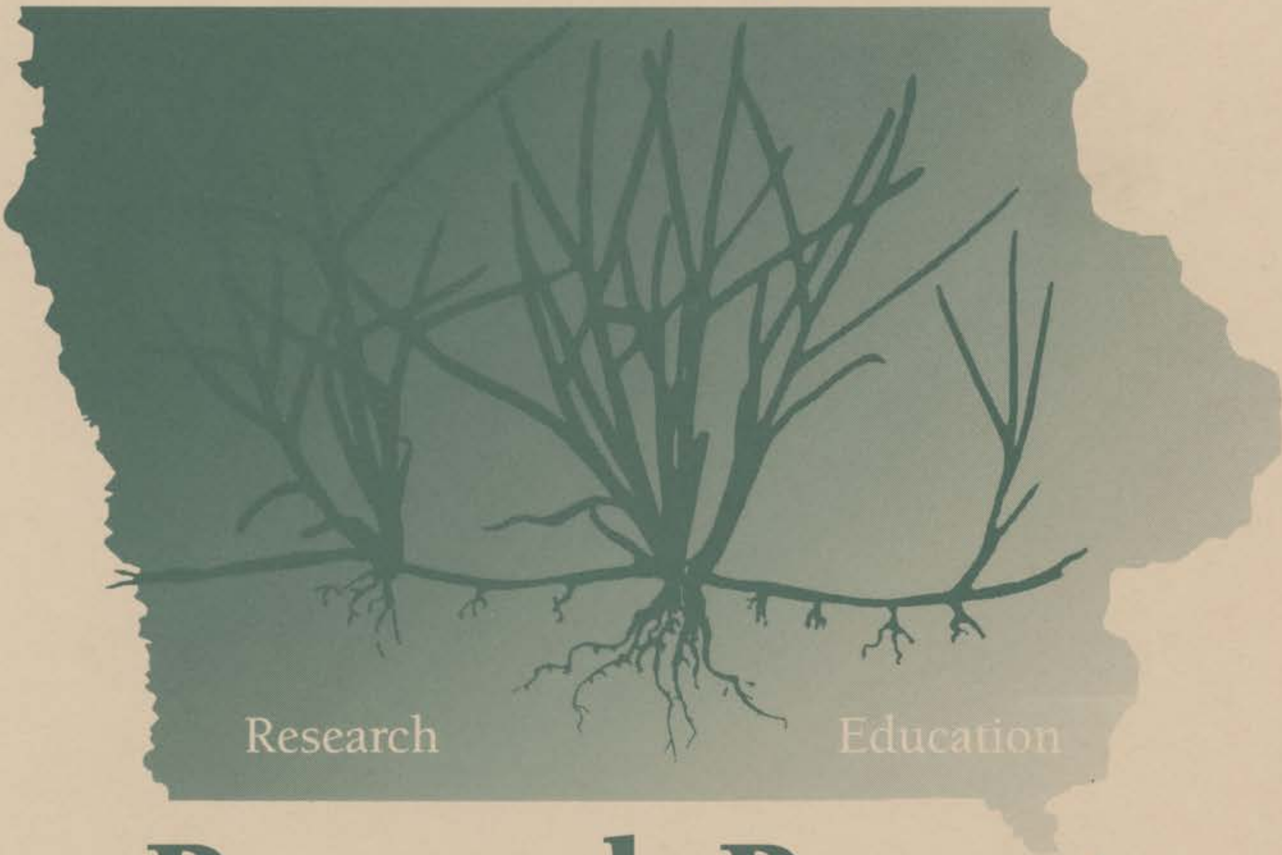
1997

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-465 | July 1997

Welcome to the Iowa Turfgrass Field Day

August 14, 1997

Sponsored by:
Department of Horticulture
Cooperative Extension
Iowa State University
and
Iowa Turfgrass Institute

Field Day Program

9:15 a.m. **Introductory Remarks** - Registration Tent

9:30 a.m. **CHOICE OF TWO TOURS**

Tour #1 **Tour Research Plots --**

1. **Trouble Shooting Clinic** -- Dr. Donald Lewis and Ms. Paula Flynn
2. **Tree Care** -- Dr. Jeff Iles
3. **Rubber Topdressing** -- Mr. Jeff Salmond
4. **Dollar Spot Trial** -- Dr. Mark Gleason
5. **Tall Fescue NTEP Variety Trials** -- Mr. Jim Dickson
6. **Herbicide Trials** -- Dr. Nick Christians
7. **Fertilizer Trials** -- Dr. Barbara Bingaman
8. **Shade Trial** -- Dr. Mohamad Khan

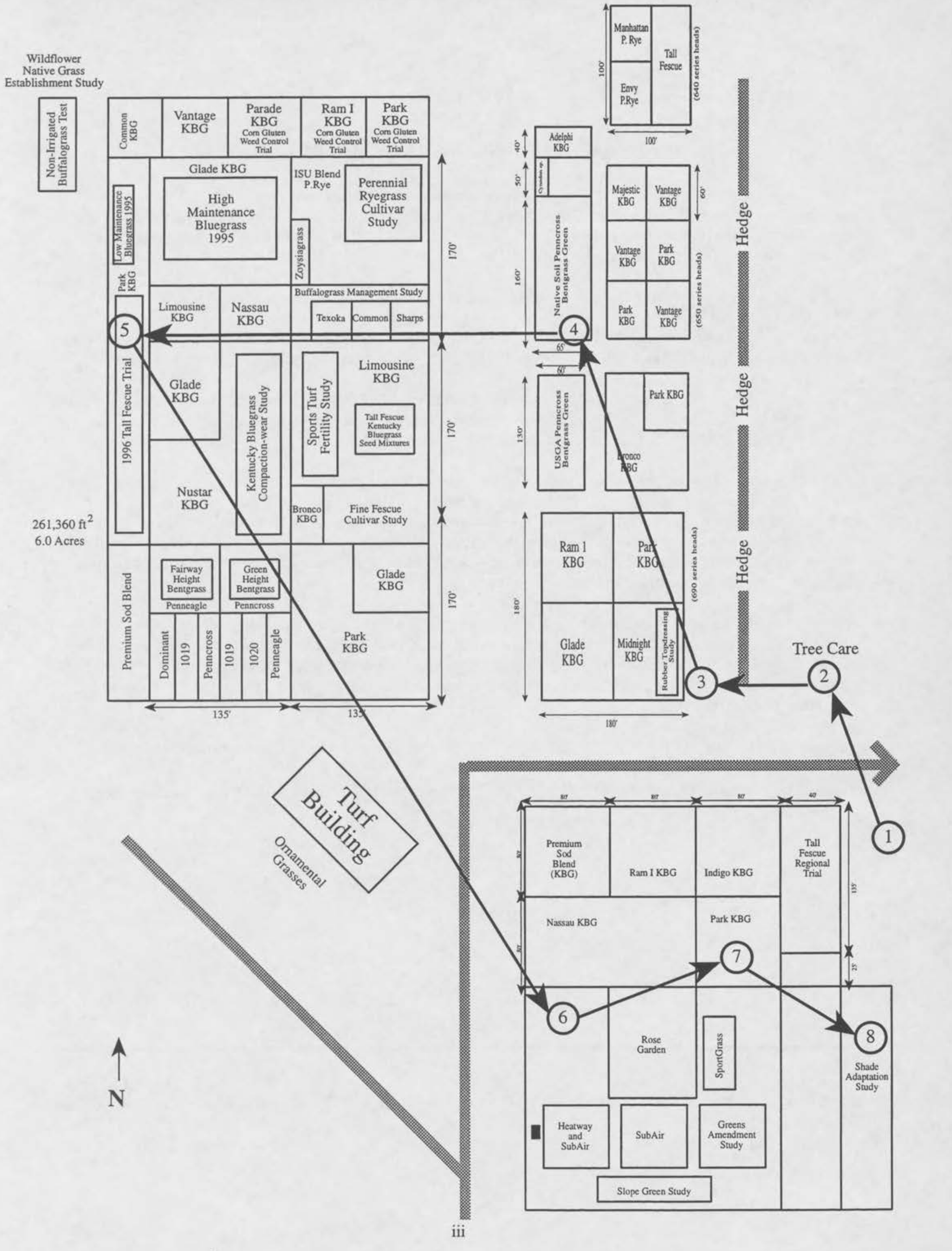
Tour #2 **Golf Course Superintendent & Sports Turf Manager Tour --**
Dr. Dave Minner and Mr. Gary Peterson

