	NS	NS

[1] Dimension was applied on May 4, 1 day charcoal on May 5, and 15 day charcoal on May 19. Overseeding with Perennial ryegrass was performed on June 2. Quality 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 2. Percentage of crabgrass cover in Kentucky bluegrass plots treated with Dimension and Dimension plus activated charcoal and then overseeded with Perennial ryegrass[1].

	Treatment	lb a.i. /Acre	June 28	July 6	July 21	Mean % crabgrass cover
1	Untreated control	NA	27	35	43	35
2	Dimension-1 day charcoal	0.5	0	1	1	1
3	Dimension-1 day charcoal	1.0	0	1	1	1
4	Dimension-1 day charcoal	2.0	0	1	2	1
5	Dimension-15 day charcoal	0.5	2	2	4	3
6	Dimension-15 day charcoal	1.0	0	1	4	2
7	Dimension-15 day charcoal	2.0	0	1	1	1
8	Dimension-no charcoal	0.5	1	1	5	2
9	Charcoal control-1 day	NA	32	45	55	44
10	Charcoal control-15 day	NA	37	48	58	48
	$LSD_{(0.05)}$		14	18	20	17

[1] Dimension was applied on May 4, 1 day charcoal on May 5, and 15 day charcoal on May 19. Overseeding with Perennial ryegrass was performed on June 2.

Table 3. The number[1] of perennial ryegrass plants/ft^2 in Kentucky bluegrass plots treated with Dimension and Dimension plus activated charcoal and then overseeded with Perennial ryegrass.[2]

	Treatment	lb a.i. /Acre	July 28	August 11	Mean Number of ryegrass plants/ft^2
1	Untreated control	NA	80	84	81
2	Dimension-1 day charcoal	0.5	126	115	122
3	Dimension-1 day charcoal	1.0	23	31	25
4	Dimension-1 day charcoal	2.0	0	0	0
5	Dimension-15 day charcoal	0.5	107	54	89
6	Dimension-15 day charcoal	1.0	19	38	25
7	Dimension-15 day charcoal	2.0	4	8	5
8	Dimension-no charcoal	0.5	80	46	69
9	Charcoal control-1 day	NA	122	46	97
10	Charcoal control-15 day	NA	199	176	191
	$LSD_{(0.05)}$		115	NS	77

[1] Four plugs per plot were sampled for Perennial ryegrass plants on July 28 and 2 plugs per plot on August 11.
[2] Dimension was applied on May 4, 1 day charcoal on May 5, and 15 day charcoal on May 19. Overseeding with Perennial ryegrass was performed on June 2.
NS = not significantly different at the 0.05 level.

1995 Trinexapac-ethyl (PRIMO) Granular Formulation Study

Barbara Bingaman, Nick Christians, and David S. Gardner

Granular formulations of the growth regulator, Trinexapac ethyl, were evaluated to confirm application rates and to test the efficacy of these products on good to high quality lawn turf. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was a 10-year old stand of 'Park' Kentucky bluegrass on a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) soil with an organic matter content of 3.6%, a pH of 7.00, 4 ppm P, and 106 ppm K.

The study was arranged in a randomized complete block design. Three replications were conducted. Individual experimental plots were 5 x 5 ft with 3 ft barrier rows between replications. Four Primo granular formulations (FL950477, FL950478, FL950473, and FL950474) and Primo 1E were screened. A fertilized control and an untreated control were included for comparisons. Primo 1E was used at the label rate for Kentucky bluegrass of 0.26 lb a.i./A (0.75 fl oz/1000 ft^2) and the Primo granule materials were applied at 0.34 lb a.i./A (Table 1).

All treatments were applied May 19. Prior to application, the experimental site was examined and the turf was found to be quite uniform in color and overall quality. A carbon dioxide backpack sprayer equipped with 8006 nozzles with a spray pressure of 20-25 psi was used to apply the Primo 1E. The granular materials were applied using plastic coated containers as 'shaker dispensers'.

The first rainfall after application occurred on May 22, and 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 for seven weeks from May 25 - July 13. Visual quality assessments were based on color, density, and phytotoxicity and recorded using a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Mowing height for collecting clippings was 2" (Table 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 treatment effects on the visual quality and clipping weights. Least significant difference (LSD) were used to compare means among the treatments.

Kentucky bluegrass phytotoxicity was detected on June 5 and June 12 in plots treated with Primo 1E. By June 19, however, the quality was uniform among all treated and untreated plots (Table 1).

Significant differences in fresh clipping weights were recorded among the treated plots for May 25, June 5, and June 12. On May 25, clippings were decreased in plots treated with Primo 1E and 2 Primo granule formulations, FL950477 and FL950478, when compared with the untreated and the fertilized control plots. On June 5 and June 12, clipping weights were significantly reduced by Primo 1E and all Primo granule formulations as compared with the untreated control (Table 2).

Total clipping weights for bluegrass treated with Primo 1E, FL950477, and FL950478 were significantly reduced when compared with the untreated control. No post inhibition stimulation was observed in bluegrass treated with these materials. Primo 1E was the most effective material in reducing clipping weights, followed by FL950477 and FL950478. Granular formulations FL950473 and FL950474 were not effective in reducing total clipping weights when compared with the untreated control (Table 2).

Table 1. Visual quality ratings[1] for 'Park' Kentucky bluegrass plots treated with Primo 1E and Primo granule formulations on May 19, 1995.

Material	May 25 (6 DAT)	June 5 (17 DAT)	June 12 (24 DAT)	June 19 (31 DAT)	June 29 (41 DAT)	July 6 (48 DAT)	July 13 (55 DAT)
1 Untreated Control	8	8	7	7	6	7	6
2 Fertilized Control	8	8	7	7	6	7	6
3 Primo 1E	8	7	5	7	6	7	6
4 Primo granule FL950477	8	8	7	7	6	7	6
5 Primo granule FL950478	8	8	7	7	6	7	6
6 Primo granule FL950473	8	8	7	7	6	7	6
7 Primo granule FL950474	8	8	7	7	6	7	6
$LSD_{(0.05)}$	NS	NS	1	NS	NS	NS	NS

[1]Quality ratings are 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 2. Clipping weights[1] from 'Park' Kentucky bluegrass plots treated with Primo 1E and Primo granule materials on May 19, 1995.

Material	May 25 (6 DAT)	June 5 (17 DAT)	June 12 (24 DAT)	June 19 (31 DAT)	June 29 (41 DAT)	July 6 (48 DAT)	July 13 (55 DAT)	Total Clipping Weights
1 Untreated Control	361	336	192	62	120	101	95	1266
2 Fertilized Control	324	326	179	58	115	85	56	1143
3 Primo 1E	293	188	107	45	97	86	66	882
4 Primo granule FL950477	301	246	137	49	102	77	51	964
5 Primo granule FL950478	315	283	160	56	112	91	46	1063
6 Primo granule FL950473	380	275	161	59	119	107	83	1184
7 Primo granule FL950474	334	281	153	54	118	100	104	1144
$LSD_{(0.05)}$	39	36	25	NS	NS	NS	NS	154

[1]Clipping weights are grams fresh tissue.
NS = Not significantly different at the 0.05 level.

Potential for Genetic Management of the Physiology of Leaf Spot Symptom Expression by Kentucky Bluegrass

Loren C. Stephens, Clinton F. Hodges, and Douglas A. Campbell

Leaf spot is commonly classified as a spring disease, but damage to leaves can be more extensive in the fall, especially with wet, moderately cool, overcast conditions (6, 7, 8, 10). The spots produced on the leaves of Kentucky bluegrass are initially dark brown, to deep purple, to almost black in coloration. Spots occur individually or scattered over the surface of infected leaf blades. As the individual spots enlarge, their centers typically become tan-colored and they are often surrounded by a chlorotic halo. If large numbers of spots occur on a single leaf, they often coalesce and cause rapid blighting of the leaf. Fewer spots on a leaf results in a progressive yellowing of the entire leaf blade. Yellowing of infected leaves occurs in the early spring, but it is the dominant symptom in fall and early winter.

Control of leaf spot by means of cultural practices, host plant resistance, and/or fungicides is difficult and expensive under the best of circumstances. Because of the difficulty of controlling leaf spot and the prevalence of the disease in the North Central States, studies on the developmental physiology of leaf spot of Kentucky bluegrass have been an ongoing part of the turf disease program at Iowa State University for a number of years. The ultimate purpose of this research has been to determine the physiology of disease development and to develop new approaches to the control and/or management of the disease.

Research conducted over the last several years has shown the growth regulator ethylene to be responsible for much of the yellowing caused by leaf spot (3, 5). Natural levels of ethylene in leaves of Kentucky bluegrass range from about 250 to 350 ppb. The ethylene content of leaves infected *B. sorokiniana* increases to 2,400 ppb or higher within 48 to 72 hour after infection and then progressively declines as the disease progresses. Visible yellowing of infected leaves can be seen within 24 hours of peak ethylene production.

The establishment of ethylene as a primary cause of yellowing of leaf-spot infected leaves provides an opportunity to develop new approaches to the management of this disease. The traditional approaches to control rely on plant resistance and/or fungicides. Both of these approaches have substantial limitations for the control of this disease. Research on new approaches to managing this disease are focused on prevention of symptom expression (yellowing) by infected leaves. One approach to managing symptom expression involves the regulation of ethylene biosynthesis during infection by means of genetic modification of the plant. To understand this approach to the problem, it is necessary to understand the biosynthesis of ethylene during the infection process. The ethylene generated during infection is produced primarily by the host plant in response to the infection (9), with relatively small amounts coming from the pathogen (1, 2). The biosynthesis of ethylene in infected leaves is as follows: methionine (Met) → S-adenosyl-L-methionine (AdoMet) → 1-aminocyclopropane-1-carboxylic acid (ACC) → ethylene (11). Research on genetic modification of Kentucky bluegrass is focused on limiting the availability of ACC for ethylene biosynthesis during the infection process.

Discovery of the gene for the enzyme ACC deaminase (4) which regulates the availability of ACC for ethylene biosynthesis may provide the most expedient approach to genetic control of ethylene biosynthesis by infected leaves. The enzyme degrades ACC and prevents it from forming ethylene. The by-products of ACC degradation are metabolized to amino acids commonly found in higher plants. The ACC deaminase gene has been introduced into tomato where it effectively decreases ethylene biosynthesis, but the gene has not been established in a perennial grass plant. Research is in progress to determine whether the deaminase gene can be established in Kentucky bluegrass. The process of establishing the gene in Kentucky bluegrass first necessitates establishing cells of the plant in callus culture. This has been achieved and whole plants have been successfully regenerated from the callus. It now remains to be determined if the ACC deaminase gene, which originates from a *Pseudomonas* bacterium, can be established in the Kentucky bluegrass callus, and if the gene will be incorporated into the cells of plants regenerated from the callus cells. If the gene is incorporated into the regenerated plants, it can then be tested for its ability to control the ethylene surge during infection and to decrease the yellowing of the leaves.

The outlook for successfully establishing the ACC deaminase gene in Kentucky bluegrass is guardedly optimistic. It has been determined that like infected leaves, Kentucky bluegrass callus cultures inoculated with *B. sorokiniana* generate ethylene. If the gene can be incorporated into the callus cells, a callus bioassay system could be developed for determining the effectiveness of the gene for controlling ethylene prior to regenerating whole plants. Work is presently in progress for introducing the ACC deaminase gene into Kentucky bluegrass callus. A DNA vector is being constructed that will include the ACC deaminase gene and the vector will be attached to another gene that is specific for expression in grasses. The vector will then be introduced to the callus cells by means of a particle gun.

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Idriella bolleyi as a Factor in the Summer Decline of Creeping Bentgrass

Clinton F. Hodges and Douglas A. Campbell

Idreilla bolleyi (Sprague) von Arx (1) (Microdochium bolleyi) has long been recognized as a common inhabitant of the roots and crowns of cereals and grasses (6, 7, 8, 9, 11, 12). Establishment of this organism as a pathogen of grass roots has been elusive; it has been regarded as a saprophyte or weak parasite (3, 13), a potentially serious pathogen (2, 14), and as a potential participant in root disease complexes (10). The various interactions of *I. bolleyi* with the roots of cereals and grasses led SALT (10) to classify the organism as a "minor pathogen" of very young and senescent root tissue.

Isolation of *I. bolleyi* roots of creeping bentgrass grown on high-sand-content golf greens has increased progressively over the last decade. The organism is usually associated with chlorotic, thinning turf of low vigor during periods of high-temperature stress. Adventitious roots of symptomatic plants are typically short, tan to brown in color without evidence of rot and little new root growth. *I. bolleyi* is almost always present in the roots with several other soil-borne organisms, some of which are known minor root pathogens or primary pathogens. Organisms commonly associated with *I. bolleyi* on adventitious roots of creeping bentgrass include *Pythium* (4), *Curvularia* (5), *Acremonium*, *Fusarium*, *Bipolaris*, and unidentified fungi that produce ectotrophic hyphae.

Research on *I. bolleyi* has been ongoing for some time as part of our sand microbiolgy program. Roots of creeping bentgrass were inoculated with seven different isolates (three from Iowa, four from the North and South Central U.S) of *I. bolleyi* and the plants were subjected to high (95° F day, 75° F night) and low (75° F day, 55° F night) temperature regimes for a period of ten weeks. The studies were intended to determine shoot and root growth, chlorophyll loss from leaves, and the development of the organism on the inoculated roots. None of the inoculated plants were killed by *I. bolleyi*, but substantial decreases in growth wee recorded. Under the high temperature regime, some isolates of *I. bolleyi* decreased shoot dry weight to 53 to 57% of the healthy controls. Under the low temperature regime, the decrease in shoot dry weight was somewhat less severe, ranging from 59 to 68%. The decrease in root dry weight ranged from 65 to 84% of the control under the high temperature regime and from 66 to 84% under the low temperature regime. However, within these ranges different isolates of the organism were functional relative to temperature. Under high temperatures one isolate decreased growth by 65%; under the low temperatures two different isolates reduced growth 66 to 67%. The various isolates of *I. bolleyi* show distinct temperature preferences for their activity.

Shoot and root growth are clearly affected by root infection by *I. bolleyi*. The growth and development of stolons was also affected by the presence of this organism in the roots of creeping bentgrass. The mean number of stolons produced by each root inoculated plant subjected to the high temperature regime was 101 to 119% greater than that produced by the healthy control plants. The mean number of stolons produced by plants subjected to the low temperature regime was 42 to 66% of the healthy control plants. These differences are especially interesting in light of the overall effect of temperature on the growth of inoculated plants. The mean total dry weight (including stolons) of the high temperature plants was somewhat less than that of the low temperature plants. Therefore, the stolon numbers on high temperature plants are the result of a proliferation of short stolons (low weight) whereas the stolons numbers on low temperature plants are the result of fewer long stolons (high weight).

The roots of inoculated plants showed fine hyphal growth of the *I. bolleyi* over their surface. The hyphae penetrated the epidermis and cortical cells but did not penetrate the vascular cylinder. Chlamydospores appeared as chain-like pigmented cells on the surface of the epidermis and some epidermal cells produced papillae-like outgrowths in response to infection. The fungus also produced elongated, heavily pigmented masses of tissue within the cortex known as cessation structures. The function of these structures is unknown. Roots infected by *I. bolleyi* also showed distinct browning by the end of the 10-week study.

The results of these studies establish *I. bolleyi* as a minor root pathogen of creeping bentgrass. It is unlikely that infection of roots by this organism, in the absence of other root infecting fungi and/or physiochemical stress, will cause death of plants. It will, however, reduce the vigor and resilence of the plants. In complexes with other root infecting fungi, it is probable that *I. bolleyi* will contribute to summer decline of creeping bentgrass.

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1995 Evaluation of Fungicides for Control of Brown Patch in Creeping Bentgrass

Mark L. Gleason

Trials were conducted at Veenker Memorial Golf Course on the campus of Iowa State University, Ames, Iowa. 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 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 21, 28, and July 7, 14, and 21.

Temperature and rainfall during June and July were close to the long-term averages for central Iowa. Disease development on the untreatd check plots was severe on all rating dates after June 21. Most, but not all, formulations suppressed disease significantly on each rating date. Treatments that included Sentinel 40WG or Eagle 40W exhibited an enhanced green color on one or more rating dates. No phytotoxicity symptoms were observed.

Table 1. 1995 Evaluation of fungicides for control of brown patch in creeping bentgrass.

Trt #	Company	Material	Rate/1000 ft^2	Intervals	Disease Severity[1] 6/21	6/28	7/14	7/26
1	Check	--	--	–	0.25 a[2]	4.0 a	3.5 a	3.75 a
2	Scotts	S-6115 G	600g	14	0.0 b	2.0 cdef	3.25 ab	2.25 abcde
3	Scotts	S-6128 G	570g	14	0.0 b	1.5 defg	0.25 ef	0.75 cdef
4	Sandoz	Sentinel 40 WG	0.167 oz.	21	0.0 b	0.0 g	0.0 f	0.75 cdef
5	Sandoz	Sentinel 40 WG	0.167 oz.	21-7	0.0 b	0.0 g	1.0 cdef	0.0 f
		alt. Daconil Ultrex	4 oz.					
6	Sandoz	Sentinel 40 WG	0.25 oz.	28	0.0 b	0.0 g	0.0 f	1.0 cdef
7	Sandoz	Sentinel 40 WG	0.167 oz.	28	0.0 b	0.0 g	0.25 ef	0.0 f
		+Tersan 1991 50 WP	2.0 oz.					
8	Sandoz	Sentinel 40 WG	0.167 oz.	14-14	0.0 b	1.0 efg	2.0 abcde	0.0 f
		alt. Tersan 1991 DF	2.0 oz.					
9	Zeneca	Heritage 50 WDG	0.2 oz.	14	0.0 b	0.0 g	0.0 f	1.0 cdef
10	Zeneca	Heritage 50 WDG	0.4 oz.	28	0.0 b	0.0 g	0.0 f	0.0 f
11	ISK Biotech	Daconil Ultrex SDG	3.8 oz.	14	0.0 b	0.0 g	0.0 f	0.0 f
12	ISK Biotech	IB 11521	6.0 oz.	14	0.0 b	0.25 g	0.0 f	0.0 f
13	Terra	Thalonil 90 DF	3.5 oz.	14	0.0 b	0.0 g	0.0 f	0.0 f
14	Terra	Thalonil 4L	6.0 fl. oz.	14	0.0 b	0.5 g	0.0 f	0.0 f
15	Dow Elanco	Rubigan AS	0.75 fl. oz.	21	0.0 b	2.5 bcd	3.0 ab	2.25 abcde
16	Dow Elanco	Rubigan AS	1.5 fl. oz.	21	0.0 b	0.75 fg	1.75 abcdef	2.25 abcde
17	Dow Elanco	Prostar 50 WP	2.0 oz.	21	0.0 b	0.25 g	0.25 ef	0.0 f
18	Dow Elanco	Prostar 50 WP	3.0 oz.	21	0.0 b	0.0 g	0.0 f	0.5 def
19	Dow Elanco	Rubigan AS	0.38 fl. oz.	21	0.0 b	0.25 g	0.75 def	0.0 f
		+Prostar 50 WP	1.0 oz.					