This tour highlights the following research and demonstration areas:
-SubAir demonstration - rootzone temperature control with air and circulated water
-Topdressing with rubber to reduce turf damage under intense traffic (Mr. Jeff Salmond)
-SportGrass - a combination of synthetic turf and real grass
-Sloped green study - IGCSA and GCSAA project
-Sand green amendment study (Dr. Young Joo)
-Fertility for establishing bentgrass on sand-based greens (Mr. Mike Faust)
-High-traffic Kentucky bluegrass variety trial
-NTEP bentgrass variety trial - putting green and fairway.

12:00 noon **Lunch and Visit with Exhibitors**

1:30 p.m. **Educational Sessions and Demonstrations**

- **Pesticide Recertification Cont. Ed. Course (2 hours)** -- Main Building
- **Natural Herbicide Research Update** -- Dr. Nick Christians
- **Turf I.D. and Weed, Disease & Insect Control Tour** -- Dr. Dave Minner
- **Equipment Demonstration** -- Equipment Display Area -- Mr. Jim Dickson
- **SubAir Demonstration** --Mr. Jeff Salmond


Wildflower Native Grass Establishment Study
Non-Irrigated Buffalograss Test
Common KBG
Vantage KBG
Parade KBG Corn Gluten Weed Control Trial
Ram I KBG Corn Gluten Weed Control Trial
Park KBG Corn Gluten Weed Control Trial
Glade KBG
High Maintenance Bluegrass 1995
ISU Blend P.Rye
Perennial Ryegrass Cultivar Study
Low Maintenance Bluegrass 1995
Zoysiagrass
Park KBG
Buffalograss Management Study
Limousine KBG
Nassau KBG
Texoka
Common
Sharps
1996 Tall Fescue Trial
Glade KBG
Kentucky Bluegrass Compaction-wear Study
Sports Turf Fertility Study
Limousine KBG
Tall Fescue Kentucky Bluegrass Seed Mixtures
Nustar KBG
Bronco KBG
Fine Fescue Cultivar Study
261,360 ft²
6.0 Acres
Premium Sod Blend
Fairway Height Bentgrass
Penneagle
Green Height Bentgrass
Penncross
Glade KBG
Dominant
1019
Penncross
1019
1020
Penneagle
Park KBG
170'
170'
170'
135'
135'
Manhattan P. Rye
Envy P.Rye
Tall Fescue
100'
100'
(640 series heads)
Adelphi KBG
40'
50'
Cynodon sp.
160'
Native Soil Penncross Bentgrass Green
Majestic KBG
Vantage KBG
Vantage KBG
Park KBG
Park KBG
Vantage KBG
60'
(650 series heads)
65'
60'
130'
USGA Penncross Bentgrass Green
Park KBG
Bronco KBG
Hedge
Hedge
Hedge
180'
Ram 1 KBG
Park KBG
Glade KBG
Midnight KBG
Rubber Topdressing Study
(690 series heads)
180'
Tree Care
1
2
3
4
5
6
7
8
Turf Building
Ornamental Grasses
N
80'
80'
80'
40'
Premium Sod Blend (KBG)
Ram I KBG
Indigo KBG
Tall Fescue Regional Trial
135'
Nassau KBG
Park KBG
25'
Rose Garden
SportGrass
Shade Adaptation Study
Heatway and SubAir
SubAir
Greens Amendment Study
Slope Green Study

Introduction

Nick E. Christians and David D. Minner

The following research report is the 18th 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. This is the first year that the entire report is available on the Internet. It can be accessed at:

http://www.hort.iastate.edu/hort/Frames/pubs/pframe.html

The 1996 season will be remembered for the severe winter desiccation that occurred during the winter of 95-96. The summer and fall of 1996 provided very good conditions for the growth of grass.

For the 7th 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.

Several new sand-based golf and athletic field research plots are under construction 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.

We would like to acknowledge Richard Moore, superintendent of the ISU Horticulture Research Station; Jim Dickson, manager of the turf research area; Barbara Bingaman, Postdoctoral researcher; Doug Campbell, research associate; Jeff Salmond and Mike Faust, graduate students; John Jordan, field technician 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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Environmental Research

Turf Management

Ornamental Studies

Introducing

Weather data for the ISU Horticulture Research Station from January 1 to December 31, 1996.

January	Precipitation (inches)	Temperature High	Low
1	0.03	33	31
2	0.01	34	30
3	0	32	8
4	0	23	1
5	0	22	0
6	0	12	-9
7	0	4	-10
8	0	15	-12
9	0	28	0
10	0	34	22
11	0	33	29
12	0.04	34	25
13	0	49	21
14	0	59	27
15	0	36	8
16	0	29	8
17	0	44	27
18	0.4	53	23
19	0.02	36	-7
20	0	3	-10
21	0	15	-1
22	0	35	5
23	0	34	9
24	0	12	6
25	0	16	-5
26	0	23	6
27	0.01	16	5
28	0	12	-6
29	0.08	32	1
30	0	10	-7
31	0	-3	-17

February	Precipitation (inches)	Temperature High	Low
1	0	2	-23
2	0	0	-19
3	0	-12	-30
4	0	-8	-31
5	0	7	-24
6	0	18	-2
7	0.01	37	0
8	0	45	34
9	0	45	32
10	0	51	25
11	0	45	34
12	0	34	24
13	0	29	21
14	0	46	23
15	0	33	24
16	0.01	26	7
17	0	25	-3
18	0	30	10
19	0	26	8
20	0	50	17
21	0	49	32
22	0	34	28
23	0	40	30
24	0.01	47	31
25	0	60	24
26	0	56	31
27	0	35	32
28	0.05	32	8
29	0	21	4