Trt #	Company	Material	Rate/1000 ft[2]	Intervals	Disease Severity[1] 6/21	6/28	7/14	7/26
20	Dow Elanco	Rubigan AS	0.75 fl. oz.		0.0 b	0.0 g	0.25 ef	0.25 ef
		+Prostar 50 WP	2.0 oz.					
21	Dow Elanco	Rubigan AS	1.5 fl. oz.	21	0.0 b	0.0 g	0.5 def	0.0 f
		+Prostar 50 WP	3.0 oz.					
22	Dow Elanco	NAF-53 2 EC	0.38 fl. oz.	21	0.0 b	2.25 bcde	1.5 bcdef	1.5 bcdef
23	Dow Elanco	NAF-53 2 EC	0.75 fl. oz.	21	0.0 b	2.0 cdef	2.25 abcd	2.75 abc
24	Dow Elanco	NAF-53 2 EC	1.5 fl. oz.	21	0.0 b	3.5 abc	2.75 abc	2.5 abcd
25	Dow Elanco	Twosome 4.42 SC	3.09 fl. oz.	21	0.0 b	0.5 g	0.0 f	1.5 bcdef
26	Rohm & Haas	Eagle 40 W	0.6 oz.	21	0.0 b	0.0 g	0.0 f	0.0 f
		alt. Prostar 50 WP	3.0 oz.	21				
27	Rohm & Haas	Eagle 40 W	0.6 oz.	21	0.0 b	0.5 g	0.25 ef	1.25 bcdef
28	Bayer	Lynx 25 DF	1.0 oz.	21	0.0 b	0.0 g	0.25 ef	0.75 cdef
29	Bayer	Bayleton 25 T/O	1.0 oz.	28	0.0 b	0.25 g	0.5 def	0.0 f
		+Prostar 50 WP	2.0 oz.					
30	Bayer	Lynx 25 DF	0.75 oz.	21	0.0 b	0.0 g	0.0 f	2.0 abcdef
31	BASF	Curalan 50 DF	2.0 oz.	14	0.0 b	1.0 efg	3.0 ab	3.25 ab
32	BASF	Curalan 50 DF	1.0 oz.	14	0.0 b	0.0 g	0.0 f	3.25 ab
		+Cleary's 3336 50 WP	2.0 oz.					
33	BASF	Curalan 50 DF	1.0 oz.	14	0.0 b	0.75 fg	0.5 ef	0.75 cdef
		+Daconil 2787 75 WP	3.0 oz.					
34	Cleary's	Spottrete	5.0 oz.	7[3]	0.0 b	4.0a	1.5 bcdef	2.0 abcdef

[1] Rating scale: 0 = no disease, 1 = 1-5% disease, 2 = 5-10%, 3 = 10-25%, 4 = 25-50%, 5 = >50% of plot symptomatic.
[2] Means in a column followed by the same letter are not significantly different (DMRT, $p = 0.05$). N = 4.
[3] First application date was 6/28.

1995 Evaluation of Fungicides for Control of Dollar Spot in Penncross Bentgrass

Mark L. Gleason

Trials were conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. 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 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. Disease development was moderately severe during late June through late July. On July 14 and 26, all treatments gave significant ($P=0.05$) disease suppression in comparison to the untreated check. No phytotoxicity symptoms were observed during the trial.

Table 1. 1995 Dollar Spot Trials, Iowa State University Horticulture Research Farm.

Trt #	Company	Material	Rate/1000 ft^2	Intervals	Number of Infection Centers 6/21	7/14	7/26
1	Check	--	--	--	72.5 a[1]	54.25 a	107.25 a
2	Scotts	S-6115 G	600g	14	26.75 abc	3.75 b	0.25 c
3	Scotts	S-6128 G	570g	14	46.0 abc	10.0 b	13.25 c
4	Sandoz	Sentinel 40 WG	0.167 oz.	21	13.5 abc	1.25 b	7.5 c
5	BASF	Curalan 50 DF	2 oz.	21	11.75 abc	3.5 b	4.0 c
6	BASF	Curalan 50 DF	1 oz.	21	0.0 c	0.25 b	15.0 c
		+Cleary's 3336 50 WP	2 oz.				
7	BASF	Curalan 50 DF	1 oz.	21	42.5 abc	21.75 b	11.5 c
		+Daconil 2787 75 WP	3 oz.				
8	ISK Biotech	Daconil Ultrex SDG	3.8 oz.	14	57.25 abc	5.0 b	3.25 c
9	ISK Biotech	IB 11521	6.0 oz.	14	70.5 a	1.5 b	0.5 c
10	Ciba	Banner MC	0.9 fl. oz.	21	59.0 abc	12.0 b	6.25 c
		+Daconil Ultrex	1.25 fl. oz.				
11	Ciba	Daconil Ultrex	1.25 fl. oz.	21	64.75 ab	19.75 b	40.5 b
12	Ciba	Banner 45 WP	0.31 fl. oz.	21	39.5 abc	6.5 b	18.5 bc
13	Ciba	Banner 45 WP	0.31 fl. oz.	21	37.75 abc	12.25 b	2.5 c
		+Daconil Ultrex	1.25 fl. oz.				
14	Terra	Thalonil 90 DF	3.5 oz.	14	32.25 abc	2.0 b	0.25 c
15	Terra	Thalonil 4 L	6.0 fl. oz.	14	63.5 ab	2.0 b	2.0 c
16	Terra	Thalonil 4 L	5.0 fl. oz.	21	26.0 abc	3.0 b	0.25 c
		+Banner 1.1 E	0.5 fl. oz.				
17	Terra	Thalonil 4L	5.0 fl. oz.	21	8.25 bc	1.0 b	0.25 c
		+Bayleton 25 DF	1.0 oz.				
18	Terra	Thalonil 4L	5.0 fl. oz.	21	7.75 bc	0.0 b	0.0 c
		+Lynx 25 DF	0.75 oz.				
19	Rohm & Haas	Fore WP	6.0 oz.	7-21	7.25 bc	1.75 b	1.25 c
		alt. Eagle 40 W	0.6 oz.				
20	Rohm & Haas	Eagle 40W	0.6 oz.	21	39.5 abc	8.0 b	1.5 c
21	Bayer	Lynx 25 DF	1.0 oz.	28	12.5 abc	6.0 b	0.0 c
22	Bayer	Bayleton 25 T/O	1.0 oz.	28	58.75 abc	16.75 b	0.25 c
23	Bayer	Lynx 25 DF	0.75 oz.	28	14.5 abc	7.0 b	0.0 c

[1] Means in a column followed by the same letter are not significantly different (DMRT, P = 0.05). N = 4.

1995 Evaluation of Fungicides for Control of Necrotic Ring Spot in Kentucky Bluegrass

Mark L. Gleason

Trials were conducted on 'Ram I' Kentucky bluegrass at the Iowa State University Horticulture Research Station north of Ames, Iowa. Fungicides were applied to turf maintained at 3-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. The trial was located on a site where necrotic ring spot symptoms and pathogen were confirmed in 1994.

Fungicide applications began on June 9 and were repeated at recommended intervals on June 28, July 7 and 21. Symptoms were apparent by June 1.

Weather during June and July was close to the long-term average for central Iowa with regard to temperature and rainfall. Disease development on the untreated check plots varied considerably among rating dates and among subplots on the same rating date. In general, treatments did not provide significantly better control than the untreated check. No phytotoxicity symptoms were observed.

Table 1. 1995 Necrotic Ring Spot Trials

					% area symptomatic[1]			
Trt #	Company	Material	Rate/ 1000 ft	Intervals	June 21	June 28	July 26	Aug. 7
1	Check	--	--	--	11.25ab	4.5ab	18.25ab	13.75ab
2	Scotts	S-6115	1,200 g	28	20.0a	7.5a	27.5a	22.5a
3	Scotts	S-6128	1,150 g	28	1.25 b	1.25ab	1.75 b	1.75 b
4	ISK Biotech	Fluazinam 500F	1.0 oz	21	4.25ab	1.5ab	4.25b	3.25b
5	ISK Biotech	Fluazinam 500F	2.0 oz	28	4.5ab	1.75ab	4.25b	4.25b
6	ISK Biotech	Fluazinam 500F	1.0 oz.	28	6.5ab	5.0ab	12.5ab	4.0b
		+Banner 1.1 EC	2.0 fl. oz.					
7	Rohm & Haas	Eagle 40 W	1.2 oz.	28	1.25b	0.5b	0.5b	0.25b

[1] Means in a column followed by the same letter are not significantly different (DMRT, P=0.05). N=4.

1995 Fairway Height Bentgrass Fertilizer Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Natural fertilizers from Toro and other natural products were screened for their effects on bentgrass quality and growth. This trial was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was in an area of 'Dominant' creeping bentgrass maintained at a mowing height of 1/2". The soil in this experimental area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 2.6%, a pH of 7.85, 6 ppm P, and 50 ppm K.

Individual experimental plots were 5 x 5 ft and there were nine treatments with three replications. Barrier rows 2 ft wide were placed between replications. The experimental design was a randomized complete block.

Five natural product fertilizers (29-0-0, 22-3-3 + Fe, 12-16-8, 1.95-1.1-30, and 18-0-18) from Toro were tested as were granular corn gluten meal, Sustane (turkey manure), and Renaissance (a natural soy product from Fairway Green Inc.). All products were applied at the yearly rate of 2 lb N/1000 ft^2 in split applications of 1 lb N/1000 ft^2. An unfertilized control was included for comparisons.

The plot was mowed to a uniform height of 1/2" before fertilizer application. A survey of the experimental area was made prior to treatment and the bentgrass was uniform in color and overall quality. The fertilizers were applied using plastic coated containers as 'shaker dispensers'. Initial applications were made on July 11.

The materials were watered-in with the irrigation system and the plot was mowed to 1/2" on July 13. The first post-application rainfall occurred on July 16. Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high (Table 2). Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Sequential applications were made on September 8. The materials were watered-in using the irrigation system and the plot was mowed to 1/2" on September 10. The first substantial post-application rainfall occurred on September 19, 20, and 21.

Phytotoxicity data were taken on July 14 and September 11. Bentgrass phytotoxicity was estimated using a 9 to 1 scale: 9 = no damage, 7 = 30% damaged, 5 = 50% damaged, and 3 = 70% damaged turf per plot (Table 1). Visual quality data were taken on July 25, August 4, 11, 23, September 1, 20, 27, October 4 and 11. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 2). Fresh clipping weights were measured on August 11, 23, September 1, 27, October 4, and 11. The mowing height for collecting clippings was 3/8" (Table 3). There were schedule modifications in data collection due to adverse weather conditions.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparisons were used to assess fertilizer effects on bluegrass quality and clipping weights.

Significant phytotoxicity was found in bentgrass treated with the Toro product with an analysis of 1.95-1.1-30 (Treatment 8). Within three days after the initial and sequential applications, as much as 50% of the bentgrass was damaged in plots treated with this material. This phytotoxicity probably was the result of the high level of K applied. Because of the low N content, it was necessary to apply a large amount of this product to equal the 1 lb N/1000 ft^2 rate. The bentgrass recovered quickly and within 10 days the symptoms were no longer present. None of the other fertilizers caused any substantial damage to the bentgrass (Table 1).

Problems were encountered with all fertilizer products. The particle sizes were too large and they remained on the bentgrass surface even after being thoroughly watered-in using the irrigation system. Much of the material was removed by the mower and the removal of product could explain the lack of definitive results.

There were no significant differences in visual turf quality among the fertilizer materials and the untreated controls. The mean visual quality also was similar for all of the treatments and did not differ from the untreated control (Table 2).

There were small differences in clipping weights but significant differences among the treatments were only recorded for October 4 and October 11 (Table 3). On October 4, the clipping weights for bentgrass treated with Renaissance were higher than the untreated control and all other fertilizers, except one of the Toro products (Treatment 8). On October 11, bentgrass fertilized with Toro fertilizer (Treatment 8) and Renaissance were significantly higher than the untreated control and all other fertilizers, except Sustane and another Toro product (Treatment 4). Mean and total clipping weights were similar for the untreated controls and all the fertilizer products.

Table 1. Phytotoxicity[1] in Kentucky bluegrass fertilized with natural product and other fertilizers.

Product	July 14	September 11	Mean phytotoxicity
1. Untreated control	9	9	9
2. Granular corn gluten meal (10% N)	9	9	9
3. Renaissance (6-0-6)	9	9	9
4. Toro fertilizer (29-0-0)	9	8	8
5. Toro fertilizer (22-3-3 + Fe)	9	9	9
6. Toro fertilizer (18-0-18)	9	8	9
7. Toro starter (12-16-8)	9	8	9
8. Toro fertilizer (1.95-1.1-30)	5	6	5
9. Sustane (5-2-4)	9	7	8
$LSD_{(0.05)}$	1	2	1

[1] Phytotoxicity was assessed using a 9 to 1 scale: 9 = healthy, 7 = 30% damaged, 5 = 50% damaged, and 3= 70% damaged turf.

Table 2. Visual turf quality[1] of Kentucky bluegrass fertilized with natural product and other fertilizers in split applications on July 11 and September 8.

Product	July 25	Aug 4	Aug 11	Aug 23	Sept 1	Sept 20	Sept 27	Oct 4	Oct 11	Mean quality
1. Untreated control	7	8	7	8	8	8	8	9	8	8
2. Granular corn gluten meal	8	8	7	8	8	8	8	9	8	8
3. Renaissance (6-0-6)	8	8	7	8	8	8	9	9	8	8
4. Toro fertilizer (29-0-0)	8	8	7	8	8	8	8	9	8	8
5. Toro fertilizer (22-3-3 + Fe)	8	8	7	8	8	8	8	9	8	8
6. Toro fertilizer (18-0-18)	8	8	7	8	8	8	8	9	8	8
7. Toro starter (12-16-8)	8	8	7	8	8	8	8	9	8	8
8. Toro fertilizer (1.95-1.1-30)	8	8	7	8	8	8	8	9	8	8
9. Sustane (5-2-4)	8	8	7	8	8	8	8	9	8	8
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1= poorest quality.
NS = not significantly different at the 0.05 level.

Table 3. Fresh clipping weights[1] of Kentucky bluegrass fertilized with natural product and other fertilizers in split applications on July 11 and September 8.

Product	Aug 11	Aug 23	Sept 1	Sept 27	Oct 4	Oct 11	Clipping Weights Mean	Clipping Weights Total
1. Untreated control	76	63	47	22	26	23	43	258
2. Granular corn gluten meal	85	68	43	24	29	31	47	280
3. Renaissance (6-0-6)	103	67	45	38	62	64	63	378
4. Toro fertilizer (29-0-0)	90	76	42	31	38	47	54	324
5. Toro fertilizer (22-3-3 + Fe)	89	70	39	27	38	34	49	297
6. Toro fertilizer (18-0-18)	73	64	39	28	37	38	47	281
7. Toro starter (12-16-8)	94	65	44	30	37	33	51	303
8. Toro fertilizer (1.95-1.1-30)	93	78	58	42	54	70	66	395
9. Sustane (5-2-4)	94	67	48	36	37	51	55	333
$LSD_{(0.05)}$	NS	NS	NS	NS	18	26	NS	NS

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

1995 Kentucky Bluegrass Fertilizer Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Natural organic fertilizers were screened with naturally derived and other fertilizers for their effects on turf quality and growth. This trial was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was an area of 'Park' Kentucky bluegrass with a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) soil with an organic matter content of 3.3%, a pH of 7.0, 7 ppm P, and 86 ppm K.

The experimental design was a randomized complete block. Individual experimental plots were 5 x 5 ft with 11 treatments and three replications. Three-foot barrier rows were placed between replications.

Corn gluten meal, Sustane (turkey manure), Ringer's organic fertilizer, Milorganite (activated sewage sludge), and two Toro materials were applied at a yearly rate of 4.0 lb N/1000 ft^2 in split applications. A natural soy product, Renaissance, was applied at different rates in single and in split applications (Table 1). An unfertilized control was included for comparisons.

Initial treatments were made on May 15. The plot was mowed to a uniform height of 2" before treatment. A pre-treatment survey of the experimental area was conducted and the bluegrass was found to be uniform in color and overall quality. The materials were applied using plastic coated containers as 'shaker dispensers'. An application of 1 lb P (Triple Super P) and K (K_2SO_4)/1000 ft^2 was made on May 17. Sequential applications were made on August 10.

Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high. 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 from May 24 through October 11. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 2 and 3). The mowing height for collecting clippings was 2" (Tables 4 and 5).

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparisons were used to assess fertilizer effects on bluegrass quality and clipping weights.

There were no symptoms of phytotoxicity on Kentucky bluegrass treated with the fertilizer products. On each data collection date, there were significant differences in bluegrass quality among the fertilizer products (Tables 2 and 3). Bluegrass quality responses to some of the fertilizers were evident on May 24 (nine days after treatment), but quality improvement was slower in response to other materials. The sequential applications of Renaissance (Treatment 7), the Ringers fertilizer and the Toro products resulted in a rapid improvement in turf quality. The mean visual quality was better than the untreated control in all fertilized plots except those receiving Renaissance at 1 lb N/1000 ft^2. The best mean quality was achieved by bluegrass treated with corn gluten meal, Renaissance, at 4.0 lbs N/1000 ft^2 in split applications, Ringer's fertilizer, and the Toro products.

Differences also were recorded on each data collection date for clipping weights among the fertilized plots. All of the fertilizers significantly increased mean clipping weights when compared with the untreated control. Initial and sequential treatment with some of the products resulted in rapid increases in clipping weights, while the response to other products was slower (Tables 4 and 5). The highest mean weights were for bluegrass treated with the Toro products, but grass treated with

Renaissance at 3.0 lb N/1000 ft^2, Renaissance at 4.0 lb N/1000 ft^2 in split applications, and the Ringer product had similar clipping weights.

Table 1. The rates and application times[1] of the fertilizer products used in the 1995 Kentucky bluegrass fertilizer study.

Fertilizer	Yearly amount (lbs N/1000 ft^2)	Initial Application (lbs N/1000 ft^2)	Sequential Application (lbs N/1000 ft^2)
1 Untreated control	NA	NA	NA
2 Corn gluten meal (10% N)	4.0	2	2
3 Sustane (5-2-4)	4.0	2	2
4 Renaissance (6-0-6)[2]	1.0	1	none
5 Renaissance (6-0-6)[2]	2.0	2	none
6 Renaissance (6-0-6)[2]	3.0	3	none
7 Renaissance (6-0-6)[2]	4.0	2	2
8 Ringers fertilizer(10-2-6)[3]	4.0	2	2
9 Milorganite (6-2-0)	4.0	2	2
10 Toro Product (12-3-9)[4]	4.0	2	2
11 Toro Product (22-2-3)[4]	4.0	2	2

[1]Initial applications were made on May 15 and sequential applications on August 10.
[2]Fairway Green's product.
[3]Ringer's fertilizer.
[4]Toro's fertilizer products.

Table 2. The visual quality[1] of Kentucky bluegrass (from May 24 to July 27) treated with natural organic and other fertilizers[2].

	Fertilizer	Yearly lbs N/1000 ft^2	May 24	May 31	June 6	June 15	June 21	June 29	July 6	July 13	July 21	July 27
1	Untreated control	NA	7	5	5	5	5	5	6	5	6	6
2	Corn gluten meal (10% N)	4.0	7	6	8	9	9	9	8	8	8	7
3	Sustane (5-2-4)	4.0	8	7	7	7	7	7	7	7	7	7
4	Renaissance (6-0-6)[2]	1.0	7	7	7	7	7	7	7	6	6	7
5	Renaissance (6-0-6)[2]	2.0	7	8	8	8	7	7	7	7	7	7
6	Renaissance (6-0-6)[2]	3.0	8	9	9	9	8	9	9	9	8	8
7	Renaissance (6-0-6)[2]	4.0	7	8	8	8	7	7	7	8	8	7
8	Ringers fertilizer(10-2-6)[3]	4.0	7	7	7	8	7	8	7	8	7	7
9	Milorganite (6-2-0)	4.0	7	6	6	7	7	7	7	7	7	7
10	Toro Product (12-3-9)[4]	4.0	9	8	8	8	7	8	8	8	7	7
11	Toro Product (22-2-3)[4]	4.0	9	9	8	8	8	8	7	7	8	7
	$LSD_{(0.05)}$	---	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 = lowest acceptable quality, and 1 = poorest quality.
[2]Initial applications made on May 15 and sequential applications on August 10.

Table 3. The visual quality[1] of Kentucky bluegrass (from August 3 to October 11) treated with natural organic and other fertilizers[2].

	Fertilizer	Yearly lbs N/1000 ft^2	Aug 3	Aug 17	Aug 23	Aug 30	Sept 6	Sept 13	Sept 20	Sept 27	Oct 11	Mean visual quality
1	Untreated control	NA	6	6	5	5	6	6	6	6	6	6
2	Corn gluten meal (10% N)	4.0	8	7	8	9	9	9	9	8	9	8
3	Sustane (5-2-4)	4.0	7	8	8	7	7	8	7	7	7	7
4	Renaissance (6-0-6)[2]	1.0	7	7	6	6	6	6	6	5	6	6
5	Renaissance (6-0-6)[2]	2.0	7	7	6	6	6	6	6	6	6	7
6	Renaissance (6-0-6)[2]	3.0	7	7	6	6	6	7	7	6	6	8
7	Renaissance (6-0-6)[2]	4.0	7	9	9	9	9	8	8	7	8	8
8	Ringers fertilizer(10-2-6)[3]	4.0	8	9	9	9	9	8	8	7	8	8
9	Milorganite (6-2-0)	4.0	7	8	7	8	8	7	7	7	7	7
10	Toro Product (12-3-9)[4]	4.0	7	9	9	9	9	9	8	8	8	8
11	Toro Product (22-2-3)[4]	4.0	7	9	8	9	9	9	8	8	8	8
	$LSD_{(0.05)}$	---	1	1	1	1	1	1	2	1	1	0.4

[1]Visual quality is based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2]Initial applications made on May 15 and sequential applications on August 10.

Table 4. The fresh clipping weights[1] of Kentucky bluegrass (from May 24 to July 27) treated with natural organic and other fertilizers[2].

	Fertilizer	May 24	May 31	June 6	June 15	June 21	June 29	July 6	July 13	July 21	July 27
1	Untreated control	289	160	184	135	36	92	59	51	30	36
2	Corn gluten meal (10% N)	287	168	263	349	68	213	153	110	72	70
3	Sustane (5-2-4)	317	225	311	289	58	159	119	96	77	77
4	Renaissance (6-0-6)[2]	315	197	254	217	46	127	90	63	53	56
5	Renaissance (6-0-6)[2]	311	232	359	323	56	214	132	113	70	73
6	Renaissance (6-0-6)[2]	313	267	455	435	78	237	181	125	97	85
7	Renaissance (6-0-6)[2]	325	252	376	341	69	172	129	97	78	72
8	Ringers fertilizer(10-2-6)[3]	329	221	346	319	56	192	132	99	77	70
9	Milorganite (6-2-0)	305	197	263	254	53	161	122	79	82	81
10	Toro Product (12-3-9)[4]	389	285	375	347	66	185	135	103	61	66
11	Toro Product (22-2-3)[4]	407	307	364	314	61	174	127	109	79	69
	$LSD_{(0.05)}$	46	26	27	24	8	40	23	29	26	21

[1]Clipping weights are expressed as grams fresh weight.
[2]Initial applications made on May 15 and sequential applications on August 10.

Table 5. The fresh clipping weights[1] of Kentucky bluegrass (from August 3 to October 11) treated with natural organic and other fertilizers[2].

	Fertilizer	Aug 3	Aug 17	Aug 23	Aug 30	Sept 6	Sept 13	Sept 20	Sept 27	Oct 11	Mean clipping weights	Total clipping weights
1	Untreated control	48	152	55	70	59	48	50	23	37	85	1613
2	Corn gluten meal (10% N)	104	242	115	193	188	147	115	50	89	158	2995
3	Sustane (5-2-4)	84	303	132	156	132	97	73	34	58	147	2800
4	Renaissance (6-0-6)[2]	67	192	73	81	68	63	48	22	40	109	2073
5	Renaissance (6-0-6)[2]	81	209	77	87	72	57	48	21	39	135	2571
6	Renaissance (6-0-6)[2]	100	271	106	105	92	72	60	33	48	166	3162
7	Renaissance (6-0-6)[2]	83	330	175	186	167	123	96	41	87	168	3198
8	Ringers fertilizer(10-2-6)[3]	82	322	164	182	168	158	96	40	67	164	3121
9	Milorganite (6-2-0)	88	298	133	159	131	94	79	38	59	141	2676
10	Toro Product (12-3-9)[4]	72	347	171	200	168	124	97	44	78	174	3313
11	Toro Product (22-2-3)[4]	86	349	153	181	158	120	96	44	69	172	3265
	$LSD_{(0.05)}$	21	51	27	29	21	34	19	7	15	13	254

[1]Clipping weights are expressed as grams fresh weight.
[2]Initial applications made on May 15 and sequential applications on August 10.

1995 ESN 2003 Mini-size Poly-coated Urea Fertilizer Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Poly-coated urea ESN 2003 mini-sized fertilizer formulations were screened with other fertilizers for their effects on Kentucky bluegrass quality and growth. This trial was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was in an area of 'Park' Kentucky bluegrass. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.3%, a pH of 7.0, 7 ppm P, and 86 ppm K.

The experimental design was a randomized complete block. Individual experimental plots were 5 x 5 ft with 12 treatments and three replications. Three-foot barrier rows were placed between replications.

Four formulations of the poly-coated ESN #2003 mini-size fertilizer were used (100%, 80/20, 60/40, and 40/60). The performance of the mini-size also was tested against regular-size ESN #2003 material (100%). Sulfur-coated urea (SCU mini-size LESCO Elite #9352), poly-coated urea (PCU mini-size Pursell's polyon), Nutralene, Triaform, soluble nitrogen (mini-size urea), Turfgo Blend, and an unfertilized control were included as comparisons. All materials were applied at an annual rate of 3.0 lb N/1000 ft^2 in split applications of 1.5 lb N/1000 ft^2 (Table 1).

The fertilizers were applied with plastic coated cartons used as 'shaker dispensers'. Initial applications were made on May 5. Sequential applications were made 12 weeks later on July 25. Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high. 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 from May 19 through October 18. There were some schedule modifications in data collection due to adverse weather conditions and turf growth. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Tables 1 and 2). The mowing height for collecting clippings was 2" (Tables 3 and 4).

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparisons were used to assess fertilizer effects on bluegrass quality and clipping weights.

There were no symptoms of phytotoxicity on any Kentucky bluegrass treated with the fertilizer products. The visual quality in fertilized plots was either better or at least as good as in untreated controls on each data collection date (Tables 1 and 2). The mean visual quality of fertilized bluegrass was better than unfertilized.

Clipping weight data indicate that mini-size urea and Triaform treated grass experienced a flush of growth for a few weeks following initial application. Bluegrass responded slower to the sulfur- and poly-coated ureas and some of the #2003 formulations, but the effects on growth persisted until the sequential applications (Table 3). After the 12-week applications, there also was a brief growth surge in grass treated with mini-size urea and Triaform. As with the initial applications, the sulfur- and poly-coated ureas and some of the #2003 materials resulted in a slower but more persistent growth response (Table 4).

The highest mean and total clipping weights were for grass treated with mini-size urea. Weights were similar, however, for grass treated with SCU mini-size, Triaform, #2003 mini-size 80/20, #2003 mini-size 40/60, #2003 mini-size 100%, #2003 regular-size, and PCU mini-size (Table 4).

Table 1. Visual quality[1] of Kentucky bluegrass (from May 19 to July 27) treated with ESN 2003 mini and other fertilizers[2].

	Fertilizer	yearly lbs N/1000 ft^2	May 19	May 25	June 5	June 12	June 19	June 29	July 6	July 13	July 21	July 27
1	Untreated control	NA	6	6	6	5	5	5	5	5	5	5
2	ESN 2003 mini - 100%	3.0	6	7	7	8	7	9	8	8	7	7
3	ESN 2003 mini - 80/20	3.0	7	8	8	8	7	8	7	8	7	7
4	ESN 2003 mini - 60/40	3.0	7	8	8	7	7	8	7	7	7	8
5	ESN 2003 mini - 40/60	3.0	8	8	8	8	7	8	7	7	7	7
6	ESN 2003 regular - 100%	3.0	8	8	8	7	7	8	7	7	7	7
7	SCU mini - Lesco E lite	3.0	8	9	9	9	7	8	7	7	7	7
8	PCU mini - Polyon	3.0	6	7	7	8	7	9	8	8	8	8
9	Nutralene[3]	3.0	7	7	7	6	6	7	7	6	7	6
10	Triaform[4]	3.0	8	8	8	6	6	7	6	6	6	7
11	Urea mini - 100%	3.0	9	9	8	8	6	7	6	7	7	7
12	Turfgo Blend	3.0	7	8	8	8	7	8	8	7	7	7
	$LSD_{(0.05)}$	---	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 = lowest acceptable quality, and 1 = poorest quality.
[2]Initial applications made on May 5, sequential applications made on July 25.
[3]Nutralene is from AgrEvo.
[4]Triaform is from The Scotts Company.

Table 2. Visual quality ratings[1] of Kentucky bluegrass (from August 3 to October 18) treated with ESN 2003 mini and other fertilizers[2].

	Fertilizer	Aug 3	Aug 11	Aug 18	Aug 30	Sept 6	Sept 13	Sept 20	Oct 4	Oct 18	Mean Visual Quality
1	Untreated control	5	5	5	5	5	5	5	5	5	5
2	ESN 2003 mini - 100%	7	7	8	8	8	7	7	8	7	7
3	ESN 2003 mini - 80/20	8	8	8	8	8	7	7	7	7	8
4	ESN 2003 mini - 60/40	8	8	8	7	7	7	7	7	7	7
5	ESN 2003 mini - 40/60	9	9	8	8	8	7	7	7	7	8
6	ESN 2003 regular - 100%	8	8	8	8	7	7	7	7	7	7
7	SCU mini - Lesco Elite	8	9	9	8	7	7	7	7	7	8
8	PCU mini - Polyon	7	7	8	8	8	8	8	8	8	8
9	Nutralene[3]	8	7	7	7	7	7	6	7	7	7
10	Triaform[4]	9	9	8	7	7	7	6	7	6	7
11	Urea mini - 100%	9	9	9	7	7	7	6	6	7	7
12	Turfgo Blend	8	8	7	7	7	7	7	8	7	7
	$LSD_{(0.05)}$	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 = lowest acceptable quality, and 1 = poorest quality.
[2]Initial applications made on May 5, sequential applications made on July 25.
[3]Nutralene is from AgrEvo.
[4]Triaform is from The Scotts Company.

Table 3. Fresh clipping weights[1] of Kentucky bluegrass (from May 5 to July 27) treated with ESN 2003 mini and other fertilizers[2].

	Fertilizer	Yearly lb N/1000 ft²	May 19	May 25	June 5	June 12	June 19	June 29	July 6	July 13	July 21	July 27
1	Untreated control	NA	205	130	199	79	38	92	50	34	25	23
2	ESN 2003 mini - 100%	3.0	288	153	315	170	76	179	121	80	57	55
3	ESN 2003 mini - 80/20	3.0	354	176	325	183	82	188	131	88	56	53
4	ESN 2003 mini - 60/40	3.0	284	151	297	147	54	147	101	67	43	44
5	ESN 2003 mini - 40/60	3.0	393	144	325	174	63	145	103	68	46	42
6	ESN 2003 regular - 100%	3.0	337	161	332	164	70	160	111	68	50	43
7	SCU mini - Lesco Elite	3.0	378	193	416	210	74	160	111	71	49	41
8	PCU mini - Polyon	3.0	253	155	291	167	76	177	141	88	61	54
9	Nutralene[3]	3.0	287	136	280	128	57	124	79	57	38	39
10	Triaform[4]	3.0	499	158	361	151	51	148	82	69	38	41
11	Urea mini - 100%	3.0	518	165	371	163	64	149	85	87	40	38
12	Turfgo Blend	3.0	311	150	341	160	71	155	106	65	44	40
	$LSD_{(0.05)}$	---	112	NS	61	34	NS	30	19	28	13	9

[1]Clipping weights are expressed as grams fresh weight.
[2]Initial applications made on May 5, sequential applications made on July 25.
[3]Nutralene is from AgrEvo.
[4]Triaform is from The Scotts Company.

Table 4. Fresh clipping weights[1] of Kentucky bluegrass (from August 3 to October 18) treated with ESN 2003 mini and other fertilizers[2].

	Fertilizer	Aug 3	Aug 11	Aug 18	Aug 23	Aug 30	Sept 6	Sept 13	Sept 20	Oct 4	Oct 18	Mean Clipping Weights	Total Clipping Weights
1	Untreated control	35	49	60	25	35	32	23	15	12	7	58	1149
2	ESN 2003 mini - 100%	99	167	181	57	89	62	53	42	41	31	116	2246
3	ESN 2003 mini - 80/20	111	190	184	49	77	52	53	42	43	27	123	2396
4	ESN 2003 mini - 60/40	123	196	177	54	86	56	42	30	25	26	107	2100
5	ESN 2003 mini - 40/60	144	210	183	46	80	56	48	32	32	18	118	2304
6	ESN 2003 regular-100%	110	199	194	56	76	49	43	32	33	19	115	2253
7	SCU mini - Lesco Elite	104	197	231	62	81	56	46	36	35	23	129	2517
8	PCU mini - Polyon	77	140	176	53	81	51	52	47	46	27	111	2141
9	Nutralene[3]	102	182	161	47	70	46	37	28	24	14	97	1899
10	Triaform[4]	178	266	203	49	77	50	41	29	25	18	127	2491
11	Urea mini - 100%	168	243	192	51	86	47	41	27	28	17	129	2536
12	Turfgo Blend	108	180	176	48	68	41	40	33	33	23	110	2137
	$LSD_{(0.05)}$	30	53	28	16	28	NS	14	16	NS	NS	18	345

[1]Clipping weights are expressed as grams fresh weight.
[2]Initial applications made on May 5, sequential applications made on July 25.
[3]Nutralene is from AgrEvo.
[4]Triaform is from The Scotts Company.
NS = not significantly different at the 0.05 level.

1995 Trinexapac-ethyl (PRIMO) Post-Regulation Response Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Primo 1E was screened in single and sequential applications with and without urea to determine the circumstances that might produce a flush of turf growth following the growth regulation period provided by this product. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was a 10-year old stand of 'Park' Kentucky bluegrass with a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) soil with an organic matter content of 3.5%, a pH of 6.70, 6 ppm P, and 110 ppm K. This site was well-fertilized this spring with 0.5 lb N/1000 ft^2 from sulfur coated urea (37-0-0) plus 0.5 lb N/1000 ft^2 from urea (46-0-0).

The experimental design was a randomized complete block with three replications and 3 ft barrier rows between replications. Individual plots were 5 x 5 ft. There were six treatments including an untreated control, a fertilized control that received Urea, and four combinations of Primo 1E with and without sequential applications and fertilizer (Table 1). For all applications, Primo 1E was used at the label rate for Kentucky bluegrass of 0.26 lb a.i./Acre (0.75 fl oz/1000 ft^2). Urea (46-0-0) was used for all fertilizer treatments at 1 lb N/1000 ft^2. Sequential applications of Primo 1E and applications of urea were made four weeks after initial applications (4 WAT).

Primo 1E was applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles and a spray pressure of 20-25 psi. Urea was applied using plastic coated containers as 'shaker dispensers'. In those plots receiving urea and Primo 1E, the Primo was sprayed after the urea had been applied.

Initial applications were made on June 7. Prior to application, the plot was mowed to a uniform 2" height and the turf was checked for overall uniformity. It was partly cloudy, 84° F with a slight breeze and the turf was dry. Sequential applications were made on July 7. Clipping weight data were taken on July 6 so the plot had a uniform height of approximately 2". It was 75° F and partly sunny with a slight breeze.

Rainfall was sporadic for the duration of this study and temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing conditions.

Visual quality rating and fresh clipping weight data were taken weekly from June 15 through August 16. Adjustments to the data collection schedule were necessary because of rain events. Visual quality was assessed by using a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Factors considered in the ratings were color, density, and uniformity (Table 1). The mowing height for collecting clippings was 2" (Table 2).

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

There were no visual quality differences among the treated and untreated plots until after the sequential applications on July 7. After this date, bluegrass treated with fertilizer at 4 WAT (Treatments 2, 4, and 6) exhibited better color and thickness than bluegrass not receiving urea (Table 1).

Clipping weights of bluegrass treated with Primo 1E were lower from June 15 through June 29. After the sequential applications of Primo 1E and urea, bluegrass in the fertilized control plots and in plots receiving only urea at 4 WAT (Treatment 4) showed a significant increase in clipping weights when compared with grass in the untreated control and in those plots treated with Primo 1E at 4 WAT (Treatments 5 and 6).

After July 21, there was a post inhibition stimulation of growth in bluegrass treated with Primo 1E and urea at 4 WAT. The clipping weights were similar to those from bluegrass treated with Primo 1E initially and fertilized with urea at 4 WAT and the fertilized control plots (Table 2).

Bluegrass in the fertilized control and in the plots treated with Primo 1E initially and fertilized at 4 WAT (Treatment 4) produced the highest total clipping weights. Bluegrass in the untreated control plots, in plots receiving only an initial Primo 1E application (Treatment 3), and in plots receiving Primo 1E initially, and in combination with urea at 4 WAT (Treatment 6), had similar total clipping weights. The lowest total clipping weights were recorded for bluegrass receiving Primo 1E initially and sequentially at 4 WAT (Treatment 5).

Table 1. The visual quality ratings[1] of Kentucky bluegrass in plots treated with Primo 1E, Primo + urea, and urea alone [2].

Product	June 15	June 21	June 29	July 6	July 13	July 21	July 27	Aug. 3	Aug. 11	Aug. 16	Mean visual quality
1 Untreated control	7	6	7	7	7	7	7	7	6	6	7
2 Fertilized control	7	6	7	7	9	9	8	8	7	7	7
3 Primo 1E (no fertilizer)	7	6	6	7	7	7	6	6	6	5	6
4 Primo 1E (4 week fertilizer)	7	6	6	7	9	9	9	9	7	7	8
5 Primo 1E (initial & 4 WAT)	7	6	6	7	6	6	5	7	6	6	6
6 Primo 1E (initial & 4 WAT) + 4 week fertilizer	7	6	6	7	8	8	9	9	8	7	7
$LSD_{(0.05)}$	NS	NS	NS	NS	1	0.3	1	0.4	1	1	NS

[1]Visual quality ratings are based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2]Initial application was made on June 7 and 4 WAT applications were made on July 7.
NS=not significantly different at the 0.05 level.

Table 2. Clipping weights[1] of Kentucky bluegrass in plots treated with Primo 1E, Primo + fertilizer, and fertilizer alone [2].