March	Precipitation (inches)	Temperature High	Low
1	0	26	0
2	0	33	14
3	0	22	5
4	0	25	-1
5	0	41	14
6	0	37	21
7	0	24	-2
8	0	11	-7
9	0	23	-5
10	0	35	4
11	0	48	18
12	0	55	30
13	0	62	34
14	0	70	36
15	0	52	24
16	0	52	22
17	0.16	57	22
18	0	49	26
19	0	41	24
20	0	31	20
21	0	41	24
22	0	42	15
23	0	48	16
24	0.04	47	26
25	0.88	66	32
26	0	32	11
27	0.01	26	8
28	0	45	20
29	0	50	28
30	0	56	26
31	0.25	47	29

April	Precipitation (inches)	Temperature High	Temperature Low
1	0.03	41	25
2		52	26
3		73	39
4		72	32
5		33	28
6		40	23
7		49	17
8		45	25
9		50	24
10		56	20
11		69	52
12		83	49
13		73	32
14		50	29
15	0.08	37	31
16	0.02	53	31
17		58	26
18		79	39
19		68	43
20		69	43
21	0.18	54	37
22		68	37
23		52	32
24		63	23
25		67	46
26		70	46
27		54	33
28		67	28
29	0.26	56	42
30	0.32	44	33

May	Precipitation (inches)	Temperature High	Temperature Low
1		62	32
2		63	34
3	0.09	54	32
4	0.47	49	39
5		62	45
6		62	43
7		54	39
8		62	45
9		76	51
10	0.83	73	57
11	0.25	58	48
12		56	41
13		51	34
14		59	31
15	0.07	57	43
16	0.01	68	51
17	0.96	74	50
18		88	60
19		89	61
20		87	66
21	0.11	70	54
22		78	50
23		79	53
24	0.41	68	57
25	0.75	57	47
26	1.19	56	49
27	0.28	53	47
28	0.40	55	47
29	0.01	55	48
30		70	49
31		71	42

June	Precipitation (inches)	Temperature High	Temperature Low
1	0.16	68	50
2	0.49	68	57
3		74	54
4		60	51
5		72	43
6		75	50
7	0.02	67	53
8	0.12	64	49
9		72	52
10		74	51
11	0.01	76	60
12	0.03	80	66
13		90	59
14		90	64
15		91	58
16		89	64
17	0.16	81	68
18	3.23	74	64
19	0.07	71	61
20		82	71
21	0.53	80	68
22	0.51	87	68
23		75	62
24	0.31	80	61
25		80	62
26		82	61
27		87	65
28		88	65
29		91	71
30		93	76

July	Precipitation (inches)	Temperature High	Low
1		88	65
2		87	62
3		82	62
4		84	57
5		81	64
6		83	57
7	0.11	87	63
8		86	65
9		78	58
10		74	52
11		78	47
12		81	57
13	0.11	82	61
14		81	57
15		81	59
16		84	58
17	0.05	84	56
18	2.24	88	67
19		91	74
20		83	68
21	0.01	70	64
22		79	66
23	0.04	83	65
24		81	56
25		77	59
26		78	56
27		81	54
28	0.04	75	64
29	0.55	78	61
30		80	60
31		76	58

August	Precipitation (inches)	Temperature High	Low
1		78	54
2		80	54
3		81	56
4		79	61
5	0.84	79	69
6	0.17	84	69
7		90	72
8	0.13	81	62
9		84	57
10		84	57
11	0.76	78	61
12	0.01	77	61
13		80	55
14		82	63
15		81	62
16		78	53
17		76	53
18		77	58
19		77	60
20	0.89	79	65
21		83	63
22		87	66
23	0.04	79	66
24		77	56
25		80	51
26		84	58
27	0.85	77	62
28		74	60
29		82	59
30		82	61
31		80	55

September	Precipitation (inches)	Temperature High	Low
1		78	54
2		82	57
3		83	64
4		81	63
5		85	65
6		84	64
7		85	59
8	0.35	84	57
9	0.20	74	58
10		79	52
11		80	52
12	0.19	71	48
13		64	43
14		64	40
15		67	34
16		72	37
17		70	47
18		71	42
19		70	44
20	0.35	69	47
21	0.02	70	54
22		65	52
23		72	47
24	0.57	63	51
25		68	40
26	0.78	58	47
27	0.66	56	47
28		56	42
29		68	46
30		67	43

October	Precipitation (inches)	Temperature High	Low
1		79	52
2		76	52
3		60	35
4		57	30
5		63	38
6		74	46
7		73	50
8		61	39
9		63	29
10		63	41
11		57	33
12		65	32
13		74	49
14		82	55
15		81	55
16		75	53
17		75	49
18	0.02	68	41
19		55	31
20		66	31
21		71	49
22		60	42
23	1.47	43	36
24	0.08	55	39
25		58	30
26		65	46
27		74	54
28		60	39
29		58	30
30	0.87	64	46
31		47	23

November	Precipitation (inches)	Temperature High	Low
1	0	31	21
2	0	34	18
3	0	38	15
4	0	59	22
5	0.98	47	40
6	0	48	41
7	0.16	50	33
8	0	53	30
9	0	42	30
10	0	38	24
11	0	27	20
12	0	30	19
13	0	25	10
14	0	25	19
15	0	29	13
16	0.34	48	28
17	1.07	55	46
18	0.15	51	20
19	0.01	32	19
20	0	29	24
21	0	31	26
22	0	31	26
23	0.03	34	25
24	0.04	35	26
25	0	26	11
26	0	19	6
27	0	21	0
28	0	24	5
29	0.05	44	3
30	0.54	37	32

December	Precipitation (inches)	Temperature High	Low
1	0	37	27
2	0	31	23
3	0	29	21
4	0.02	22	7
5	0	33	14
6	0.01	32	24
7	0.13	35	23
8	0	35	15
9	0	27	19
10	0	32	18
11	0	35	24
12	0	35	31
13	0	35	30
14	0.04	39	30
15	0.29	40	31
16	0	35	15
17	0	34	15
18	0	17	7
19	0	8	0
20	0	6	-4
21	0	25	-7
22	0	38	20
23	0	23	17
24	0	17	4
25	0	5	-4
26	0	2	-6
27	0	3	-9
28	0	31	-7
29	0.11	31	5
30	0	12	-1
31	0	27	-3

Results of Regional Kentucky Bluegrass Cultivar Trials

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.

Two trials were underway at Iowa State University during the 1996 season. The first, a high-maintenance study, was established in 1995, and received 4 lb N/1000 ft^2/yr, and is irrigated as needed. The second trial was established in 1995 and received 1 lb N/1000 ft^2/yr in September but was non-irrigated. They are mowed at two inches. 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 evaluate cultivars under conditions similar to those maintained in a park or school ground.

The values listed under each month in Tables 1 and 2 are the averages of visual quality ratings made on three replicated plots for the two studies. Visual quality was based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Yearly means of monthly data were taken and are listed in the last column. The first cultivar received the highest average rating for the entire 1996 season. The cultivars are listed in descending order of average quality.

Data for genetic color (Gcol), spring green-up (Grn), leaf texture (Leaf), and percentage spring ground cover (Scov) also are included for the high-maintenance, irrigated trial and the low-maintenance trial.

Table 1. The 1996 ratings for the 1995 high-maintenance, irrigated Kentucky bluegrass trial.