Product	June 15	June 21	June 29	July 6	July 13	July 21	July 27	Aug. 3	Aug. 11	Aug. 16	Total Clipping Weights
1 Untreated control	235	30	127	123	64	95	66	65	67	58	929
2 Fertilized control	230	30	128	131	99	153	122	96	99	91	1179
3 Primo 1E (no fertilizer)	185	19	85	114	76	86	76	75	84	73	872
4 Primo 1E (4 week fertilizer)	188	20	92	112	112	168	136	114	115	97	1155
5 Primo 1E (initial & 4 WAT)	175	25	81	91	31	30	37	57	77	77	680
6 Primo 1E (initial & 4 WAT) + 4 week fertilizer	183	18	85	111	53	71	95	110	124	113	964
$LSD_{(0.05)}$	42	8	17	NS	39	33	22	14	14	16	170

[1]Clipping weights are grams fresh tissue.
[2]Initial application was made on June 7 and 4 WAT applications were made on July 7.
NS=not significantly different at the 0.05 level.

Toro BioPlex *MP* and Multipurpose Soil Biostimulent Effects on a Sand - Based Green; First Year Results.

Nick E. Christians and James R. Dickson

The following study is a cooperative trial that is being conducted by Iowa State University (ISU), Colorado State University, and North Carolina State University. It is funded by the Toro Company.

Two liquid products designed to be "soil building" amendments in the Toro BioPro line (Multipurpose and BioPlex *MP*) are being tested in a multi-year trial. The purpose of the trials is to evaluate the synergistic plant growth effects of the components of each product. To test these effects, each component is applied alone and in all possible combinations with the other components of the product. Additionally, molasses is being evaluated alone and in combination with two BioPlex *MP* components (humic acid and growth hormones). These substances were applied ten times, at two-week intervals, throughout the 1995 growing season.

The ISU trial is being conducted on Penncross creeping bentgrass growing on a sand-based golf green which was constructed in 1984. The turf was killed with glyphosate and replanted in September, 1994. This new turf had completely filled in by mid-July, 1995, about five weeks after the trial had begun. It was maintained at a mowing height of 3/8-inch until late October and then gradually lowered to 1/4-inch.

This report summarizes the results of the first year's work performed at the Iowa State University Horticulture Research Station north of Ames, Iowa. It includes information pertaining to turf shoot clipping yield and root growth. This trial is being continued in 1996.

There were no apparent visual quality differences between the treatments until mid-October. At that date, it became apparent that the grass receiving the 1:3 mix + growth hormones treatment was going dormant sooner than the grasses which received other treatments. The significance of this phenomena is not yet apparent and the plots will be observed in the spring as the grass emerges from dormancy.

There were treatment differences in clipping weight for the September 1 (at the 90% level) and October 19-22 (at the 95% level) data. Treatment 3 produced greater clipping yields in early September and Treatment No. 6 produced greater yields in late October. There were no treatment differences for the annual total clipping weights however, so no apparent patterns are evident at this time.

There were no treatment differences discovered in the data from either root sampling event.

Table 1. Treatments.

Trt No	Treatment	Trt No	Treatment
1	control[†]	11	molasses + humic acid + growth hormones A
2	5-3-2[‡]	12	5-3-2 + humic acid + growth hormones A
3	molasses	13	1:3 mix[¶]
4	humic acid	14	micronutrients
5	growth hormones A[§]	15	growth hormones B[#]
6	5-3-2 + humic acid	16	1:3 mix + micronutrients
7	5-3-2 + growth hormones A	17	1:3 mix + growth hormones B
8	molasses + humic acid	18	micronutrients + growth hormones B
9	molasses + growth hormones A	19	1:3 mix + micronutrients + growth hormones B
10	humic acid + growth hormones A		

† Control = 4-1-3 (N-P_2O_5-K_2O) per 1000 ft^2/yr. All treatments also contain this treatment.
‡ 5-3-2 = refined molasses + micronutrients + vitamins
§ growth hormone A = IAA, GA, and cytokinins from kelp
¶ 1:3 mix = compost derivatives with humic substances
# growth hormones B = IBA, NAA, GA

Table 2. 1995 Mean clipping yields (g).

Trt No.	Aug 4	Aug 22	Sept 1	Sept 28	Oct 19-22		Total
1	27.55	30.97	30.74	17.63	75.39	bcd*	182.28
2	27.46	26.40	25.80	18.06	76.52	bcd	174.24
3	26.52	29.97	31.28	19.48	78.43	abc	185.68
4	32.79	28.62	29.28	17.89	76.70	abcd	185.27
5	28.89	27.80	28.40	15.91	67.09	cd	168.09
6	30.17	26.93	26.36	20.21	88.65	a	192.33
7	28.58	26.21	25.13	16.60	72.58	bcd	169.10
8	28.84	27.26	25.93	16.58	72.51	bcd	171.11
9	32.44	28.20	30.31	16.78	67.16	cd	174.89
10	32.99	28.83	27.41	20.06	70.54	bcd	179.84
11	28.38	28.41	26.58	19.56	79.71	ab	182.64
12	26.41	27.26	26.88	14.75	72.18	bcd	167.48
13	28.03	28.73	26.90	16.19	69.32	bcd	169.17
14	28.20	29.24	24.56	18.59	70.79	bcd	171.38
15	29.55	29.97	25.29	20.38	81.10	ab	186.29
16	30.88	26.95	23.30	17.33	66.62	cd	165.08
17	28.42	26.97	27.92	16.46	65.11	d	164.88
18	28.44	28.45	30.49	18.48	75.90	bcd	181.77
19	30.50	28.07	30.03	19.22	77.84	abc	185.65
$LSD_{(0.05)}$	NS	NS	NS	NS	11.98	NS	NS

* Means followed by the same letter are not significantly different (P = 0.05)

Table 3. 1995 Mean root yields (g) at three depth intervals.

	August 2 cm				October 22 cm			
Trt No.	0-5	5-10	10-15	Total	0-5	5-10	10-15	Total
1	0.848	0.285	0.119	0.417	1.288	0.440	0.342	0.775
2	0.980	0.311	0.242	0.511	1.359	0.422	0.167	0.649
3	0.972	0.259	0.225	0.485	0.971	0.330	0.129	0.547
4	0.762	0.277	0.289	0.443	1.368	0.397	0.183	0.614
5	1.321	0.218	0.193	0.578	1.267	0.276	0.172	0.589
6	1.328	0.264	0.147	0.580	1.223	0.282	0.109	0.477
7	0.862	0.308	0.322	0.521	0.943	0.370	0.214	0.509
8	0.957	0.297	0.161	0.472	1.393	0.333	0.209	0.769
9	1.322	0.367	0.259	0.650	1.015	0.261	0.254	0.582
10	1.445	0.326	0.259	0.677	1.112	0.217	0.201	0.361
11	1.106	0.290	0.214	0.537	1.002	0.256	0.206	0.455
12	1.066	0.372	0.271	0.569	1.398	0.454	0.615	0.795
13	0.782	0.404	0.250	0.479	1.123	0.419	0.128	0.486
14	0.645	0.361	0.279	0.428	1.353	0.183	0.156	0.465
15	0.979	0.328	0.232	0.513	1.201	0.571	0.138	0.717
16	0.811	0.295	0.280	0.462	1.035	0.340	0.203	0.511
17	0.902	0.249	0.145	0.373	1.024	0.301	0.162	0.345
18	0.830	0.183	0.095	0.369	1.141	0.268	0.138	0.547
19	1.056	0.251	0.147	0.485	1.042	0.298	0.128	0.513
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS

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

Dianna L. Liu, Jason T. Gates, and Nick E. Christians

The herbicidal activity of corn gluten hydrolysate (CGH) has been demonstrated in petri dish and greenhouse bioassays and it has proved to be more effective than that of corn gluten meal (CGM). CGH was not available in sufficient quantities for field work until 1994. In 1994, two types of CGH (CGH-A and CGH-B) and CGM, which contains 10% nitrogen by weight, were used to compare their effectiveness for crabgrass control in 1 by 1 ft Kentucky bluegrass plots. CGH-A, containing 15% nitrogen by weight, was prepared by treating an aqueous slurry of corn gluten meal with amylases and proteinases, followed by filtration to remove the solubilized carbohydrates. CGH-B, containing 12% N by weight, was prepared by a simplified procedure which did not include amylases in the treatment. The 1994 data showed that at a rate of 10 lb/1000 ft^2, CGH-A had 60% crabgrass control which was significantly more effective than the 30% of CGM. In general, the crabgrass control activity of CGH-B was in between CGM and CGH-A. At rates higher than 20 lb/1000 ft^2, there was no statistical difference in the crabgrass reduction for all three samples. However, a great variation in crabgrass germination among the replications was observed.

This trial was repeated on the same site in 1995 at the Iowa State University Horticulture Research Station. The soil in this site is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.0%, a pH of 6.3, 12 ppm P, and 103 ppm K. This experiment was conducted in the same area of Indigo Kentucky bluegrass and arranged in the same randomized complete block design as the 1994 study. The individual plots were 1 x 1 ft with three replications. The three samples were applied at rates of 0, 5, 10, 20, 30, and 40 lbs materials per 1000 ft^2 (Table 1). All the treatments were applied on April 15, 1995. The CGM was applied in dry form by using a hand-held shaker, while the CGH was dissolved in 150 ml water and sprayed by using a backpack sprayer equipped with a single nozzle at a pressure of 20 psi.

Turf quality was evaluated visually based on color and uniformity of turf. Data were taken weekly for 10 weeks (week 3 to week 12) after the application of treatments (Table 2). The degree of crabgrass control was assessed by counting the number of crabgrass plants per individual plot on July 1 and 22, 1995, and expressed as percent reduction in crabgrass number compared against the untreated-control (Table 3). Data were analyzed with the Statistical Analysis System (SAS) version 6.09 using the General Linear Model (GLM) procedure. Least Significant Difference (LSD) means comparisons were used to assess treatment effects on bluegrass quality and crabgrass control.

The results of statistical analysis showed there were significant differences in turf quality. In general, the higher the rates of material, the better the turf quality (Table 2). Both CGH-A and CGH-B samples had higher quality than the CGM in the first five evaluation weeks indicating that the water-soluble materials degraded quicker and gave the nitrogen response faster.

There were significant differences in percent crabgrass reduction for the data on July 22, but not on July 1, 1995. The results for percent crabgrass reduction demonstrate that the higher the rates of samples, the more crabgrass reduction (Table 3). At the application rate of 10 lb/1000 ft^2, CGH-A had 50% , CGH-B had 24%, and CGM had 39% crabgrass reduction in week 14, but these values were not statistically significantly different from each other. At 30 lb and 40 lb/1000 ft^2, CGH-A had 58%, and 80%, and CGM had 67% and 72% crabgrass reduction, respectively, which were significantly different from the untreated control. In general, the data from the 1995 study showed that CGH-A had the best crabgrass control in all three samples followed by CGM. It was very wet in the spring 1995 when the treatments were applied. Temperatures were cool which may have delayed the crabgrass germination period, and the temperature was very high in the summer. All of these factors may have contributed to the high crabgrass infestation and poor crabgrass control from this year's study.

Table 1. Treatments of granular corn gluten meal (CGM) and two corn gluten hydrolysates (CGH-A and CGH-B). Each of the products were applied at five different rates as shown.

		Treatment*		
No.	Sample	Rate (lb /1000 ft^2)	gram/plot	ml H_2O /plot
1.	Untreated Control	NA	NA	N/A
2.	Granular CGM	5	2.268	N/A
3.	Granular CGM	10	4.536	N/A
4.	Granular CGM	20	9.072	N/A
5.	Granular CGM	30	13.608	N/A
6.	Granular CGM	40	18.144	N/A
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	150

* Treatments 2-6 were applied as granular materials. Treatments 7-16 were dissolved in H_2O prior to spraying.

Table 2. 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 Application									
Sample	Rate lb/1000 ft^2	3	4	5	6	7	8	9	10	11	12
Untreated Control	0	6	6	6	6	6	6	7	6	6	6
CGM	5	6	6	6	7	8	6	6	8	7	6
	10	7	6	8	8	7	8	8	7	7	7
	20	7	7	8	7	7	7	7	7	8	7
	30	7	8	9	9	8	9	9	8	9	8
	40	8	8	8	9	8	7	9	8	9	9
CGH-A	5	8	7	7	7	8	7	7	7	7	7
	10	8	7	8	8	6	9	7	8	8	7
	20	9	8	8	8	8	9	6	6	7	7
	30	9	9	8	8	8	7	9	8	9	9
	40	9	9	8	9	9	7	9	8	9	9
CGH-B	5	8	6	7	7	8	7	7	7	7	7
	10	6	5	7	6	8	7	6	7	8	6
	20	8	8	9	7	7	7	8	7	8	7
	30	8	8	8	8	8	7	8	7	8	8
	40	9	9	8	9	8	8	9	8	9	9
$LSD_{(0.05)}$		2	1	2	2	2	2	2	2	1	2

* Plots were evaluated weekly for 10 weeks starting on May 5, 1995 using a 9 to 1 scale: 9= best quality, 6= acceptable quality, and 1= dead turf.

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

Table 3. 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 Reduction in Crabgrass Number (%)*	
Sample	Rate (lb/1000 ft^2)	Rate (g/m^2)	July 1, 1995 Week 11	July 22, 1995 Week 14
Untreated Control	0	0	0	0
CGM	5	25	10	36
	10	49	7	39
	20	98	27	30
	30	147	87	67
	40	196	80	72
CGH-A	5	25	0	30
	10	49	7	50
	20	98	90	52
	30	147	60	58
	40	196	80	83
CGH-B	5	24.4	23	20
	10	48.8	27	24
	20	97.7	53	37
	30	146.5	47	56
	40	195.9	20	41
$LSD_{(0.05)}$**			N.S.	51

* Values are means of 3 replicates as compared against the untreated control, which is considered as 0% reduction. The untreated-control had an average of 5 and 18 crabgrass plants in each plot on July 1 and July 22, respectively.

** Least significant difference value was used to compare the statistical difference between means at 5% level. N.S. means that the difference between two means is not statistically significant.

Using a Split Application to Improve the Effectiveness of Corn Gluten Meal Products

Jason T. Gates, Dianna L. Liu, and Nick E. Christians

It has been proven that corn gluten meal and corn gluten hydrolysate have the ability to act as natural organic weed and feed products. Corn gluten meal's ability to act as a herbicide is through preemergently inhibiting the roots of germinating seedlings. Corn gluten meal is able to provide nutrition for the plant because it contains 10% nitrogen. In order to improve the effectiveness of this product, different rates and methods of application are being researched. Previous studies have shown that corn gluten meal gives a quick N response which would suggest a fast rate of degradation. One method of application that has made synthetic pesticides with accelerated rates of degradation more effective is to apply a split application. With corn gluten meal being effective at recommended rates of 20 lb/1000 ft^2, this form of application would be possible. By dividing the rate into two separate applications, the product becomes easier to apply and could potentially improve the material's ability to control weeds. The two separate applications would also provide a more consistent source of nitrogen, making the desirable plants more competitive.

The study was conducted at the Iowa State University Horticulture Research Station. The soil on the site is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.0%, a pH of 6.3, 12 ppm P, and 103 ppm K. The primary stand of turf was comprised of 'Indigo' Kentucky bluegrass. Early in the season, the plot was seeded with crabgrass. Two types of hydrolysate (CGH-A and CGH-B) and corn gluten meal were studied at five different rates (Table 1). CGH-A was enzymatically degraded more than CGH-B. Each treatment was placed on a 1 x 1 ft plot arranged in a randomized complete block design. Three-foot buffer zones were established between each of the three replications. The first treatment was applied on April 15, 1995. Half of each rate was applied at this time making the application rates 0, 2.5, 5, 10, 15, and 20 lb/1000 ft^2. The corn gluten meal sample was applied in dry form by shaking the container and dispersing the material evenly over the plot. The hydrolysate samples were weighed and then dissolved into 150 ml of water. This solution was sprayed using a CO_2 backpack sprayer with one nozzle operating at 20 psi. The second application used the same procedure and was applied on May 20, 1995. This application was applied at the same rates bringing the total product applied for the year to 0, 5, 10, 20, 30, and 40 lb/1000 ft^2.

Turf quality data were taken for a ten-week period beginning the third week after application and ending on week twelve. Quality data was based on the turfgrass aesthetics. Turfgrass color and thickness of the stand were the two major criteria in determining the quality ratings. Ratings went from 1 to 9 with a rating of one as dead and nine as best quality (Table 2). With corn gluten meal containing a natural organic slow release form of nitrogen, the turfgrass quality can be improved considerably. As the rate of the product increases, the nitrogen rate increases giving a greater effect to turfgrass quality. The hydrolysate products also are different from the corn gluten meal products in composition. CGH-A contains 15% nitrogen CGH-B contains 12% N and corn gluten meal contains 10% nitrogen by weight. More nitrogen is being put down per pound of hydrolysate.

To assess the degree of weed control, crabgrass plants were counted within each individual plot on July 1 and July 22. The data were analyzed using the Statistical Analysis System (SAS) version 6.09 using the General Linear Model (GLM) procedure.

The results from both crabgrass counts are displayed in Table 3. Data are expressed as percent reduction from the control plots. If no control was achieved from the application, it is represented with a zero percent reduction from the control. Statistical differences can be seen within products as the rate of the product is increased. There is no statistical difference between the products. At the recommended rate of 20 lb/1000 ft^2, CGM had 42% reduction, CGH-A had 90% reduction and CGH-B had 56% reduction.

These percent reductions in crabgrass are not significantly different from each other (LSD = 69). Statistical differences between CGH-A and the untreated control occurred at lower rates. CGH-A showed a significant difference at 20 lb/1000 ft^2, while CGH-B and CGM did not show a significant difference until application rates were at 30 lb/1000 ft^2.

Since the study took place in the field, weather effects on the products must be considered. After the first application, weather conditions were cold and wet. The hydrolysate products degrade quickly and are very water soluble. With cold weather keeping the crabgrass from germinating, the first application of hydrolysate products probably had little or no effect on controlling weeds. The second application on May 20 would have normally been too late, but with the cool wet spring, it was applied at just the right time. The split application allowed our window of application to be expanded and increased the products' effectiveness over that recorded in 1994 where single applications were used (Pages 81-82 of 1995 Iowa Turfgrass Research Report). Making use of split application has been shown to produce a positive effect on the use of hydrolysate product in the 1995 study.

Table 1. The treatments were set up in the following fashion. Each of the products were applied at five different rates as shown.

Treatment*		Rate (lb/1000 ft^2)		Volume of H_2O
No.	Sample	Total Rate	Each Application Rate	per plot (ml)
1.	Untreated Control	0	0	N/A
2.	Granular CGM	5	2.5	N/A
3.	Granular CGM	10	5	N/A
4.	Granular CGM	20	10	N/A
5.	Granular CGM	30	15	N/A
6.	Granular CGM	40	20	N/A
7.	Gluten Hydrolysate A	5	2.5	150
8.	Gluten Hydrolysate A	10	5	150
9.	Gluten Hydrolysate A	20	10	150
10.	Gluten Hydrolysate A	30	15	150
11.	Gluten Hydrolysate A	40	20	150
12.	Gluten Hydrolysate B	5	2.5	150
13.	Gluten Hydrolysate B	10	5	150
14.	Gluten Hydrolysate B	20	10	150
15.	Gluten Hydrolysate B	30	15	150
16.	Gluten Hydrolysate B	40	20	150

* Treatments 2-6 were applied as granular materials. Treatments 7-16 were dissolved in H_2O prior to spraying.

Table 2. Turf quality data was taken for 11 weeks starting on the third week from application.