	Cultivar	Gcol	Grn	Leaf	Scov	May	June	July	Aug	Sept	Oct	Mean
1	Blacksburg	6.0	6.3	8.0	56.7	6.0	7.7	8.0	7.0	7.3	7.7	7.3
2	H86-690	8.0	6.0	7.3	60.0	6.3	8.0	7.0	7.3	7.7	7.3	7.3
3	ZPS-2572	6.0	5.3	7.0	53.3	5.7	7.7	7.7	7.3	7.7	7.7	7.3
4	PST-B2-42	7.3	5.7	7.0	56.7	5.7	7.7	7.3	7.3	7.3	8.0	7.2
5	Award	7.3	5.3	6.7	46.7	5.0	7.3	7.7	7.7	7.7	7.3	7.1
6	Limousine	6.7	5.7	7.3	60.0	6.7	8.0	6.7	6.3	7.0	6.7	6.9
7	MED-1497	7.0	6.0	5.7	43.3	4.0	7.7	7.3	7.7	8.0	7.0	6.9
8	BAR VB 3115B	5.7	5.3	7.3	66.7	6.7	8.0	5.7	6.7	7.0	6.7	6.8
9	Unique	6.3	5.3	6.7	53.3	5.7	7.7	7.0	6.7	7.0	7.0	6.8
10	Baron	6.7	5.3	6.3	56.7	6.3	7.0	6.7	6.7	6.7	7.0	6.7
11	Haga	6.7	5.7	6.7	63.3	6.7	8.0	6.0	6.3	6.7	6.7	6.7
12	PST-BO-141	7.7	6.3	6.0	40.0	4.7	7.3	6.7	6.7	7.0	7.7	6.7
13	Baronie	5.7	5.3	6.3	50.0	5.0	7.7	6.3	7.0	6.7	6.7	6.6
14	Challenger	6.7	5.3	6.7	36.7	4.3	6.0	7.0	7.3	7.0	7.3	6.5
15	Midnight	6.7	5.7	7.0	33.3	4.0	7.0	7.0	7.0	6.7	7.3	6.5
16	BAR VB 233	6.0	6.0	7.0	53.3	5.0	7.7	6.7	6.3	6.7	6.3	6.4
17	Ba 73-373	7.0	6.0	6.0	46.7	5.7	7.3	6.3	6.3	6.3	6.3	6.4
18	Bartitia	6.0	6.3	7.3	43.3	5.0	6.7	6.3	6.7	7.0	7.0	6.4
19	Caliber	6.3	5.7	6.3	60.0	6.7	7.3	6.3	5.7	6.0	6.3	6.4
20	Classic	6.7	5.7	6.7	50.0	6.0	7.7	5.7	5.7	6.3	7.3	6.4
21	LKB-95	5.0	5.3	8.0	56.7	6.0	7.7	6.3	5.7	6.3	6.3	6.4

	Cultivar	Gcol	Grn	Leaf	Scov	May	June	July	Aug	Sept	Oct	Mean
22	Shamrock	6.7	6.0	6.7	40.0	4.7	6.3	6.7	6.7	7.0	7.0	6.4
23	Coventry	7.3	5.7	5.3	36.7	4.0	6.0	7.0	7.0	6.7	7.3	6.3
24	J-1567	7.0	5.3	6.3	36.7	5.0	7.0	6.3	6.7	6.3	6.7	6.3
25	A88-744	7.7	5.0	6.0	36.7	5.7	5.7	6.0	6.0	7.0	7.0	6.2
26	Ba 81-220	6.3	6.3	6.3	36.7	4.7	6.7	6.0	6.0	7.0	6.7	6.2
27	Ba 81-270	6.3	5.3	5.7	40.0	4.7	6.3	6.0	6.3	6.7	7.0	6.2
28	NuStar	6.3	5.7	7.0	36.7	5.3	6.7	6.0	5.7	6.3	7.3	6.2
29	Raven	7.3	4.7	6.3	43.3	5.3	6.3	6.7	6.7	6.0	6.3	6.2
30	TCR-1738	7.3	5.0	6.7	33.3	4.3	5.3	6.7	6.7	7.0	7.0	6.2
31	ZPS-2183	6.7	5.0	7.0	43.3	4.7	6.7	6.7	6.0	6.3	6.7	6.2
32	Abbey	7.0	6.3	6.3	53.3	5.3	6.7	6.7	5.7	6.0	6.3	6.1
33	Ba 70-060	6.7	5.3	6.0	33.3	4.7	6.3	6.7	5.7	6.3	6.7	6.1
34	Ba 81-058	6.7	5.3	6.3	36.7	4.7	6.0	6.3	6.0	6.7	7.0	6.1
35	J-1936	7.3	6.0	6.0	30.0	4.3	6.0	6.3	6.3	6.7	6.7	6.1
36	Jefferson	7.3	5.0	7.0	40.0	5.0	6.3	6.0	6.0	6.3	7.0	6.1
37	MED-1991	7.0	6.0	7.0	40.0	4.7	6.3	6.3	6.3	6.3	6.7	6.1
38	Nimbus	5.7	6.0	7.7	40.0	4.7	7.0	6.3	6.0	6.7	5.7	6.1
39	Pick 8	7.0	5.3	6.0	40.0	4.3	6.3	6.3	6.3	6.3	6.7	6.1
40	NuGlade	7.3	5.3	6.3	33.3	4.3	5.0	7.0	6.7	6.7	7.0	6.0
41	Platini	6.0	5.3	6.7	40.0	5.7	6.0	6.0	6.5	7.0	6.0	6.0
42	BAR VB 6820	7.0	6.0	7.7	33.3	3.7	6.3	6.7	6.0	6.3	6.3	5.9
43	Ba 79-260	7.3	5.0	6.3	46.7	4.7	6.0	6.7	5.3	5.7	7.3	5.9
44	Ba 81-113	6.7	5.7	6.7	40.0	4.7	7.0	6.3	5.7	6.0	6.0	5.9
45	Ba 87-102	6.7	6.0	6.3	36.7	4.3	6.3	7.0	5.7	6.0	6.3	5.9
46	Chateau	6.0	6.0	5.7	30.0	4.3	5.3	6.0	6.3	7.0	6.7	5.9
47	MED-1580	6.7	6.0	6.3	36.7	4.3	6.7	6.7	5.3	6.0	6.3	5.9
48	NJ 1190	5.7	6.0	7.3	30.0	3.7	6.0	7.0	6.3	6.3	6.3	5.9
49	PST-638	8.0	6.0	6.0	33.3	4.3	5.3	6.3	6.3	6.3	6.7	5.9
50	J-1576	6.7	5.7	6.7	30.0	3.7	6.3	6.0	6.0	6.0	6.7	5.8
51	J-2579	6.7	5.3	7.7	30.0	3.7	5.7	6.3	6.0	6.3	6.7	5.8
52	Kenblue	6.3	5.7	8.0	56.7	5.7	6.7	5.0	5.3	6.0	6.3	5.8
53	Marquis	7.0	5.3	6.0	36.7	4.3	6.0	7.0	5.3	5.7	6.3	5.8
54	NJ-54	6.3	6.3	6.3	26.7	4.0	6.0	7.0	5.3	6.3	6.3	5.8
55	Princeton 105	7.0	6.0	6.7	30.0	4.0	5.3	8.0	5.7	6.0	7.0	5.8
56	SRX 2205	6.7	6.0	8.3	43.3	4.7	6.3	6.3	5.7	5.7	6.3	5.8
57	ZPS-309	5.7	5.3	6.7	40.0	3.7	6.0	7.0	6.0	6.3	6.0	5.8
58	America	7.7	6.3	7.3	30.0	4.3	6.0	6.0	5.3	5.7	7.0	5.7
59	Ascot	7.0	5.3	6.0	26.7	4.0	6.0	7.5	6.5	6.0	6.0	5.7
60	Ba 75-490	6.7	5.7	5.7	30.0	3.7	5.3	5.7	6.0	6.0	7.3	5.7
61	J-1561	7.3	5.3	6.7	36.7	4.0	5.7	7.5	5.7	6.0	6.7	5.7
62	PST-A7-245A	6.3	5.7	5.7	30.0	3.7	5.7	6.3	5.7	6.0	7.0	5.7
63	PST-A7-60	6.7	5.3	7.0	30.0	4.0	5.7	6.0	5.7	6.0	6.7	5.7
64	PST-B3-180	7.0	5.3	7.0	23.3	3.3	4.3	6.7	6.0	6.7	7.3	5.7
65	Ba 76-197	6.3	5.3	6.3	23.3	3.7	5.3	5.7	5.7	6.7	6.7	5.6
66	HV 130	7.0	6.0	6.0	26.7	3.7	5.7	6.3	5.3	5.7	6.7	5.6

	Cultivar	Gcol	Grn	Leaf	Scov	May	June	July	Aug	Sept	Oct	Mean
67	J-2582	6.3	5.0	6.3	30.0	3.7	5.0	6.7	5.7	5.7	6.7	5.6
68	Livingston	6.3	5.7	6.3	26.7	3.3	5.3	5.0	6.0	6.3	7.3	5.6
69	MED-18	6.7	5.3	6.3	30.0	3.0	5.3	5.7	6.0	6.3	7.0	5.6
70	PST-BO-165	6.7	5.7	5.7	33.3	4.0	6.0	5.7	5.3	5.7	6.7	5.6
71	Pick-3561	6.0	5.3	7.0	33.3	3.3	5.3	7.0	5.7	6.3	6.0	5.6
72	SR 2100	8.0	5.7	5.0	30.0	3.7	5.0	6.7	5.3	5.7	7.3	5.6
73	Wildwood	7.0	5.3	7.0	36.7	5.3	6.0	5.3	5.3	5.7	6.0	5.6
74	Glade	7.0	6.0	7.0	23.3	3.0	5.3	6.0	5.7	6.0	7.0	5.5
75	NJ-GD	7.0	6.0	6.3	30.0	4.0	5.3	5.0	6.0	6.3	6.3	5.5
76	Sodnet	7.0	5.7	6.7	30.0	3.7	5.7	5.3	5.7	6.7	6.0	5.5
77	BAR VB 5649	6.3	5.7	6.3	33.3	4.0	6.0	5.3	5.7	5.7	6.0	5.4
78	Baruzo	6.7	5.3	7.7	33.3	4.0	6.3	5.3	5.3	6.0	5.3	5.4
79	Fortuna	7.0	5.3	7.0	26.7	3.7	4.7	6.7	5.3	5.7	6.3	5.4
80	LTP-621	6.0	6.0	6.0	23.3	3.0	4.7	7.0	5.7	6.0	7.7	5.4
81	SR 2000	7.3	5.7	5.3	20.0	3.0	4.7	5.7	5.7	6.0	7.3	5.4
82	Sidekick	7.0	6.0	5.7	30.0	4.0	4.3	6.0	5.3	6.3	6.7	5.4
83	Allure	6.7	6.3	5.0	26.7	3.3	5.3	6.5	7.5	6.3	6.5	5.3
84	PST-P46	7.3	5.3	6.7	20.0	3.0	4.7	6.0	5.7	6.3	6.0	5.3
85	Ba 75-173	7.0	6.0	6.3	26.7	3.3	5.0	6.5	5.0	5.7	6.7	5.2
86	Ba 81-227	6.7	5.7	5.7	23.3	3.3	4.7	6.0	5.0	5.3	7.0	5.2
87	HV 242	6.7	5.7	7.0	20.0	3.3	4.7	6.0	6.0	6.3	5.7	5.2
88	Ba 76-372	7.3	5.7	5.0	20.0	3.7	4.3	5.0	5.0	5.7	6.7	5.1
89	Conni	6.0	5.7	7.3	23.3	3.3	4.0	6.0	5.3	5.3	6.3	5.1
90	Eclipse	6.7	5.3	6.0	23.3	3.7	4.7	6.0	4.7	5.7	6.7	5.1
91	J-1555	7.0	6.3	6.7	23.3	3.3	5.0	6.0	5.0	5.7	6.3	5.1
92	Cardiff	6.7	5.3	6.3	26.7	2.7	5.0	5.0	5.3	6.0	6.3	5.0
93	Compact	5.3	5.3	5.0	16.7	3.3	4.3	5.5	5.3	5.7	5.7	4.9
94	Pic-855	7.0	5.3	6.3	26.7	3.3	4.7	4.7	5.0	6.0	6.0	4.9
95	VB 16015	8.0	5.3	6.0	33.3	3.7	4.3	5.7	4.7	5.3	5.7	4.9
96	Ba 77-702	7.0	4.7	5.7	20.0	2.7	4.0	6.5	4.7	5.3	6.3	4.8
97	Lipoa	7.7	5.7	8.0	30.0	3.3	5.0	5.7	4.3	5.0	5.7	4.8
98	SR 2109	6.7	6.0	6.0	16.7	3.0	4.0	4.5	6.0	5.7	6.3	4.8
99	Ba 75-163	7.7	5.3	5.3	16.7	2.3	3.7	4.3	5.0	5.3	6.7	4.6
100	DP 37-192	6.7	5.3	7.0	33.3	3.0	4.7	5.0	4.7	5.7	4.7	4.6
101	LTP-620	6.7	5.0	5.3	16.7	3.0	3.7	6.5	4.3	5.3	7.0	4.5
102	ZPS-429	6.7	5.7	6.0	26.7	4.0	4.7	5.5	5.5	5.5	6.5	4.4
103	PST-A418	8.0	6.3	5.0	13.3	2.0	2.7	6.5	3.7	4.7	7.3	4.3
	$LSD_{(0.05)}$	1.5	3.1	1.3	44.5	4.6	3.5	3.0	2.7	3.1	1.6	2.5

Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
Gcol (Genetic color); Grn (Green-up); Leaf (Leaf texture); Scov (Spring ground cover)

Table 2. The 1996 ratings for the 1995 low-maintenance, non-irrigated Kentucky bluegrass trial.