Treatment: Sample	Treatment: Rate lb/1000 ft²	Turf Quality* — Number of Weeks After Application: 3	4	5	6	7	8	9	10	11	12
Untreated Control		6	5	6	6	5	6	5	6	6	6
CGM	5	7	6	7	6	7	6	7	7	7	6
	10	6	6	6	7	6	7	7	6	6	7
	20	6	6	6	6	6	7	7	7	7	7
	30	6	6	8	8	8	7	9	8	8	8
	40	7	7	8	9	8	8	9	9	9	9
CGH-A	5	7	6	6	7	7	7	6	6	6	5
	10	7	7	7	7	7	8	8	7	7	8
	20	9	8	9	8	9	8	9	8	8	8
	30	8	8	9	9	9	9	9	9	9	9
	40	9	9	9	9	9	9	9	9	9	9
CGH-B	5	6	6	6	6	7	7	6	6	6	6
	10	7	6	7	7	6	8	7	8	8	8
	20	8	7	8	8	8	8	8	8	8	8
	30	8	8	9	9	9	9	8	8	8	8
	40	8	8	9	9	9	9	9	9	9	9
$LSD_{(0.05)}$		2	1	1	2	1	2	1	1	1	1

Visual quality was assessed using a 1-9 scale. A score of 1 = dead turf while 9 = best quality.
*Values are means of scores of 3 replicates compared against untreated-control.

Table 3. Crabgrass counts were taken on two separate dates to determine the effectiveness of control from the split application.

Treatment: Sample	Treatment: Rate (lb/1000 ft²)	Percent Reduction in Crabgrass Number (%)*: July 1, 1995 Week 11	July 22, 1995 Week 14
Control	0	0	0
CGM	5	60	44
	10	0	9
	20	12	42
	30	67	69
	40	64	80
CGH-A	5	0	0
	10	62	68
	20	92	90
	30	93	93
	40	81	91
CGH-B	5	0	0
	10	23	31
	20	56	56
	30	71	70
	40	54	55
$LSD_{(0.05)}$		77	69

* Values are means of 3 replicates as compared against the untreated control, which is considered a 0% reduction.

1995 Field Study to Evaluate Corn Gluten Meal and Corn Gluten Hydrolysate for Crabgrass Control in Turf

Dianna L. Liu, David S. Gardner, and Nick E. Christians

Powdered corn gluten meal (CGM) and corn gluten hydrolysate (CGH), both containing approximately 10% nitrogen, were evaluated as natural herbicides for crabgrass control in turf. This trial was located in an area of 'Park' Kentucky bluegrass at the Iowa State University Horticulture Research Station. The soil in the area of this study is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 2.6%, a pH of 6.7, 5 ppm P, and 90 ppm K.

Five rates, 0, 5, 10, 15, and 20 lb/1000 ft^2, of CGM and CGH materials were arranged in a factorial design with 25 combinations. A rate of 20 lb/1000 ft^2 of another commercial source of corn gluten meal (Gardens Alive!, Lawrenceburg, IN), which was applied on April 19, 1995, was included in the treatments as a comparison (Table 1). A total of 26 treatments were randomly arranged and replicated three times. Individual experimental plots were 5 x 5 ft and there were 2-ft barrier rows between replications. CGM was applied on April 17, 1995 using a hand-held shaker. CGH was dissolved in H_2O and sprayed using a backpack carbon dioxide sprayer equipped with #8006 nozzles at a pressure of 30 psi. After the treatments, the materials were watered-in with the irrigation system. Supplemental irrigation was used to provide adequate moisture to maintain the grass in a good growing condition.

Visual quality data were taken on May 31, June 15, and June 23. Visual quality was rated using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1= poorest quality turf (Table 2). Crabgrass control was assessed by making visual estimations of the percentage of crabgrass cover per individual plot. The data on percent crabgrass cover were taken July 14, July 21, and August 18, 1995, and were expressed as percent crabgrass reduction (Table 3).

Data were analyzed with the Statistical Analysis System version 6.09 using the General Linear Model (GLM) procedure. Least Significant Difference (LSD) means comparisons were used to assess treatment effects on bluegrass quality and crabgrass control.

There was a significant difference in turf quality among treatments. Turf quality was improved by the application of either CGM or CGH at the rates greater than 5 lb/1000 ft^2.

There was no statistically significant difference in crabgrass reduction due to the treatments for all three evaluation periods because of the high variation among the replicates, but there were observed trends among treatments #4, #12, #13, #18, #21 when compared to the untreated control. The unusual weather pattern of 1995 likely played an important role in the erratic results of this study. Crabgrass germinated far later than the application of samples which may have been inactivated due to microbial activity in the soil.

Table 1. Treatments by using the combination of 5 different rates of powdered corn gluten meal and corn gluten hydrolysate samples and 1 rate of Gardens Alive! CGM

Treatment No.	Treatment Sample and Rate (CGM lb/1000 ft^2 + CGH lb/1000 ft^2)	CGM* (grams/plot***)	Hydrolysate ** (grams/plot***)
1	Untreated control	0	0
2	No CGM + 5 lb/1000 ft^2 CGH	0	57
3	No CGM + 10 lb/1000 ft^2 CGH	0	114
4	No CGM + 15 lb/1000 ft^2 CGH	0	170
5	No CGM + 20 lb/1000 ft^2 CGH	0	227
6	5 lb/1000 ft^2 CGM	57	0
7	5 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	57	57
8	5 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	57	114
9	5 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	57	170
10	5 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	57	227
11	10 lb/1000 ft^2 CGM	114	0
12	10 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	114	57
13	10 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	114	114
14	10 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	114	170
15	10 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	114	227
16	15 lb/1000 ft^2 CGM	170	0
17	15 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	170	57
18	15 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	170	114
19	15 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	170	170
20	15 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	170	227
21	20 lb/1000 ft^2 CGM	227	0
22	20 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	227	57
23	20 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	227	114
24	20 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	227	170
25	20 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	227	227
26	Gardens Alive! CGM**** @ 20 lb/1000 ft^2	227	0

* CGM (Code # 1616-62-10) was applied in dry form on April 14, 1995.
** Hydrolysate (Code # 1616-62-5) was dissolved in water prior to spraying on April 17.
*** Plot Size is 5 x 5 ft
**** Gardens Alive! CGM was applied in dry form on April 19, 1995.

Table 2. The effect of corn gluten meal (CGM) and/or corn gluten hydrolysate (CGH) on Kentucky bluegrass visual quality*

Treatment		Turf Quality **		
No.	Rate of CGM + CGH (lb/1000 ft^2)	May 31	June 15	June 23
1	Untreated control	6	6	6
2	No CGM + 5 lb/1000 ft^2 CGH	6	6	6
3	No CGM + 10 lb/1000 ft^2 CGH	7	7	7
4	No CGM + 15 lb/1000 ft^2 CGH	7	7	8
5	No CGM + 20 lb/1000 ft^2 CGH	8	8	7
6	5 lb/1000 ft^2 CGM	6	6	7
7	5 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	7	7	7
8	5 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	7	7	7
9	5 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	7	8	8
10	5 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	7	7	7
11	10 lb/1000 ft^2 CGM	7	7	7
12	10 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	7	7	8
13	10 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	7	7	7
14	10 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	7	7	7
15	10 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	8	8	8
16	15 lb/1000 ft^2 CGM	7	7	7
17	15 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	7	7	7
18	15 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	7	8	7
19	15 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	7	8	8
20	15 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	8	8	7
21	20 lb/1000 ft^2 CGM	8	7	7
22	20 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	8	8	7
23	20 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	7	8	7
24	20 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	8	8	8
25	20 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	8	8	8
26	Gardens Alive! CGM @ 20 lb/1000 ft^2	8	8	7
	$LSD_{(0.05)}$	1	1	1

* Plots were evaluated on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

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

Table 3. The effect of corn gluten meal (CGM) and/or corn gluten hydrolysate (CGH) on crabgrass control in Kentucky bluegrass field plots.

Treatment		Percent Crabgrass Reduction (%)*		
No.	Rate of CGM + CGH (lb/1000 ft^2)	July 14	July 21	August 18
1	Untreated control	0	0	0
2	No CGM + 5 lb/1000 ft^2 CGH	44	19	22
3	No CGM + 10 lb/1000 ft^2 CGH	50	42	38
4	No CGM + 15 lb/1000 ft^2 CGH	69	61	68
5	No CGM + 20 lb/1000 ft^2 CGH	38	38	38
6	5 lb/1000 ft^2 CGM	44	48	44
7	5 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	25	19	24
8	5 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	49	23	4
9	5 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	38	42	36
10	5 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	44	47	31
11	10 lb/1000 ft^2 CGM	25	38	19
12	10 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	69	62	53
13	10 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	69	57	59
14	10 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	50	48	40
15	10 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	44	33	50
16	15 lb/1000 ft^2 CGM	19	24	10
17	15 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	50	43	40
18	15 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	44	52	59
19	15 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	6	19	26
20	15 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	69	67	74
21	20 lb/1000 ft^2 CGM	56	52	48
22	20 lb/1000 ft^2 CGM + 5 lb/1000 ft^2 CGH	19	19	23
23	20 lb/1000 ft^2 CGM + 10 lb/1000 ft^2 CGH	44	43	41
24	20 lb/1000 ft^2 CGM + 15 lb/1000 ft^2 CGH	50	57	54
25	20 lb/1000 ft^2 CGM + 20 lb/1000 ft^2 CGH	25	24	53
26	Gardens Alive! CGM @ 20 lb/1000 ft^2	44	34	28
	LSD(0.05)**	NS	NS	NS

* Values are means of 3 replicates as compared with the untreated control. The untreated control had an average of 27, 35, and 67 crabgrass plants in each plot on July 14, July 21, and August 18, respectively.

** Least significant difference was used to compare the statistical difference between means at 5% level. NS indicates that the difference between two means is not statistically significant.

1995 Field Study Comparing the Efficacy of Five Different Corn Gluten Meal and Corn Gluten Hydrolysate Products for Crabgrass Control

Dianna L. Liu and Nick E. Christians

Three different corn gluten meal (CGM) and two corn gluten hydrolysate (CGH) products were evaluated for their efficacy as natural crabgrass control products in turf. This trial was located in an area of 'Park' Kentucky bluegrass at the Iowa State University Horticulture Research Station. The soil in this experimental area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.1% a pH of 7.2, 6 ppm P, and 110 ppm K.

Three different CGM products and two CGH products were tested at 10, 15, 20, and 30 lb/1000 ft^2 (Table 1). An untreated control was included as a comparison. A total of 21 treatments were randomly arranged and replicated three times. Individual experimental plots were 5 x 5 ft with 3 ft barrier rows between replications. All the treatments were applied on April 25, 1995. The CGM samples were applied with a hand-held shaker while the CGH samples were dissolved in an adequate volume of water (Table 1) and sprayed by using a backpack carbon dioxide sprayer equipped with 3-XR TeeJet 8005 VS nozzles at a pressure of 25-30 psi. To evaluate the effect of application timing on efficacy, four additional treatments of the CGH (sample #4) at 15 lb/1000 ft^2 were added to each replicate for four consecutive weeks, i.e. sprayed on May 2, May10, May 16, and May 23, 1995.

The treatments were watered-in with the irrigation system. Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high in mid- to late summer. Supplemental irrigation was used to provide adequate moisture to maintain the grass in a good growing condition.

Visual quality data were taken on June 8, June 13, June 20, and July 11. Visual quality was measured using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1= poorest quality (Table 2). Crabgrass control was assessed by making visual estimations of the percentage of crabgrass cover per individual plot. Percent crabgrass cover data were taken on July 14, July 21, and August 18, 1995 and expressed as percentage of crabgrass reduction (Table 3).

Data were analyzed with the Statistical Analysis System (SAS) version 6.09 using the General Linear Model (GLM) procedure. Least Significant Difference (LSD) means comparisons were used to assess treatment effects on bluegrass quality and crabgrass control.

Turf quality was significantly improved from the untreated control at the rates of 10 lb/1000 ft^2 or higher. The higher the application rates the better the turf quality. The gluten hydrolysate residue (sample #5) had the least effect on turf quality in all of the samples.

The unusual results on crabgrass control for samples #1, #2, #3, and #4 were likely due to the wet, cool spring followed by hot, dry weather in mid- to late summer (July and August). These conditions favor crabgrass infestation. Based on the statistical analysis, there was a significant difference in the percentage of crabgrass reduction due to the treatments and replicates. Treatments 15, 22, 23, 24, and 25, which were 15 lb/1000 ft^2 of the whole gluten hydrolysate applied five consecutive weeks, displayed more crabgrass reduction than the untreated control. When compared with the untreated control, treatments 15, 22, 23, 24, and 25 had reductions of 40%, 47%, 44%, 76%, and 81% respectively. In general, the treatments applied in May (Treatments 22, 23, 24, and 25) had better crabgrass control than the early application on April 25, 1995. Treatment #25, which was applied on May 23, 1995, had the greatest crabgrass reduction of all the treatments. Sample #5, which is the residue of CGH, was seen to have very little effect on crabgrass control. From this study, we have learned that the timing of application is crucial to have effective crabgrass control especially for water soluble CGH samples.

Table 1. Corn gluten meal (CGM) and corn gluten hydrolysate (CGH) samples and their rates used in this study.

No.	Treatment* Sample**	Rate (lb/1000 ft^2)	Material (grams/25 ft^2)	Water Used (ml)
1	Untreated Control	0	0	N/A
2	#1	10	114	N/A
3	#1	15	170	N/A
4	#1	20	227	N/A
5	#1	30	341	N/A
6	#2	10	114	N/A
7	#2	15	170	N/A
8	#2	20	227	N/A
9	#2	30	341	N/A
10	#3	10	114	N/A
11	#3	15	170	N/A
12	#3	20	227	N/A
13	#3	30	341	N/A
14	#4	10	114	1300
15	#4	15	170	1900
16	#4	20	227	2600
17	#4	30	341	3800
18	#5	10	114	1300
19	#5	15	170	1900
20	#5	20	227	2600
21	#5	30	341	3800
22-25***	#4	15	170	1900

* All the treatments were applied on April 25, 1995, unless stated otherwise.
All CGMs were applied in dry form by using ice cream containers as shakers.
CGH was dissolved in H_2O and applied using a backpack sprayer equipped with 3-XR TeeJet 8005VS nozzles at pressure 25-30 psi.

** #1 Granular corn gluten meal from Grain Processing Corporation (GPC, Muscatine, IA)
#2 Powdered corn gluten meal (GPC, Muscatine, IA)
#3 Powdered corn gluten (Gardens Alive!, Lawrenceburg, IN)
#4 Whole gluten hydrolysate Code# 1616-62-5 (GPC, Muscatine, IA)
#5 Gluten hydrolysate residue Code# 1616-62-9 (GPC, Muscatine, IA)

*** Treatments #22-25 were the same as treatment #15, and were sprayed for four consecutive weeks to compare the timing effect.

Table 2. The effect of corn gluten meal (CGM) or corn gluten hydrolysate (CGH) on Kentucky bluegrass visual quality*.

Treatment			Turf Quality **			
No.	Sample#	Rate (lb/1000^2)	June 6	June 13	June 20	July 11
1	Untreated Control	0	7	7	6	6
2	#1	10	7	8	6	6
3	#1	15	7	8	8	8
4	#1	20	8	8	9	9
5	#1	30	8	8	9	8
6	#2	10	7	8	8	7
7	#2	15	8	8	8	7
8	#2	20	7	8	8	7
9	#2	30	8	9	9	8
10	#3	10	7	7	7	8
11	#3	15	7	8	8	8
12	#3	20	7	8	8	8
13	#3	30	7	8	9	8
14	#4	10	7	7	7	7
15	#4	15	7	7	7	7
16	#4	20	7	8	8	7
17	#4	30	8	8	8	8
18	#5	10	7	7	6	7
19	#5	15	7	7	6	7
20	#5	20	7	7	7	7
21	#5	30	8	7	8	8
22	#4	15	8	8	8	8
23	#4	15	8	8	9	8
24	#4	15	9	9	9	8
25	#4	15	9	9	9	8
	LSD (0.05)		1	1	1	1

* Plots were evaluated on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1= poorest quality.

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

Table 3. The effect of corn gluten meal (CGM) or corn gluten hydrolysate (CGH) on crabgrass control in Kentucky blegrass field plots.

Treatment			Percent Crabgrass Reduction (%)*		
No.	Sample#	Rate (lb/1000^2)	July 14	July 21	August 10
1	Untreated Control	0	0	0	0
2	#1	10	39	38	39
3	#1	15	5	27	11
4	#1	20	27	23	29
5	#1	30	0	35	32
6	#2	10	0	0	16
7	#2	15	14	50	34
8	#2	20	0	0	8
9	#2	30	0	19	5
10	#3	10	5	8	24
11	#3	15	9	12	0
12	#3	20	9	19	32
13	#3	30	36	42	37
14	#4	10	0	35	18
15	#4	15	54	69	50
16	#4	20	0	15	26
17	#4	30	14	8	26
18	#5	10	27	8	32
19	#5	15	0	0	16
20	#5	20	0	0	21
21	#5	30	0	4	5
22**	#4	15	32	50	47
23**	#4	15	23	50	41
24**	#4	15	76	88	76
25**	#4	15	80	87	81
	LSD (0.05)		56	47	36

* Values are means of 3 replicates as compared to the untreated control. The untreated control had an average percent crabgrass cover of 37, 43, and 63% on July 14, July 21, and August 10, respectively.

** Treatments 22- 25 were applied 4 consecutive weeks after the initial application on April 24, 1995.

1995 Corn Gluten Hydrolysate Weed Control Study

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Corn gluten hydrolysate was screened for efficacy as an annual grass and broadleaf natural product herbicide in turf. This trial is a long-term study started in 1995. It is being conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experiment is located in an area of 'Ram 1' Kentucky bluegrass. The soil in this experimental area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.1%, a pH of 6.7, 4 ppm P, and 109 ppm K.

The experimental design is a randomized complete block. Individual experimental plots are 5 x 5 ft and three replications were conducted with 3 ft barrier rows between replications. Corn gluten hydrolysate was applied at 0, 5, 10, 15, and 20 lbs product/1000 ft^2 (Table 1). These rates translate to 0.5, 1.0, 1.5, and 2.0 lbs N/1000 ft^2. All treated plots received one preemergence application in early spring. An untreated control was included for comparisons.

A survey of the experimental area was made prior to treatment and the bluegrass was uniform in color and overall quality. The hydrolysate was dissolved in water and applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles at 30 psi. Application of the materials was on April 17.

The materials were watered-in with the irrigation system. The first post-application rainfall occurred on April 17. Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

The experimental plot was checked for phytotoxicity on April 18 and periodically throughout the season. Visual quality data were taken on May 12, May 25, June 7, June 21, and July 21. Visual quality was measured using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Crabgrass control was assessed by making visual estimations of the percentage of crabgrass cover per individual plot. Crabgrass control data were taken on July 6, July 21, and August 2 (Table 2). Broadleaf weed control data will be taken in the early spring of 1996.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparisons were used to assess CGM effects on bluegrass quality and crabgrass control.

No phytotoxic symptoms were detected on any treated bluegrass. Turf quality was improved by the hydrolysate as compared with the untreated control plots. Hydrolysate at 10, 15, and 20 lbs product/1000 ft^2 significantly increased the visual quality on May 25, June 7, and June 21 and the mean quality when compared with the untreated control and hydrolysate at 5 lbs product/1000 ft^2 (Table 1).