	Cultivar	Gcol	Grn	Leaf	Scov	May	June	July	Aug	Sept	Oct	Mean
1	Eagleton	6.7	7.0	7.0	80.0	7.7	7.7	6.3	7.3	7.3	8.0	7.4
2	Baronie	6.3	8.0	7.3	70.0	7.0	7.7	6.3	7.0	7.0	7.3	7.1
3	Caliber	6.7	8.0	7.0	60.0	6.7	7.3	6.3	6.0	7.0	7.3	6.8
4	BAR VB 233	6.7	7.3	6.7	53.3	6.0	7.7	5.7	6.0	7.7	7.3	6.7
5	Baron	7.0	8.0	7.0	56.7	6.0	6.3	6.0	7.0	7.0	6.7	6.5
6	Kenblue	6.0	6.7	6.7	70.0	6.0	7.3	6.3	6.7	6.7	6.0	6.5
7	BAR VB 3115B	7.0	6.3	6.7	43.3	5.0	6.7	5.3	6.0	6.7	6.7	6.1
8	Canterbury	7.0	7.0	7.0	46.7	5.0	5.7	5.0	6.3	6.3	7.3	5.9
9	Blue Star	6.3	7.3	7.7	43.3	4.7	6.3	5.7	6.0	6.0	5.7	5.7
10	South Dakota	6.7	6.3	6.0	36.7	5.3	6.0	5.3	5.7	6.0	6.0	5.7
11	BAR VB 5649	6.7	7.7	7.0	40.0	4.7	6.3	5.7	5.3	6.0	5.3	5.6
12	PST-A7-60	6.7	8.0	6.3	36.7	4.3	5.3	5.7	5.7	6.0	6.0	5.5
13	Bartitia	7.3	7.7	7.0	40.0	3.7	6.3	5.0	5.3	6.0	6.0	5.4
14	Baruzo	6.3	8.0	7.3	33.3	4.3	6.0	5.0	5.3	6.0	5.7	5.4
15	Lipoa	7.3	8.0	7.0	50.0	4.7	5.3	4.7	5.0	4.7	5.0	4.9
16	PST-B9-196	8.0	7.0	6.0	30.0	3.7	4.7	5.3	5.0	4.7	5.3	4.8
17	BH 95-199	7.3	7.0	6.7	40.0	3.0	4.7	4.0	4.3	6.0	6.0	4.7
18	MTT 683	6.0	7.7	6.7	33.3	3.3	5.7	4.3	4.7	4.7	4.7	4.6
19	ZPS-429	7.3	7.7	7.3	26.7	3.3	4.7	4.3	4.7	4.3	5.0	4.4
20	VB 16015	8.0	7.7	5.7	26.7	2.3	4.3	3.7	4.3	4.3	4.3	3.9
21	BAR VB 6820	6.7	7.7	6.7	20.0	2.0	3.3	2.7	3.0	3.0	4.0	3.0
	$LSD_{0.05}$	1.5	1.6	1.4	18.8	1.7	1.2	1.7	1.7	1.8	1.2	1.2

Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
Gcol (Genetic color); Grn (Green-up); Leaf (Leaf texture); Scov (Spring ground cover)

NTEP 1995 Kentucky Bluegrass Cultivar Trial - High Maintenance, High Traffic
1996 Progress Report

David D. Minner

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 103 cultivars. Each cultivar was replicated three times. This trial, a high-maintenance traffic study, was seeded in August, 1995, and received 4 lb N/1000 ft^2/yr, and is irrigated as needed. The study is mowed at two inches. The objective of the high-maintenance study was to investigate cultivar performance under a cultural regime similar to that used on high-traffic areas in Iowa. Traffic treatment will begin in the summer of 1997 once plots are completely covered with grass.

The values listed under each month in Table 1 are the averages of visual quality ratings made on three replicated plots. Visual quality was based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Yearly means of monthly data were taken and are listed in the last column. The first cultivar on the table received the highest average rating for the entire 1996 season. The cultivars are listed in descending order of average quality.

Genetic color (Gcol), spring green-up (Grn), leaf texture (Leaf), spring density (Den), percentage spring ground cover (Scov), summer ground cover (Sucov), and fall ground cover (Fcov) data are included for the high-maintenance, irrigated traffic trial.

Table 1. The 1996 quality ratings for the high-maintenance Kentucky bluegrass test. Traffic treatment will begin in 1997.

	Cultivar	Gcol	Grn	Leaf	Den	Scov	Sucov	Fcov	Visual quality[1]						
									May	June	July	Aug	Sept	Oct	Mean
1	Ba 75-490	7.7	5.3	6.3	7.0	96.3	96.3	99.0	8.0	7.0	8.3	7.3	7.7	7.7	7.7
2	Chateau	7.0	5.3	5.7	7.7	88.0	93.0	99.0	7.3	7.7	8.0	7.0	7.3	7.7	7.5
3	Ba 81-270	7.3	5.3	5.3	7.3	88.0	93.0	99.0	6.3	7.3	8.0	7.3	7.3	8.0	7.4
4	Limousine	7.7	5.0	6.7	8.3	63.3	78.3	99.0	5.0	8.0	8.7	7.7	7.3	7.0	7.3
5	NJ 1190	7.3	5.3	6.7	7.3	63.3	80.0	96.0	6.0	7.3	8.3	7.3	7.3	7.3	7.3
6	Classic	6.0	5.7	7.3	6.7	97.7	97.7	99.0	8.7	6.7	7.3	6.3	7.0	7.3	7.2
7	Raven	6.0	5.3	5.7	7.7	93.0	96.3	99.0	7.3	7.7	7.7	6.7	6.7	7.0	7.2
8	Conni	7.0	5.3	7.3	8.0	78.3	87.7	97.7	6.0	7.7	8.0	7.0	7.0	7.0	7.1
9	PST-A7-245A	6.7	6.0	5.3	7.0	70.0	83.3	97.7	6.0	7.0	7.3	6.3	7.3	8.3	7.1
10	PST-BO-165	7.0	6.7	5.7	8.0	65.0	81.7	99.0	5.7	7.7	8.0	7.0	7.0	7.3	7.1
11	Allure	6.3	6.0	6.0	7.0	80.0	88.3	99.0	6.3	7.0	7.3	6.7	7.3	7.3	7.0
12	Nimbus	5.3	6.3	6.7	7.3	97.3	96.0	99.0	8.3	7.3	7.3	6.3	6.3	6.3	7.0
13	PSt-BO-141	6.7	6.0	6.3	7.7	75.0	86.7	99.0	6.0	7.7	7.3	6.3	7.3	7.3	7.0
14	Blacksburg	7.7	5.0	6.0	7.3	78.3	86.7	97.7	5.7	7.3	8.0	7.0	6.7	7.0	6.9
15	Fortuna	6.3	6.3	6.0	7.7	71.3	81.3	92.7	6.0	7.3	7.3	6.3	7.0	7.7	6.9
16	NuStar	6.3	5.7	7.0	7.0	83.3	90.0	96.0	6.7	7.0	7.7	6.7	7.0	6.7	6.9
17	Ba 77-702	6.3	5.3	6.3	7.0	75.0	86.7	97.7	6.0	7.0	7.7	6.7	7.0	6.7	6.8
18	Coventry	7.7	6.3	5.0	7.0	61.7	76.7	92.7	6.0	6.0	7.7	6.7	7.0	7.7	6.8
19	J-1561	8.3	6.3	6.3	7.7	63.3	78.3	97.7	5.0	7.7	7.7	6.7	6.7	7.3	6.8
20	LKB-95	7.7	5.3	6.7	7.3	80.0	88.3	96.0	6.7	7.3	7.0	6.0	7.0	7.0	6.8
21	Unique	7.3	5.7	6.7	8.0	71.7	85.0	97.7	5.7	8.0	7.3	6.3	6.7	6.7	6.8
22	Ba 73-373	6.0	5.3	5.7	7.7	83.3	90.0	97.7	6.0	7.7	7.0	6.0	6.7	6.7	6.7
23	Challenger	7.3	5.0	6.3	7.3	78.0	85.0	96.0	6.0	7.0	7.3	6.3	6.7	6.7	6.7
24	Haga	5.7	5.7	7.0	7.0	90.0	93.3	99.0	7.3	7.0	7.0	6.0	6.3	6.7	6.7
25	J-2582	7.0	5.3	6.3	7.3	80.0	88.3	99.0	5.7	7.3	7.3	6.3	6.7	7.0	6.7
26	PST-A7-60	7.3	5.3	6.7	8.0	70.0	83.3	94.3	6.0	8.0	7.3	6.3	6.3	6.3	6.7
27	Platini	7.7	5.3	6.3	7.0	81.7	90.0	99.0	6.7	7.0	7.3	6.3	6.7	6.3	6.7
28	Ba 75-173	6.7	5.0	6.0	7.0	81.7	90.0	99.0	6.7	7.0	7.0	6.0	6.3	6.3	6.6
29	Baronie	6.7	5.7	6.7	6.7	90.0	95.0	99.0	7.0	6.7	6.7	5.7	6.7	7.0	6.6
30	Eclipse	6.7	5.7	6.3	7.3	76.7	88.3	97.7	6.3	7.3	6.7	5.7	6.7	7.0	6.6
31	HV 130	7.0	6.0	6.3	7.0	73.3	85.0	99.0	6.0	7.0	7.0	6.0	6.7	6.7	6.6
32	NuGlade	8.3	6.0	6.0	7.3	53.3	71.7	88.0	4.7	6.0	7.7	6.7	7.0	7.3	6.6
33	SRX 2205	6.0	5.7	7.0	6.7	84.7	93.0	99.0	7.0	6.7	7.0	6.0	6.3	6.3	6.6
34	ZPS-429	6.0	5.7	6.0	7.0	71.7	83.3	97.7	5.7	7.0	7.7	6.7	6.3	6.0	6.6
35	America	7.3	5.7	6.3	7.3	70.0	81.7	96.0	6.0	6.7	7.0	6.0	6.7	6.7	6.5
36	Ba 70-060	6.3	5.7	6.0	6.7	74.7	86.3	97.7	6.3	5.7	7.3	6.3	6.7	6.7	6.5
37	Ba 81-058	7.7	6.0	6.0	6.7	73.3	85.0	99.0	6.0	6.7	7.3	6.3	6.3	6.3	6.5