Crabgrass cover was less in bluegrass treated with hydrolysate at 10, 15, and 20 lbs product/1000 ft^2 when compared with hydrolysate at 5 lbs product/1000 ft^2 and the untreated controls. Crabgrass populations were reduced 45, 56, and 66% by hydrolysate at 10, 15, and 20 lbs product/1000 ft^2, respectively (Table 2).

Table 1. Visual Quality[1] of Kentucky Bluegrass treated with Corn Gluten Hydrolysate on April 17 for the 1995 Corn Gluten Hydrolysate Weed Study.

	Material	lbs product /1000 ft^2	May 12	May 25	June 7	June 21	July 21	Mean Quality
1.	Untreated control	NA	7	6	6	6	5	6
2.	Corn gluten hydrolysate (10% N)	5	7	6	6	7	6	6
3.	Corn gluten hydrolysate (10% N)	10	7	7	7	7	7	7
4.	Corn gluten hydrolysate (10% N)	15	9	9	8	8	7	8
5.	Corn gluten hydrolysate (10% N)	20	9	9	8	9	7	8
	$LSD_{(0.05)}$		NS	1	1	1	NS	1

NS = not significantly different at the 0.05 level.

[1] Visual quality was assessed with a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Table 2. Percentage of Crabgrass Cover in Kentucky Bluegrass treated with Corn Gluten Hydrolysate on April 17 for the 1995 Corn Gluten Hydrolysate Weed Study.

	Material	lbs product /1000 ft^2	Percent Crabgrass Cover				
			July 6	July 21	August 2	Mean Crabgrass Cover	% Reduction in Crabgrass Cover
1.	Untreated control	NA	45	53	69	56	0
2.	Corn gluten hydrolysate (10% N)	5	32	47	66	48	14
3.	Corn gluten hydrolysate (10% N)	10	20	30	43	31	45
4.	Corn gluten hydrolysate (10% N)	15	12	25	37	25	56
5.	Corn gluten hydrolysate (10% N)	20	13	20	24	19	66
	$LSD_{(0.05)}$		21	18	21	17	31

Corn Gluten Meal Crabgrass Control Study - Year Five

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

A study screening corn gluten meal (CGM) for efficacy as a natural herbicide and fertilizer in turf was begun in 1991, and has been for five consecutive seasons on the same site. It is being conducted at the Iowa State University Research Station north of Ames, Iowa. The experiment is located in an area of 'Parade' Kentucky bluegrass. The soil in this experimental area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.2% a pH of 6.6, 9.2 ppm P, and 87 ppm K.

Individual experimental plots are 5 x 5 ft with five treatments and three replications. The experimental design is a randomized complete block.

Granular corn gluten meal was applied at 0, 2, 4, 6, 8, 10, and 12 lbs N/1000 ft^2 (Table 1). Corn gluten meal is 10% N and these rates translate to 0, 20, 40, 60, 80, 100, and 120 lbs CGM/1000 ft^2. All treatments were made to the same plots as in previous years. The CGM was measured into plastic coated ice cream containers that were used as 'shaker dispensers'. The CGM was applied in a single early spring preemergence application on April 13, 1995.

The materials were watered-in with the irrigation system. The first post-application rainfall occurred on April 17. Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

The plot was evaluated for phytotoxicity on April 15 and periodically throughout the growing season. Visual quality data were taken on July 21. Visual quality was measured using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Crabgrass control was assessed by making visual estimations of the percentage of crabgrass cover per individual plot. Crabgrass control data were taken on July 21, August 2, and August 10 (Table 2). Broadleaf weed control data were taken May 9, 1996 (Table 4).

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparisons were used to assess CGM effects on bluegrass quality, crabgrass control, and dandelion and clover control.

There was no phytotoxicity observed in the Kentucky bluegrass treated with CGM. There were significant increases in turf quality among the CGM treatments when compared with the untreated control (Table 1). The best quality was observed in turf that received either 60, or 80, or 100, or 120 lbs CGM/1000 ft^2.

Crabgrass populations were extremely high in 1995 due to wet conditions early in the germination period. Outbreaks of crabgrass were found in treated plots that had either very low numbers or no crabgrass in 1994.

When compared with the untreated control plots, however, significant levels of crabgrass control were achieved with CGM in 1995. Significant differences in the percentage of crabgrass cover were found between the treated and untreated controls on all collection dates (Table 2). The lowest percent cover was in bluegrass that received 60 lbs CGM/1000 ft^2, but the control level was not different from that recorded for CGM at 40, 80, 100, and 120 lbs/1000 ft^2. Crabgrass cover was significantly reduced by CGM treatment at all but the 20 lbs/1000 ft^2 level when compared with the untreated controls. A partial explanation of this may be that this area had only 2 lbs N/1000 ft^2 for the last 5 years and the turf is beginning to thin. Reductions were 88, 93, 75, 75, and 84% for 40, 60, 80, 100, and 120 lbs/1000 ft^2 CGM, respectively.

The number of crabgrass plants was significantly reduced in plots treated with CGM (40, 60, 80, 100, and 120 lbs CGM/1000 ft^2) when compared with the untreated control. The least crabgrass plants were found in bluegrass that received 40 and 60 lbs CGM/1000 ft^2, but the level of crabgrass control was not different from that achieved by CGM at 80, 100, and 120 lbs CGM/1000 ft^2. Reductions of crabgrass numbers were 86, 88, 71, 75, and 82% in bluegrass treated with 40, 60, 80, 100, and 120 lbs CGM/1000 ft^2, respectively (Table 3).

Comparisons can be made among the reductions in crabgrass cover data from previous years. Percentage reductions in 1995 were less than those recorded in previous years for each CGM treatment (Table 3).

Reductions in dandelion and clover in CGM treated plots were first documented in 1994. Comparisons of the 1994 and 1995 data show that reductions of dandelion and clover were less in 1995 (Table 4).

Table 1. Visual Quality[1] of Kentucky Bluegrass treated with granular corn gluten meal on April 17 for the long-term crabgrass study.

	Material	lbs N/1000 ft^2	lbs CGM/1000 ft^2	July 21
1.	Untreated control	0	0	6
2.	Corn gluten meal	2	20	7
3.	Corn gluten meal	4	40	8
4.	Corn gluten meal	6	60	9
5.	Corn gluten meal	8	80	9
6.	Corn gluten meal	10	100	9
7.	Corn gluten meal	12	120	9
	$LSD_{(0.05)}$			1

[1] Visual quality was assessed with a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Table 2. Percentage of crabgrass cover in Kentucky Bluegrass plots treated with granular corn gluten meal (CGM) on April 17 for the long-term crabgrass study.

			Percent crabgrass cover (%)				
	Material	lbs CGM /1000 ft^2	July 21	August 2	August 10	Mean % Cover	% Reduction in Cover
1.	Untreated control	0	28	24	45	25	---
2.	Corn gluten meal	20	17	18	29	16	36
3.	Corn gluten meal	40	4	3	6	3	88
4.	Corn gluten meal	60	2	2	2	2	93
5.	Corn gluten meal	80	8	8	8	6	75
6.	Corn gluten meal	100	8	9	8	6	75
7.	Corn gluten meal	120	7	4	5	4	84
	$LSD_{(0.05)}$		9	15	19	10	40

Table 3. Comparisons of the percentage of crabgrass reduction in Kentucky bluegrass plots treated with granular corn gluten meal (CGM) in 1991 through 1995.

lbs CGM /1000 ft^2	lbs N /1000 ft^2	Percent crabgrass reduction (%)				
		1991	1992	1993	1994	1995
0	0	0	0	0	0	0
20	2	58	85	91	70	36
40	4	86	98	98	97	88
60	6	97	98	93	98	93
80	8	87	93	93	87	75
100	10	79	94	95	86	75
120	12	97	100	100	98	84
$LSD_{(0.05)}$		26	44	31	39	40

Table 4. Comparisons of the percentages of broadleaf weed reduction in Kentucky bluegrass plots treated with granular corn gluten meal (CGM) in 1994 and 1995.

lbs CGM /1000 ft^2	lbs N /1000 ft^2	Percent weed reduction (%)			
		Clover		Dandelion	
		1994	1995	1994	1995
0	0	0	0	0	0
20	2	81	56	71	49
40	4	90	64	100	77
60	6	98	93	100	89
80	8	100	76	98	96
100	10	94	84	100	98
120	12	90	93	100	100
$LSD_{(0.05)}$		NS	48	50	65

NS = not significantly different at the 0.05 level.

1995 Corn Gluten Meal Rate Weed Control Study - Year One

Barbara R. Bingaman, Nick E. Christians, and David S. Gardner

Corn gluten meal (CGM) was screened for efficacy as a natural annual grass herbicide in turf. This trial is a long-term study started in 1995 that will be continued on the same area for several years. It is being conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experiment is located in an area of 'Ram 1' Kentucky bluegrass. The soil in this experimental area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.0%, a pH of 6.7, 4 ppm P, and 109 ppm K.

The experimental design is a randomized complete block. Individual experimental plots are 10 x 10 ft with five treatments and three replications. Corn gluten meal was applied at four different regimes of single and split applications (Table 1). The annual rate for all treated plots is 40 lbs CGM/1000 ft^2, which is equivalent to 4 lbs N/1000 ft^2. The CGM treatments were: four applications of 1 lb N/1000 ft^2, split applications of 2 lbs N/1000 ft^2, an initial application of 3 lbs plus a sequential of 1 lb N/1000 ft^2, and an initial application of 4 lbs N/1000 ft^2. An unfertilized control was included for comparisons. A survey of the experimental area was made prior to treatment and the bluegrass was uniform in color and overall quality.

Initial applications were made April 13. Sequential applications for Treatment 2 were made on May 30, August 10, and September 21. The split application for Treatment 3 and the sequential application for Treatment 4 were made on August 10. The CGM was applied using plastic coated containers as 'shaker dispensers'.

The materials were watered-in with the irrigation system. Rainfall was sporadic throughout the duration of this trial and temperatures were unusually high. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

The experimental plot was checked for phytotoxicity after the initial and all subsequent applications. Visual quality data were taken May 12, 25, June 7, 21, July 6, and 21. Visual quality was measured using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 2). Crabgrass control was assessed by making visual estimations of the percentage of crabgrass cover per individual plot. Crabgrass control data were taken on July 6, 21, and August 2 (Table 3). Broadleaf weed control data were taken on May 9, 1996.

Data were analyzed with the Statistical Analysis System version 6.06 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparisons were used to assess CGM effects on bluegrass quality and crabgrass control.

There were no phytotoxic symptoms detected on treated bluegrass. Visual quality was better for bluegrass treated with CGM treatments than for untreated bluegrass (Table 2). Bluegrass receiving a single application at 4 lbs CGM/1000 ft^2, and grass treated with an initial application of 3 lbs CGM/1000 ft^2 plus a sequential of 1 lb CGM/1000 ft^2, exhibited the best quality throughout the season. The best mean visual quality for the season was in bluegrass receiving an initial treatment of 4 lbs CGM/1000 ft^2.

There was less crabgrass in plots treated with corn gluten meal, but the differences among the treatments were not significant due to a high degree of variability among replications. Crabgrass cover was reduced 28, 45, 44, and 54% , when compared with the untreated controls by Treatments 2, 3, 4, and 5, respectively (Table 3).

Table 1. Rates and timing[1] of application of corn gluten meal for the long-term rate crabgrass study started in 1995.

Material	Yearly lbs N/1000 ft^2	Yearly lbs CGM/1000 ft^2	lbs N /1000 ft^2	lbs N /1000 ft^2	lbs N /1000 ft^2	lbs N /1000 ft^2
1. Untreated control	NA	NA	NA	NA	NA	NA
2. Corn gluten meal	4	40	1	1	1	1
3. Corn gluten meal	4	40	2	0	2	0
4. Corn gluten meal	4	40	3	0	1	0
5. Corn gluten meal	4	40	4	0	0	0

[1] Initial applications were made on April 13, sequential applications of Treatment 2 on May 30, Treatments 2, 3, and 4 on August 10, and Treatment 2 on September 21.

Table 2. Visual quality[1] of Kentucky bluegrass treated with powdered corn gluten meal for the long-term rate crabgrass study started in 1995[2].

Material	Yearly lbs N/1000 ft^2	May 12	May 25	June 7	June 21	July 6	July 21	Mean Quality
1. Untreated control	NA	5	6	6	6	6	6	6
2. Corn gluten meal	4	6	7	7	8	7	7	7
3. Corn gluten meal	4	8	8	8	7	7	7	7
4. Corn gluten meal	4	8	9	8	8	8	8	8
5. Corn gluten meal	4	8	9	8	9	9	9	9
$LSD_{0.05}$		1	1	1	1	1	1	1

[1] Visual quality was assessed with a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2] Initial applications were made on April 13, sequential applications of Treatment 2 on May 30, Treatments 2, 3, and 4 on August 10, and Treatment 2 on September 21.

Table 3. Percentage of crabgrass cover in Kentucky bluegrass treated with corn gluten meal for the long-term rate crabgrass study started in 1995[1].

Material	Yearly lbs N/1000 ft^2	Percent crabgrass cover				
		July 6	July 21	August 2	Mean Crabgrass Cover	% Reduction in Crabgrass Cover
1. Untreated control	0	17	28	39	28	0
2. Corn gluten meal	4	10	28	22	20	28
3. Corn gluten meal	4	4	20	22	15	45
4. Corn gluten meal	4	8	22	17	16	44
5. Corn gluten meal	4	5	18	16	13	54
$LSD_{0.05}$		NS	NS	NS	NS	NS

NS = not significantly different at the 0.05 level.
[1] Initial applications were made on April 13, sequential applications of Treatment 2 on May 30, Treatments 2, 3, and 4 on August 10, and Treatment 2 on September 21.

Corn Gluten Meal/Pendimethalin Interaction Study - 1995

David S. Gardner, Nick E. Christians, and Barbara R. Bingaman

Studies conducted at Iowa State University since 1985 have shown that corn gluten meal applied to the soil has an inhibitory effect on the germination and establishment of a variety of weed species. These findings led to the issuance of three U.S. patents and the release of the product called A-MAIZING LAWN for the pre-emergent control of crabgrass in turf. An area of current interest in developing CGM as a herbicide, is whether application, in combination with a sub-lethal rate of a synthetic herbicide, can result in either increased control of crabgrass at the current recommended rate, or a reduction from the recommended rate. The purpose of this study was to investigate the weed control of corn gluten meal combined with sub-lethal rates of the dinitroanaline herbicide, pendimethalin. Three greenhouse studies and a field study were conducted during 1995.

Greenhouse Studies

The studies were conducted in the Iowa State University Horticulture Greenhouses. There were twenty treatments, including the control, that were applied to 4-inch black plastic pots arranged as a randomized complete block design with three rows of pots per block. There were three replications per treatment. The pots were filled with a Nicollet field soil (fine-loamy, mixed, mesic Aquic Hapludoll). The soil surface area within the pots was 10.56 in^2. Each pot was seeded by hand with large crabgrass (1994 ISU Horticulture Farm) at a rate of 0.3 grams per pot. A light coating of topsoil was applied after seeding.

Granular corn gluten meal (Grain Processing, Inc., Muscatine, Iowa) was applied by hand and Pendimethalin (LESCO Pre-M, LESCO, Inc.) dissolved in 2 ml of water was applied using a mist atomizer (DeVilbiss Co., Somerset, PA). There were four rates of corn gluten meal that were combined with five rates of LESCO Pre-M (Table 1). The label rate of LESCO Pre-M is 0.9 to 1.4 oz / 1000 ft^2 (1.5 to 2.25 lbs a.i./1000 ft^2).

Data were collected as counts of living crabgrass plants 28 days after treatment. The data collected from the three experiments were pooled for the analysis . The data were analyzed using the General Linear Models procedure of SAS (version 6.07). The least significant difference (LSD) test was used to compare the treatment means.

In the greenhouse, the sub-lethal rate of pendimethalin was more effective in reducing crabgrass germination than the corn gluten meal. Conditions in the greenhouse mimic those in the field, but there are two important differences between the two that effect the outcome of this study. One, the pendimethalin was applied to bare soil. Since there was no interference due to a thatch layer, much less material was required. Second, is that corn gluten meal was applied at the same time as the crabgrass seed and thus may not have had adequate time to disperse before germination.

Field Study

The field study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa on common Kentucky bluegrass turf. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with a pH of 5.95, an organic matter content of 2.2%, 9.7 ppm P, and 86 ppm K. There were twenty treatments, including the control, that were applied to 5 x 5 ft plots arranged as a randomized complete block design with two rows of ten plots per block and 2 ft barrier rows between blocks. There were three replications per treatment.

Powdered corn gluten meal (Grain Processing, Inc.) was applied on April 13. Pendimethalin (LESCO Pre-M) was applied on April 25 using a carbon dioxide backpack sprayer equipped with #8006 nozzles at 30 psi. There were four rates of corn gluten meal that were combined with five rates of LESCO Pre-M (Table 2).

Data were collected as estimates of percent crabgrass cover on August 10. The data were analyzed using the General Linear Models procedure of SAS (version 6.07). The least significant difference test (LSD) was used to compare the treatment means.

In the field, increasing the rate of corn gluten meal reduced crabgrass cover as much as increasing the rate of Pre-M, suggesting an additive effect when the products are applied in combination. The results suggest that application of 30 lbs of CGM and 0.15 oz Pre-M/1000 ft^2 provides the same control of crabgrass as would either 20 lbs of CGM with 0.31 oz Pre-M/1000 ft^2, or 10 lbs of CGM with 0.46 oz of Pre-M/1000 ft^2. Control using higher rate combinations than these did not differ significantly from that of the three combinations stated above.

Previous studies suggest that corn gluten meal applied alone at 20 lbs/1000 ft^2 provides 40 - 60% control of crabgrass during the first year; that control increases to ≥ 85% in subsequent years. The results of these studies suggest that the applicator can improve control of crabgrass by applying pendimethalin at a sub-lethal rate in addition to corn gluten meal. This may be advantageous to those who wish to use some organic products, but still desire nearly complete control of crabgrass during the first season of corn gluten meal use. In subsequent years, corn gluten meal alone might provide adequate control of crabgrass, or the combination with pendimethalin could be used to provide more effective control.

This was the first year for the field study. Weather conditions during the 1995 growing season were ideal for crabgrass growth which resulted in higher than normal weed pressure. The field study will be repeated in the same location in 1996. A greenhouse study investigating the effects of combining corn gluten meal with sub-lethal rates of other synthetic herbicides used in turf will be conducted in 1996. Results of these studies will be published in the 1997 Iowa Turfgrass Research Report.

Table 1. Percent reduction in crabgrass survival by using different combinations of corn gluten meal and LESCO Pre-M tested in the greenhouse.

CGM Applied	LESCO Pre-M Applied (oz/1000 ft^2)				
(lbs/1000 ft^2)	0	0.15	0.31	0.46	0.61
	Reduction (%)				
0	0	76.0	87.9	80.2	93.7
10	18.7	76.5	81.5	86.5	92.4
20	34.9	72.3	91.6	96.5	92.8
30	52.0	74.2	93.2	96.5	98.4

†$LSD_{0.05, 8 d.f.}$ = 10.5% for differences among all of the treatments

Values given are based on counts of living plants 28 days after treatment.

Table 2. Percent reduction in crabgrass cover from the control by using different combinations of corn gluten meal and LESCO Pre-M tested in the field during 1995.

CGM Applied	LESCO Pre-M Applied (oz/1000 ft^2)				
(lbs/1000 ft^2)	0	0.15	0.31	0.46	0.61
	Reduction (%)				
0	0	5.3	37.7	45.4	42.8
10	14.3	41.6	49.4	68.8	62.3
20	32.5	49.4	74.8	84.4	77.4
30	27.3	80.5	72.7	75.9	94.1

†$LSD_{0.05, 2 d.f.}$ = 28.0% for differences among all of the treatments

Broadleaf and Grass Weeds Control with Corn Gluten Hydrolysate (Greenhouse Study)

Dianna L. Liu and Nick E. Christians

The objective of this study was to evaluate the effects of corn gluten hydrolysate (CGH) on plant survival of 19 monocotyledonous and dicotyledonous plants. The growth medium was prepared by placing soil in three-inch square plastic pots (Belten Plastics, St. Paul, MN) to a surface area of 42.25 cm^2 and a depth of 4 cm. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 6.2%, a pH of 7.73, 62 ppm P, and 229 ppm K.

The eleven mononcotyledonous species were annual bluegrass (*Poa annua* L.), annual ryegrass (*Lolium multiflorum* Lam.), barnyardgrass (*Echinochloa crusgali* (L.) Beauv.), creeping bentgrass (*Agrostis palustris* Huds.), giant foxtail (*Setaria faberi* Herrm.), green foxtail (*Setaria viridis* (L.) Beauv.), large crabgrass (*Digitaria sanguinalis* (L.) Scop.), orchardgrass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), quackgrass (*Agropyron repens* (L.) Beauv.), Yellow foxtail (*Seteria lutescens* (Weigel) Hubb.). The eight dicotyledonous species used in this study were black medic (*Medicago lupulina* L.), buckhorn plaintain (*Plantago lanceolata* L.), common lambsquarters (*Chenopodium album* L.), curly dock (*Rumex crispus* L.), dandelion (*Taraxacum officinale* Weber), purslane (*Portulaca oleracea* L.), redroot pigweed (*Amaranthus retroflexus* L.), velvetleaf (*Abutilon theophrasti* Medic.). The seeding rates used varied from 86 to 130 seeds per pot depending on species. All seeds were planted on the soil surface before powdered CGH was applied. Five rates of CGH at 0, 1, 2, 4, and 8 g/dm^2, ie 0, 20, 40, 80, and 160 lb/1000 ft^2 were applied for each weed species.

All 95 pots were placed on a mist bench for three to seven days depending on the germination rate of a particular species. Once seeds in the untreated control pot reached a stable plant coverage, all pots were moved to a greenhouse bench. Temperature in the greenhouse was maintained in the range of 65 to 90° F. The plants were subjected to drought stress for a period of five days. Plant susceptibility to CGH was assessed by the number of live plants in each pot (Table 1).

The study was replicated three times between February 28 and April 2, 1996. The statistical design was a complete randomized block. Data were analyzed using the Statistical Analysis System (SAS) version 6.09 analysis of variance (ANOVA) procedure to estimate the significance of CGH effects on plant survival. Least significant difference (LSD) tests were used to compare significanly different means.

The CGH reduced the survival of all 19 species at all four application rates compared to the untreated controls. The higher the application rate, the greater the reduction. Buckhorn plaintain, common lambsquarters, creeping bentgrass, and yellow foxtail were the most susceptible species exhibiting > 74% reduction at the lowest tested rate of CGH (20 lb/1000 ft^2). There was no difference in these four application rates for plant survival of buckhorn plaintain, creeping bentgrass, and yellow foxtail. Barnyardgrass, black medic, curly dock, dandelion, giant foxtail, large crabgrass, purslane, and redroot pigweed were the second most susceptible plant species having > 50% reduction in plant survival at 20 lb/1000 ft^2. Annual ryegrass, green foxtail, perennial ryegrass, and quackgrass were the least susceptible species with < 32% reductions at 20 lb/1000 ft^2. At the application rate of 40 lb/1000 ft^2, all 19 species had > 50% reduction in plant survival. Black medic and buckhorn plaintain had 100% reduction in plant survival, and common lambsquarters, creeping bentgrass, curly dock, giant foxtail, orchardgrass, purslane, redroot pigweed, and yellow foxtail had > 84% reduction compared to the untreated control. All species, except annual ryegrass, had 100% control at the highest application rate of 160 lb/1000 ft^2.

Table 1. The effect of corn gluten hydrolysate on the survival of 19 plant species.

Plant species	% Reduction in Plant Survival*			
	1 g/dm^2	2 g/dm^2	4 g/dm^2	8 g/dm^2
Annual bluegrass	45	72	91	100
Annual ryegrass	20	63	79	90
Barnyardgrass	51	75	100	100
Black medic	63	100	100	100
Buckhorn plaintain	95	100	100	100
Common lambsquarters	75	85	100	100
Creeping bentgrass	82	97	100	100
Curly dock	61	89	100	100
Dandelion	48	58	95	100
Giant foxtail	56	86	96	100
Green foxtail	31	53	78	100
Large crabgrass	59	69	94	100
Orchardgrass	44	81	92	100
Perennial ryegrass	31	76	80	100
Purslane	61	92	100	100
Quackgrass	42	81	87	100
Redroot pigweed	69	88	99	100
Velvetleaf	49	77	95	100
Yellow foxtail	82	90	97	100

* The percentage is the degree of reduction in plant survival compared to the untreated control. All the values are the average of 3 replicates. LSD(0.05) = 22%. Data are expressed as percent reduction in plant survival from the control.

The Effects of Common De-icing Chemicals on Turfgrass

David D. Minner and Barbara R. Bingaman

Runoff from de-icing products applied to walkways, driveways, etc. results in damaged and dead turfgrass borders. The purpose of this study is to assess the level of damage caused by several common de-icer products. Our approach was to simulate a brine runoff by spraying salt solution directly on turf plots throughout the winter and evaluating injury during the growing season. In addition, we applied the de-icers in granular form to turf plots.

The first year of this study was conducted in the winter and early spring of 1996 at the Iowa State University Research Station north of Ames, Iowa The experimental plots were in an area of established common Kentucky bluegrass.

Brine solution de-icer study: Individual experimental plots were 2 x 4 ft with three replications. Because of possible de-icer runoff, each individual plot was completely surrounded by a 1 ft border. Treatments containing Potassium chloride, 30% Urea + 70% $CaCl_2$, 50% Urea + 50% $CaCl_2$, 67% Urea + 33% $CaCl_2$, Urea, Rock Salt, Safe Step (50% salt + 50% Potassium Chloride), Magnesium Chloride, and $CaCl_2$ pellets were evaluated. A control was treated with only water for comparison. Treatment rates of 2, 4, and 8 oz/yd^2 were applied nine times during the winter to simulate typical amounts of product used in the ice melt industry (Table 1). This resulted in 18, 36, or 72 oz/yd^2 of total material applied for each treatment. Magnesium chloride is a hydrated salt and was applied at a higher rate (153 oz/yd^2) to account for the extra water. Treatments were randomly placed within each replication. The de-icers were dissolved in water and applied using a carbon dioxide backpack sprayer. TeeJet flat fan EVS #8008, white nozzles were used at 45 psi. Windbreak 'cages' were employed to prevent drift of the materials. No runoff or drift was observed after treatment differences became apparent. Nine applications were made beginning February 22 and ending March 19, 1996. A deer 'cannon' was placed to minimize browsing damage. Turfgrass plugs were taken from each plot in replication 2 after the 5th application of materials. Two plugs were taken for each treatment. The plugs were placed into pots and maintained on a mist bench in the greenhouse until the grass began to green up.

Granular de-icer study: Individual experimental plots were 2 x 2 ft with three replications. Because of possible de-icer runoff, each individual plot was completely surrounded by a 1 ft border. Treatments containing Potassium chloride, 30% Urea + 70% $CaCl_2$, Urea, Rock Salt, Safe Step (50% salt + 50% Potassium Chloride), Magnesium Chloride, and $CaCl_2$ pellets were evaluated. An untreated control was included for comparisons. Treatment rates of 1, 6, and 12 oz/yd^2 were used to simulate typical amounts of product used in the ice melt industry (Table 2). Treatments were randomly placed within each replication. The amount of de-icer products equivalent to 10 individual applications was applied (Table 2). The materials were spread evenly over the plots. The products were applied March 15, 1996. A deer 'cannon' was placed to minimize browsing damage.

Phytotoxicity and percent living plant material data were taken for the both the brine and granular studies on April 10 and May 9 (Tables 1 and 2). Phytotoxicity was assessed using a scale from 10 to 1: 10 = no injury and 1 = foliage completely brown. Percent living material was estimated as the percentage of green plant material per plot. Some of the plots, especially those treated with rock salt, were damaged by deer browsing. In these plots, the remaining plant material was considered to represent the entire plot in the data collection. On April 15, Kentucky bluegrass percent recovery data were taken on the plugs from the brine study that were maintained in the greenhouse. Recovery was assessed using a scale from 10 to 1: 10 = best recovery and 1 = no living plants (Table 1).

Data were analyzed using the Statistical Analysis System (SAS) and the Analysis of Variance procedure. Fisher's least significant difference (LSD) tests were used to compare the effects of the de-icers on turfgrass phytotoxicity and percent living material.

Table 1. Phytotoxicity and percent living green plant material data for field plots and percent Kentucky bluegrass recovery data for plugs from field plots treated with de-icing products for the 1996 De-Icer Study.

				Field Plots						Plugs[3]
				Phytotoxicity[1]			% Living green plant material[2]			
	De-Icer product	Rate oz/yd²	Total applied oz/yd²	April 10	May 9	Mean	April 10	May 9	Mean	% KB Recovery after 5 applications
1	Untreated Control	NA	NA	7.7	9.7	8.7	53	98	76	8
2	30% Urea + 70% $CaCl_2$	2	18	5.7	8.7	7.2	48	97	73	6
3	30% Urea + 70% $CaCl_2$	4	36	2.7	3.0	2.8	20	26	23	3
4	30% Urea + 70% $CaCl_2$	8	72	1.0	1.0	1.0	0	1	1	2
5	50% Urea + 50% $CaCl_2$	2	18	5.0	6.0	5.5	40	83	62	9
6	50% Urea + 50% $CaCl_2$	4	36	1.7	1.3	1.5	3	1	2	5
7	50% Urea + 50% $CaCl_2$	8	72	1.0	1.0	1.0	0	1	1	1
8	67% Urea + 33%% $CaCl_2$	2	18	2.3	3.0	2.7	8	22	15	8
9	67% Urea + 33%% $CaCl_2$	4	36	1.0	1.0	1.0	0	1	1	4
10	67% Urea + 33%% $CaCl_2$	8	72	1.0	1.0	1.0	0	1	1	1
11	KCl	2	18	5.0	7.7	6.3	28	88	58	9
12	KCl	4	36	2.0	3.3	2.7	3	27	15	1
13	KCl	8	72	1.0	1.0	1.0	0	1	1	3
14	Urea	2	18	1.7	1.3	1.5	3	2	3	3
15	Urea	4	36	1.0	1.0	1.0	0	1	1	1
16	Urea	8	72	1.0	1.0	1.0	0	1	1	1
17	Rock Salt	2	18	5.0	7.0	6.0	25	82	53	7
18	Rock Salt	4	36	1.7	1.7	1.7	3	12	8	1
19	Rock Salt	8	72	1.0	1.0	1.0	0	1	1	1
20	Safe Step	2	18	4.7	7.7	6.2	28	82	55	8
21	Safe Step	4	36	2.3	4.3	3.3	8	55	32	6
22	Safe Step	8	72	1.0	1.0	1.0	0	1	1	1
23	Mg Cl_2 (47% a.i.)	4	39	2.7	5.0	3.8	8	57	33	3
24	Mg Cl_2 (47% a.i.)	9	77	1.3	1.0	1.2	0	1	1	3
25	Mg Cl_2 (47% a.i.)	17	153	1.0	1.0	1.0	0	1	1	1
26	$CaCl_2$ pellets	2	18	4.0	7.7	5.8	27	93	60	5
27	$CaCl_2$ pellets	4	36	1.7	2.7	2.2	2	24	13	1
28	$CaCl_2$ pellets	8	72	1.0	1.0	1.0	0	1	1	1
	$LSD_{0.05}$			0.9	1.2	0.9	9	17	11	nonreplicated

[1]Phytotoxicity was assessed using a scale from 10 to 1 with 10 = no injury and 1 = foliage completely brown.

[2]Percent living plant material was assessed as percentage of green per plot.

[3]Plugs were taken from Rep 2 on 3/14/96 after 5 treatment applications. Percent recovery was assessed using a scale from 10 to 1 with 10 = best recovery and 1 = no living plants.

Table 2. Phytotoxicity and percent living green plant material data for field plots treated with de-icing products for the 1996 Granular De-Icer Study.

	De-Icer product	Rate oz/yd[2]	Total applied oz/yd[2]	Phytotoxicity[1]			% Living green plant material[2]		
				April 10	May 9	Mean	April 10	May 9	Mean
1	Untreated Control	NA	NA	7.7	9.7	8.7	43	100	72
2	30% Urea + 70% $CaCl_2$	1	126	6.0	10.0	8.0	37	100	68
3	30% Urea + 70% $CaCl_2$	6	756	1.3	1.0	1.2	2	1	1
4	30% Urea + 70% $CaCl_2$	12	1512	1.3	1.0	1.2	1	1	1
5	KCl	1	126	6.3	9.0	7.7	27	95	61
6	KCl	6	756	1.3	1.3	1.3	2	2	2
7	KCl	12	1512	1.0	1.0	1.0	0	1	1
8	Urea	1	126	3.3	3.0	3.1	10	42	26
9	Urea	6	756	1.0	1.0	1.0	0	1	1
10	Urea	12	1512	1.0	1.0	1.0	0	1	1
11	Rock Salt	1	126	5.0	9.3	7.2	22	97	59
12	Rock Salt	6	756	1.0	1.0	1.0	0	1	1
13	Rock Salt	12	1512	1.0	1.0	1.0	0	1	1
14	Safe Step	1	268	5.7	8.7	7.2	27	95	61
15	Safe Step	6	1609	1.0	1.3	1.2	0	1	1
16	Safe Step	12	3217	1.0	1.0	1.0	0	1	1
17	Mg Cl_2 (47% a.i.)	1	126	3.7	6.0	4.8	10	85	48
18	Mg Cl_2 (47% a.i.)	6	756	1.0	1.0	1.0	0	1	1
19	Mg Cl_2 (47% a.i.)	12	1512	1.0	1.0	1.0	0	1	1
20	$CaCl_2$ pellets	1	126	5.7	8.3	7.0	22	97	59
21	$CaCl_2$ pellets	6	756	1.0	1.3	1.2	0	1	1
22	$CaCl_2$ pellets	12	1512	1.0	1.0	1.0	0	1	1
	$LSD_{0.05}$			1.2	0.9	0.8	3	6	5

[1]Phytotoxicity was assessed using a scale from 10 to 1 with 10 = no injury and 1 = foliage completely brown.
[2]Percent living plant material was assessed as percentage of green plant material per plot.

Rubber Tire Particles as a Topdressing Amendment for High Traffic Grass

David D. Minner

The rubber tire recycling industry produces several grades, sizes, and shapes of processed rubber. All recycled rubber is not the same. Suitable materials for athletic field use must be free of all metal fibers and slivers, and must be of a size that is compatible with hollow coring and can easily filter into the turf canopy. Some rubber particles may contain nylon strands from "cord reinforced tires". It is doubtful that the nylon will limit plant growth, however, the effect of the nylon on water retention and plant growth is not known. To ensure a consistent rubber product only a trace of nylon should be present.

There are two distinct sources for rubber at this time. One is crumb rubber that comes from chipping whole tires, and the other is rubber buffings that comes from the retread industry when tire treads are ground before recapping. Processing and distribution of crumb rubber is more advanced at this time and commercial rubber materials are available in the 1/4 inch and 2 mm (.08 in) size. The "coarse crumb" and "medium crumb" materials used in this study are from the tire chipping and screening process (Table 1.). There has been very little effort in commercially producing screened rubber buffings for turf use. Consequently, this product is usually given away for the price of shipping. "Buffings" are shreds of rubber that are ground directly from the intact tire before it is recapped with a new tread. Buffings have no metal or nylon cord since only the rubber tread is recycled. The particles range in size from 2 inches to 0.25 mm (about the size of medium sand). Smaller particles are rounded but many are shreds that have a length to width aspect ratio of approximately 5:1. Two buffing products have been screened for use in this study (Table 1.)

A study was initiated in May, 1995 at the Iowa State University Horticulture Research Station, north of Ames, Iowa to evaluate various sizes of "crumb" and "buffing" rubber for use as a topdressing material on high traffic grass areas. The purpose of this study was to determine the maximum amount of rubber that can be applied without causing reduced grass performance. On 6 May 1995 a mature stand of 'Midnight' Kentucky bluegrass was mowed at a 1/2-inch height to remove most of the grass blades and then solid tine cored on 3-inch centers with 1/2-inch tines. All topdressing materials were then hand spread and raked into the plots that consisted of grass stubble and core holes. The sand topdressing and the non-treated control plots also received the same preparation of mowing and coring.

Our interest is the longer term effect on grass performance as rubber accumulates in the surface mat and top two inches of soil. Our proposed application rate of 1.5 inches could not be accomplished in the first year. The maximum amount of material that we felt could be applied was 0.75 inches. We plan on using a larger (3/4-inch) hollow tine to incorporate more rubber in 1996. Traffic treatments will also begin in the spring of 1996.

One of the more interesting effects from rubber was noted on frozen ground. On 9 March 1996 sand topdressing and the no rubber control treatment produced a significantly harder surface (Gmax of 349 and 241, respectively, with the 2.25 kg hammer) compared with the high rate of rubber topdressing (Gmax of 107 to 116 for the 0.75-inch rubber topdressing treatments).

Table 1. Particle size analysis for sand, crumb rubber, and buffings rubber used as topdressing.

Size	Sieve Mesh	Diameter mm	Sand	Coarse Crumb	Medium Crumb	Medium Buffing	Course Buffing
Gravel	1/4 in	6.3	0.0	0.0	0.0	0.0	0.0
Fine Gravel	10	2.0	0.4	85.0	23.7	4.5	13.9
Very Coarse	18	1.0	1.5	13.4	56.6	50.6	79.9
Coarse	35	0.5	17.2	0.5	9.1	35.1	6.1
Medium	60	0.25	55.7	0.4	7.1	7.7	0.1
Fine	100	0.15	19.1	0.1	2.4	1.6	0.0
Very Fine	<100	<0.15	4.2	0.1	1.0	0.3	0.1

Table 2. Treatment schedule for various "crumb" and "buffing" rubber materials applied as topdressing to a mature stand of 'Midnight' Kentucky bluegrass.

Treatment	Proposed Rate (in.)	Amount Applied May 6, 1995 (in.)	Amount Applied Sept. 11, 1995 (in.)	Total As Of May 1, 1996 (in.)
1. Coarse crumb	0.75	.38	--	.38
2.	1.50	.38	.37	.75
3. Medium crumb	0.75	.38	--	.38
4.	1.50	.38	.37	.75
5. Medium buffing	0.75	.38	--	.38
6.	1.50	.38	.37	.75
7. Coarse buffing	0.75	.38	--	.38
8.	1.50	.38	.37	.75
9. Sand	1.50	.38	.37	.75
10. Control	--	--	--	--

Table 3. Surface hardness data from 0.05 and 2.25 kg hammers for various rubber particle topdressing treatments.