	Cultivar	Gcol	Grn	Leaf	Den	Scov	Sucov	Fcov	Visual quality[1] May	June	July	Aug	Sept	Oct	Mean
38	MED-1991	7.7	5.7	6.0	7.3	68.3	83.3	97.7	5.7	7.3	7.0	6.0	6.3	6.7	6.5
39	Marquis	6.7	5.7	6.0	7.0	80.0	88.3	99.0	6.3	7.0	7.0	6.0	6.3	6.3	6.5
40	PST-P46	7.0	5.3	6.3	7.7	78.3	88.3	99.0	6.7	7.7	7.0	6.0	6.0	5.7	6.5
41	Abbey	6.3	5.7	5.7	7.0	65.0	80.0	94.3	6.3	6.7	6.7	5.7	6.3	6.7	6.4
42	Ba 79-260	8.3	5.3	6.3	7.3	75.0	86.7	99.0	5.3	7.0	7.3	6.3	6.3	6.0	6.4
43	Ba-113	5.7	6.0	6.0	8.0	81.7	90.0	99.0	6.3	8.0	6.7	5.7	6.0	6.0	6.4
44	Baron	6.3	5.7	6.0	7.0	71.7	85.0	96.0	6.3	6.3	7.0	6.0	6.7	6.3	6.4
45	Bartitia	6.7	5.7	6.7	8.0	65.0	83.3	96.3	5.3	7.3	7.0	6.0	6.7	6.0	6.4
46	J-1555	7.7	6.3	6.0	6.3	65.0	81.7	97.7	5.3	6.3	7.3	6.3	6.7	6.7	6.4
47	LTP-621	6.3	6.7	7.0	6.3	80.0	88.3	96.3	6.0	6.3	7.3	6.3	6.3	6.0	6.4
48	Livingston	6.7	5.0	6.3	6.7	68.0	81.3	94.3	6.7	5.3	7.0	6.0	6.7	6.7	6.4
49	NJ-54	7.7	6.7	6.0	6.3	75.0	83.3	92.7	5.7	6.0	7.3	6.3	6.7	6.7	6.4
50	NJ-GD	7.0	5.7	6.0	6.3	65.0	78.3	94.3	6.3	6.3	6.7	5.7	6.7	6.7	6.4
51	PST-B2-42	7.7	6.3	7.0	7.7	65.0	81.7	99.0	5.7	6.7	7.0	6.0	6.7	6.7	6.4
52	Shamrock	7.3	6.0	6.0	6.0	65.0	81.7	99.0	5.3	6.0	7.3	6.3	6.7	6.7	6.4
53	TCR-1738	8.0	6.0	6.3	6.7	51.7	76.7	99.0	5.3	6.0	7.3	6.3	7.0	6.7	6.4
54	BAR VB 233	7.0	5.7	6.3	6.7	66.7	80.0	94.3	5.7	6.0	7.0	6.0	6.7	6.3	6.3
55	MED-18	7.7	5.3	6.3	7.7	55.0	75.0	99.0	4.7	6.7	7.3	6.3	6.3	6.3	6.3
56	Pick 8	7.0	5.3	6.0	7.0	80.0	90.0	99.0	5.3	7.0	7.0	6.0	6.3	6.0	6.3
57	Pick-3561	7.3	5.0	6.0	7.7	61.7	78.3	97.7	4.3	7.0	7.0	6.3	6.7	6.7	6.3
58	Princeton 105	7.3	6.0	6.0	7.0	65.0	81.7	99.0	5.7	6.7	6.7	5.7	6.3	6.7	6.3
59	SR 2100	6.7	5.3	5.7	7.0	76.7	85.0	94.3	5.3	6.7	7.0	6.0	6.3	6.7	6.3
60	Wildwood	7.3	5.7	6.7	7.7	76.7	85.0	96.0	6.7	6.7	7.0	6.0	6.0	5.3	6.3
61	ZPS-309	7.3	5.7	6.0	7.0	73.0	84.7	99.0	6.3	7.0	7.0	6.0	6.0	5.7	6.3
62	Ba 76-372	7.3	6.3	6.0	6.3	48.3	70.0	94.3	4.0	6.3	7.3	6.3	6.7	6.7	6.2
63	Ba 81-227	7.3	5.3	6.0	6.3	51.7	73.3	96.3	4.7	5.3	7.0	6.0	7.0	7.0	6.2
64	Compact	6.7	5.7	6.0	6.0	63.3	78.3	99.0	5.0	5.7	7.0	6.0	6.7	7.0	6.2
65	Jefferson	6.7	5.3	6.7	6.3	68.0	84.7	96.0	5.7	5.7	6.7	5.7	6.7	7.0	6.2
66	PST-B3-180	7.3	5.7	6.3	7.3	58.3	75.0	92.7	4.7	6.3	7.0	6.0	6.7	6.7	6.2
67	Ascot	7.7	5.7	6.3	8.0	60.0	75.0	93.0	5.3	7.3	6.7	5.7	6.3	5.7	6.1
68	ZPS-2183	7.0	5.7	5.7	7.0	48.3	71.7	91.3	4.3	6.3	7.3	6.3	6.3	6.0	6.1
69	ZPS-2572	8.0	5.3	6.3	7.7	45.0	68.3	91.3	4.7	6.0	6.7	5.7	6.7	6.7	6.1
70	Award	8.0	5.7	6.0	6.7	41.7	66.7	92.7	4.3	6.0	6.7	5.7	6.7	6.7	6.0
71	J-1956	7.7	5.7	6.0	7.3	53.3	76.7	97.7	47.3	5.7	7.0	6.0	6.3	6.7	6.0
72	PST-638	7.7	5.7	5.3	6.3	68.3	80.0	93.0	5.3	6.3	6.7	5.7	6.0	6.0	6.0
73	Pick-855	7.0	5.3	6.7	6.3	65.0	80.0	99.0	4.7	6.3	7.0	6.0	6.0	6.0	6.0
74	SR 2000	8.3	5.3	6.0	6.7	48.3	66.7	83.0	4.3	6.3	7.0	6.0	6.3	6.0	6.0
75	Sodnet	8.0	6.0	6.7	7.7	60.0	78.3	96.3	5.3	7.0	7.0	6.0	5.7	5.0	6.0
76	VB 16015	8.3	6.0	6.0	7.0	58.3	78.3	99.0	5.3	7.0	6.3	5.3	6.0	6.0	6.0