	Treatment Source	Rate (in)	0.05 kg Hammer				2.25 kg Hammer		
			9/22/95	3/9/96*	3/12/96	4/17/96	3/9/96*	3/12/96	4/17/96
1.	Coarse crumb	0.38	66	148	101	67	185	86	54
2.	Coarse crumb	0.75	55	109	78	63	110	75	47
3.	Medium crumb	0.38	68	165	110	67	200	89	54
4.	Medium crumb	0.75	60	126	83	60	116	80	50
5.	Medium buffing	0.38	64	129	100	60	192	100	53
6.	Medium buffing	0.75	56	121	80	57	107	86	50
7.	Coarse buffing	0.38	69	113	107	66	185	94	54
8.	Coarse buffing	0.75	61	104	84	60	112	85	55
9.	Sand	0.75	74	370	102	77	349	65	59
10.	Control	--	74	162	115	63	241	110	55
	$LSD_{(0.05)}$		5	56	12	8	65	NS	4

*Frozen ground conditions.

Table 4. Turf color, grass quality, cushion, percentage sand topdress or rubber showing, and grass density for Kentucky bluegrass topdressed with various rubber materials on 22 September 1995.

	TreatmentSource	Rate (in)	Grass color[1]	Grass quality[2]	Cushion[3]	% Topdress or rubber showing[4]	Grass density[5]
1.	Coarse crumb	.38	8.0	8.7	5.7	0.0	8.0
2.	Coarse crumb	.75	8.3	9.0	9.3	5.0	8.3
3.	Medium crumb	.38	6.7	7.7	5.0	0.0	8.3
4.	Medium crumb	.75	8.7	8.7	9.7	3.3	8.3
5.	Medium buffing	.38	8.7	9.3	7.3	0.0	8.7
6.	Medium buffing	.75	8.3	8.7	9.3	8.3	8.3
7.	Coarse buffing	.38	8.7	9.7	6.7	0.0	8.7
8.	Coarse buffing	.75	6.7	7.3	10.0	23.3	7.3
9.	Sand	.75	9.0	8.0	4.0	15.0	8.0
10.	Control	--	8.7	9.3	5.3	0.0	9.3
	$LSD_{(0.05)}$		NS	NS	0.7	10.5	NS

[1]Grass color was rated using a 10 to 1 scale: 10 = darkest green.
[2]Grass quality was rated using a 10 to 1 scale: 10 = best quality.
[3]Cushion was rated on a 10 to 1 scale: 10 = most cushion.
[4]Percent topdress or rubber showing was recorded as % of plot.
[5]Grass density was rated using a 10 to 1 scale: 10 = highest density.
NS = not significantly different at the 0.05 level.

Growth and Development of Three Container-grown Deciduous Shrubs Started from Bare-root and Potted Liner Stock

Jeffery K. Iles

Background and Justification

Rewholesalers, garden centers, and other sellers of woody ornamental plants routinely receive bare-root nursery stock in late winter or early spring that is potted and sold later in the season. But bare-root plants are sometimes slow to establish in containers which makes transplanting difficult, particularly when sold during the busy spring and early summer months. Potted liners that come with well-developed root systems show potential for shortening the production cycle, permitting the development of higher quality plants with better developed root systems sooner in the season. Anecdotal reports describing superior growth and improved visual quality of containerized potted liners abound, however, no scientific studies comparing potted liners potted into containers vs. conventional bare-root/container-grown stock have been conducted.

Objective

(1) Monitor shoot and root growth of three woody shrub species as influenced by nursery stock type and size, and container size, throughout two growing seasons.

Materials and Methods

The study was designed as a randomized complete block with three replications. In April, 1996, bare-root and potted liner plants of *Cornus sericea* `Cardinal', *Spiraea* x *bumalda* `Goldflame', and *Syringa* x *prestoniae* `James MacFarlane' were obtained from Sherman Nursery Co., Charles City, Iowa, and potted as described below:

Cornus sericea `Cardinal'	*Spiraea* x *bumalda* `Goldflame'	*Syringa* x *prestoniae* `James MacFarlane'
3 1/2" potted liner	3 1/2" potted liner	3 1/2" potted liner
(12 into 2 gal. containers)	(12 into 2 gal. containers)	(12 into 2 gal. containers)
(12 into 3 gal. containers)	(12 into 3 gal. containers)	(12 into 3 gal. containers)
4-6" bare-root	6-9" bare-root	4-6" bare-root
(12 into 1 gal. containers)	(12 into 1 gal. containers)	(12 into 1 gal. containers)
(12 into 2 gal. containers)	(12 into 2 gal. containers)	(12 into 2 gal. containers)
6-12" bare-root	9-12" bare-root	6-12" bare-root
(12 into 2 gal. containers)	(12 into 2 gal. containers)	(12 into 2 gal. containers)
(12 into 3 gal. containers)	(12 into 3 gal. containers)	(12 into 3 gal. containers)

Plant height and width, and shoot and root dry weights will be taken from representative samples on 1 June and September, 1996, and 1 June and September, 1997.

Effect of Several Organic and Inorganic Mulches on Tree Growth and Soil Properties

Jeffery K. Iles

Background and Justification

Mulching ornamental plants in the landscape with organic materials is enthusiastically endorsed and practiced by many green industry professionals. Yet several actual or perceived problems associated with the use of mulch (unacceptable appearance, lack of stability, potential fire hazard, rapid decomposition, etc.) have prompted many to use inorganic or synthetic mulches. But fears that materials like rock, gravel, and crushed brick may cause potentially injurious high temperatures both above and below inorganic mulches, alkalinization of the soil, and mechanical injury to the stems of plants have caused many landscape and tree-care professionals to question the use of these and other inorganic materials. To date, there have been no studies that have directly compared the effects of inorganic and organic mulches on tree growth and associated soil properties.

Objective

(1) To evaluate and compare the effects of inorganic and organic mulches on several soil properties and growth of two tree species.

Materials and Methods

Bare-root, 4 to 6-foot branched *Acer rubrum* `Fairview Flame′ and *Tilia cordata* `Olympic′ were planted at the Iowa State University Horticulture Research Station in April, 1996. The experimental design was a completely randomized block with five replications. Mulch treatments (wood chips, shredded bark, pea gravel, crushed brick, and 1 1/2 inch river rock) 3 inches deep and in 5-foot squares around each tree, and an unmulched weed-free control, were randomly assigned to each tree species in each block. Organic mulches were placed directly on bare ground while inorganic mulches were underlaid with spunbonded polypropylene fabric. Tree growth measurements (shoot growth and caliper) will be taken in September 1996 and 1997. Soil moisture, pH, and temperature will be monitored weekly (during the growing season) in 1996 and 1997.

This study was funded in part by a grant from the International Society of Arboriculture.

Effect of Post-frost Pruning on Winter Hardiness of Selected Garden Chrysanthemums

Jeffery K. Iles

Background and Justification

Pruning aboveground tissues back to the plant crown in preparation for winter is a common cultural practice for garden chrysanthemums (*Dendranthema* x *grandiflorum*). But some landscape managers suggest pruning immediately before the onset of low temperatures may be responsible for predisposing plants to winter injury. In fact, researchers in Germany found several species of garden chrysanthemums suffered considerable winter injury if they were "cut back" in late fall. Unfortunately, additional data, either concurring or disagreeing with the study in Germany, are not available. Therefore, this research sought to ameliorate the information deficit by testing the cultural practice of pruning back garden chrysanthemums to the ground before the onset of low winter temperatures.

Objective

(1) To evaluate the effect of pruning nineteen species of garden chrysanthemums in November and December on winter survival.

Materials and Methods

Rooted cuttings of nineteen chrysanthemum cultivars were obtained from Yoder Brothers, Inc., and field-planted in a randomized complete block design with five replications on 1 June, 1995. Pruning treatments were: (1) plants pruned to 1" above the crown on 1 November, 1995; (2) plants pruned to 1" above the crown on 1 December, 1995; and (3) plants not pruned. Survival percentages and regrowth dry weights will be taken 1 June, 1996.

Chrysanthemum Cultivars Used in the Study

`Baby Tears´
`Barbara´
`Bravo´
`Christine´
`Dark Triumph´
`Debonair´
`Donna´
`Grenadine´
`Goldmine´
`Jennifer
`Jessica´
`Linda´
`Lynn´
`Megan´
`Raquel´
`Shelly´
`Target´
`Tracy´
`Triumph´

Does Premature Branch Removal and Improper Pruning Predispose Trees to Sunscald Injury?

Jeffery K. Iles

Background and Justification

Sunscald, occurring in both summer and winter, has been reported as a major problem for shade trees in northern locations. Thin- and/or smooth-barked deciduous tree species such as birch, maple, linden, ash, and crabapple seem to be most susceptible, however, sunscald has even been reported on some evergreen species. Numerous materials have been tested and used to prevent sunscald injury in the Midwest. But lately, researchers in the Eastern United States have recommended the practice of trunk wrapping be discontinued. Their reasons for this decision are: (1) wraps prevent photosynthetic tissues in the bark of young trees from trapping the sun's energy, thereby reducing the trees ability to manufacture sugars and other important compounds; (2) wraps placed over wounds and improperly pruned branches create unnaturally moist conditions that encourage fungal and bacterial growth on these wounds; (3) if left in place too long, they may girdle and injure the trunk; (4) the cozy environment created by wraps may actually encourage insect activity; and (5) they are unsightly if installed and then forgotten. In addition, there is very little scientific evidence showing trunk wraps prevent sunscald injury. However, climatic conditions during winter in the Eastern U.S. are dramatically different than conditions in the Midwest where higher light intensities, and rapidly changing temperatures seem to favor the incidence of sunscald. Therefore Midwesterners have been reluctant to abandon the practice of trunk wrapping. Some theorize that regardless of whether a tree is wrapped or not, careless acts or ill-advised tree care practices like wounding, flush-cut pruning, and/or removing too many branches, particularly those lower branches along the trunk, at time of planting can predispose trees to sunscald injury. Unfortunately, studies have not been conducted that would help the landscape manager make informed decisions about how to prevent sunscald injury.

Objective

(1) To evaluate the effects of premature branch removal and flush-cutting on incidence of sunscald injury on two tree species.

Materials and Methods

Bare-root, 4 to 5 foot branched *Acerx freemanii* 'Armstrong' and *Tilia cordata* 'June Bride' were planted at the Iowa State University Horticulture Research Station in April, 1996. The experimental design was a completely randomized block with five replications. Treatments were randomly assigned to each tree species in each block and were: (1) lowest pair of branches removed at planting using recommended pruning practices; (2) lowest and next lowest pair of branches removed at planting using recommended pruning practices; (3) lowest pair of branches removed at planting using flush-cut technique; (4) lowest and next lowest pair of branches removed at planting using flush-cut technique; and (5) no pruning done at planting. Tree height, trunk diameter, and shoot growth measurements will be taken on 1 September 1996 and 1997, and trees will be continuously monitored for evidence of sunscald injury.

Elms on the Comeback Trail

Jeffery K. Iles

Introduction

Dutch elm disease (DED) caused by the fungus *Ophiostoma ulmi*, is one of the most destructive plant diseases of the 20th century, and it remains a threat to American elms (*Ulmus americana*) even today. From the initial stand of infected trees in the Ohio River Valley in 1932, the disease spread outward at a rate of about 50 miles per year. And by the mid-1980's, the disease that became known as "the cancer of the tree world" had left its devastating calling card in practically all of the United States and southern Canada.

Countless hours and dollars have been spent protecting existing American elms and developing effective strategies and techniques to control DED in North America and Europe. Proven or potentially useful DED control measures include: (1) eliminating breeding sites for the predominant vector of DED, the European elm bark beetle (*Scolytus multistriatus*), (2) reducing beetle populations with well-timed insecticide applications or by attracting beetles to "trap trees" treated with herbicide, and (3) preventing infection through the use of injected fungicides, or injecting the natural bacterium *Pseudomonas syringae* which is antagonistic to the fungus causing DED. But because of growing anti-pesticide (synthetic or naturally-occurring) sentiment, and/or the prohibitive cost of implementing many of the aforementioned control strategies, researchers have redirected their efforts to developing disease tolerant or resistant elms. European and Asiatic elms have played a significant role in the breeding, selection, and cultivar release efforts, but recently greater emphasis has been given to breeding and selecting American elms. The goal of finding or creating a disease tolerant American elm seemed improbable 20 years ago, but hopes have been revived with the release by the USDA of two cultivars showing high levels of DED tolerance.

New American Elm Cultivars

The new American elm cultivars, **`Valley Forge´** and **`New Harmony´**, are products of the U.S. National Arboretum tree genetics program and have demonstrated high levels of tolerance to both aggressive and non-aggressive strains of the fungus causing Dutch elm disease. Tolerance to DED is characterized by reduced wilting and crown dieback after fungal inoculation. In fact, according to Dr. Denny Townsend, these trees have the ability to recover from DED infection even after symptom expression. But it is important to remember that neither tree is completely immune to DED.

Of the thousands of American elms screened, `Valley Forge´ has shown the best tolerance to DED. The tree has an upright, arching, broadly vase-shaped branching structure with a full, dense canopy of leaves. Asexually produced progeny from the original parent tree are 26 feet tall with an average crown spread of 30 feet after 12 growing seasons. Summer leaves are green, turning yellow in autumn. The bark is typical of the species, with grayish, flat-topped ridges separated by diamond-shaped fissures. `Valley Forge´ is considered hardy in USDA zones 5 through 7.

While not as disease tolerant as `Valley Forge´, `New Harmony´ still ranks in the top three among the thousands of American elms subjected to intensive inoculation with the DED fungus. The parent tree of `New Harmony´ displays a broad, vase-shaped crown and has grown approximately 68 feet tall and 72 feet wide. Leaf and bark characteristics are similar to those of `Valley Forge´, but because of its acceptable performance in Minnesota, `New Harmony´ is considered hardy in USDA zones 4 through 7.

The combination of environmental adaptability, Dutch elm disease tolerance, and highly-prized vase-shaped crown will make these selections extremely popular, however, it will probably take a number of years before these trees become commonplace in nurseries and retail garden centers. In the meantime, tree managers should consider the many commercially available hybrid elms for augmenting and diversifying the municipal tree population. Some of the more important introductions are described in the following paragraphs.

Hybrid Elm Selections

`Accolade´ (*Ulmus japonica* x *Ulmus wilsoniana*) - Also known as Thornhill elm, this hybrid was released by the Morton Arboretum, Lisle, Illinois. The tree displays a handsome vase-shaped canopy, deep green glossy leaves, has shown resistance to DED, elm leaf beetle, and leaf miner, but only moderate tolerance of urban soil conditions such as clayiness and seasonal wetness.

**`Cathedral´** (*Ulmus pumila* x *Ulmus japonica*) - One of several excellent cultivars developed by Smalley and Lester at the University of Wisconsin. `Cathedral´ has demonstrated good tolerance to DED, experiencing only branch tip injury when infected with the fungus. The tree has a broad vase shape, medium to light green leaves in summer and yellow fall foliage. In addition, `Cathedral´ is highly tolerant to *Verticillium* wilt and is resistant to attack by the elm leaf miner.

**`Frontier´** (*Ulmus carpinifolia* x *Ulmus parvifolia*) - Released in 1990 by the USDA, `Frontier´ has demonstrated a high degree of resistance to DED, moderate resistance to elm leaf beetle, and high tolerance to the phytoplasma-caused elm yellows. Emerging leaves in spring are red, gradually changing to yellow-green in summer, finally turning red-purple in autumn. `Frontier´ becomes pyramdial instead of vase-shaped as it matures, however, it still should make a desirable street, park, landscape, or highway tree. Because it has sustained severe low temperature injury in Minnesota, `Frontier´ is considered reliably hardy only through USDA hardiness zone 5.

**`Homestead´** (*Ulmus pumila* x complex hybrid from the Netherlands elm breeding program) - Another USDA release, `Homestead´ has a symmetrical, somewhat pyramidal crown that becomes arching as the tree ages. Its dark green summer leaves turn golden-yellow in fall and the growth rate is reportedly rapid. `Homestead´, best used in USDA hardiness zones 5 through 8, is considered highly resistant to DED, but is susceptible to elm leaf beetle.

**`Independence´** (*Ulmus americana* `Moline´ x *Ulums americana* W 185-21) - `Independence´ is one of six clones that comprise the much heralded American Liberty multiclone variety. Patented by Smalley and Lester (Univ. of Wisconsin, Madison), `Independence´ develops an upright, vase-shaped crown typical of the species and has demonstrated tolerance to DED, but may be quite susceptible to elm yellows.

**`Patriot´** (*Ulmus* `Urban´ x *Ulmus wilsoniana* `Prospector´) - Developed by A.M. Townsend at the U.S. National Arboretum and released by the USDA, `Patriot´ has a moderately vase-shaped crown, resembling a more upright American elm. It has shown a high level of resistance to DED, high tolerance to elm yellows, and reduced susceptibility to the elm leaf beetle. `Patriot´ is adapted to a wide variety of soil conditions, grows best in full sun, and is considered cold hardy through USDA hardiness zone 4.

**`Pioneer´** (*Ulmus glabra* x *Ulmus carpinifolia*) - `Pioneer´ is a vigorous, fast-growing USDA selection with large, dark green leaves and a globe-shaped crown. Hardy in USDA zones 5 through 8, it has proven resistant to DED and elm yellows, but elm leaf beetle feeding may be problematic. Because of its broad, spreading habit, `Pioneer´ is best suited to spacious grounds like those found in parks, golf courses, and large commercial properties.

**`Prospector´** (*Ulmus wilsoniana*) - This seedling selection was released in 1990 by the USDA. `Prospector´ elm has an American elm-like vase-shaped crown but its branches become pendulous at a much lower height. Newly expanding leaves are orange-red, but gradually darken to green, finally turning yellow in autumn. `Prospector´ is resistant to DED, tolerant to elm yellows, resistant to elm leaf beetle, and is considered adaptable in USDA hardiness zones 4 through 7.

**`Regal´** (*Ulmus* `Commelin´ x *Ulmus* `Hoersholmiensis´) - Selected at the University of Wisconsin, `Regal´ develops a strong central leader with an upright or columnar growth habit when young, becoming more ovate with age. Leaves are dark green in summer, show no appreciable fall coloration, and because they are rather sparsely borne, cast a honeylocust-like light shade that makes possible the successful culture of turfgrass in the vicinity of the tree. `Regal´ is considered highly resistant to DED and *Verticillium* wilt, and is hardy in USDA zones 4 through 7.

**`Sapporo Autumn Gold´** (*Ulmus pumila* x *Ulmus japonica*) - Released by the University of Wisconsin in 1973, this elm has demonstrated high resistance to DED and tolerance to *Verticillium* wilt. `Sapporo Autumn Gold´ displays vigorous growth, is quite tolerant of urban stresses, and can be utilized in USDA hardiness zones 4 through 8. The tree is upright and irregular when young, becoming somewhat vase-shaped with age. And as the cultivar name suggests, autumn leaves are handsome golden-yellow.

Over the past 30 to 40 years, plant breeders have spent considerable time, effort, and resources searching for elms having resistance to DED and other pests, and possessing the graceful crown architecture of the revered American elm. The recent release of *Ulmus americana* `Valley Forge´ and `New Harmony´, and the improved availability of many excellent hybrid elms is certain to spark renewed interest for elms of all kinds. But those responsible for making tree selection decisions must temper their understandable enthusiasm for these and future elm introductions. Establishing large-scale monocultures or overusing any tree species would be a tragic and ill-advised repeat of history.

Introducing

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