	Cultivar	Gcol	Grn	Leaf	Den	Scov	Sucov	Fcov	Visual quality[1] May	June	July	Aug	Sept	Oct	Mean
77	Ba 87-102	7.0	6.0	6.0	7.3	53.3	73.3	92.7	5.3	6.0	6.7	5.7	6.0	6.0	5.9
78	Baruso	6.7	5.7	7.0	7.3	78.3	86.7	97.7	5.7	7.0	6.3	5.3	5.7	5.3	5.9
79	Caliber	7.0	5.0	6.3	6.3	76.3	86.3	94.3	6.3	6.3	6.3	5.3	5.7	5.3	5.9
80	HV 242	7.7	6.0	6.0	6.3	63.3	78.3	94.3	5.3	6.0	7.0	6.0	6.0	5.3	5.9
81	Kenblue	5.7	6.3	7.7	6.3	76.3	86.3	97.7	7.3	5.7	6.3	5.3	5.3	5.3	5.9
82	MED-1497	8.3	6.0	6.0	7.0	48.3	70.0	89.7	5.0	5.7	7.0	6.0	6.3	5.7	5.9
83	MED-1580	7.3	6.3	6.7	6.7	58.3	73.3	89.3	5.0	5.3	7.0	6.0	6.0	6.3	5.9
84	SR 2109	7.3	5.7	6.0	6.7	51.7	68.3	84.7	4.3	5.3	7.3	6.3	6.3	6.0	5.9
85	A88-744	7.7	6.0	5.7	6.3	41.7	65.0	88.0	4.7	5.3	6.3	5.3	6.3	6.7	5.8
86	BAR VB 3115B	6.3	5.3	6.0	5.7	60.0	78.3	97.7	6.0	5.3	6.3	5.3	5.7	6.0	5.8
87	Ba 81-220	6.3	6.3	6.0	7.3	56.7	71.7	86.7	4.7	6.7	6.7	5.7	5.7	5.3	5.8
88	Lipoa	7.3	6.0	7.0	7.0	66.7	80.0	94.3	5.0	7.0	6.7	5.7	5.3	5.0	5.8
89	PST-A418	8.3	6.0	5.7	7.7	40.0	66.7	96.0	4.3	6.0	6.7	5.7	6.0	6.0	5.8
90	BAR VB 5649	7.3	5.3	6.0	7.0	48.3	71.7	94.3	5.0	5.7	6.7	5.7	6.0	5.3	5.7
91	J-1567	7.3	6.0	6.0	7.0	46.7	70.0	93.0	3.7	6.3	6.7	5.7	6.0	6.0	5.7
92	J-1576	8.0	5.7	6.0	7.0	28.3	61.7	90.0	3.7	5.0	7.0	6.0	6.0	6.3	5.7
93	J-2579	7.3	5.3	6.3	7.3	50.0	68.3	89.3	4.7	5.7	7.0	6.0	5.7	5.3	5.7
94	Midnight	8.3	6.0	6.0	7.3	38.3	68.3	97.7	3.7	5.3	6.7	5.7	6.3	6.7	5.7
95	Ba 75-163	8.0	5.7	6.0	6.0	50.0	75.0	99.0	4.7	5.3	6.7	5.7	5.7	5.3	5.6
96	H86-690	7.7	5.7	6.0	6.0	61.7	73.3	84.7	5.7	6.0	6.0	5.0	5.7	5.3	5.6
97	Glade	7.7	6.3	6.0	7.0	50.0	70.0	91.0	4.7	5.0	6.7	5.7	5.7	5.3	5.5
98	LTP-620	6.7	5.7	6.0	5.3	46.7	73.3	97.7	3.7	5.3	6.3	5.3	6.0	6.3	5.5
99	Sidekick	7.0	5.7	5.0	6.7	41.7	68.3	99.0	4.7	6.0	5.7	4.7	5.7	6.3	5.5
100	DP-37-192	7.7	6.3	6.0	7.3	51.7	66.7	87.7	4.3	7.0	6.3	5.3	5.0	4.7	5.4
101	BAR VB 6820	8.0	5.0	6.0	7.0	30.0	63.3	94.3	3.3	6.0	6.3	5.3	5.7	5.0	5.3
102	Ba 76-197	6.7	6.3	5.7	6.0	31.7	60.0	86.3	3.7	5.0	6.3	5.3	5.3	4.7	5.1
103	Cardiff	7.7	6.0	6.0	6.7	26.7	58.3	88.0	3.0	4.0	5.7	4.7	5.7	5.0	4.7
	$LSD_{0.05}$	1.0	2.4	0.9	1.4	38.4	23.0	21.5	2.5	3.4	1.7	1.6	1.2	1.3	1.3

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

Gcol (Genetic color); Grn (Green-up); Leaf (Leaf texture); Den (Spring density); Scov (Spring ground cover); Sucov (Summer ground cover); Fcov (Fall ground cover).

Regional Tall Fescue Cultivar Evaluation - 1996

Nick. E. Christians and James R. Dickson

This was the establishment year of data from the new tall 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 129 tall fescue cultivars. Cultivars were evaluated for seedling vigor in 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 the fall of 1996. The trial is maintained at a 2-inch mowing height, 3.5 lbs N/1000 ft^2 will be applied during the growing season, and the area will be irrigated when needed to prevent drought. Preemergence herbicide was applied once in the spring. Seedling vigor was rated on a 9 to 1 scale: 9 = best vigor and 1 = worst vigor.

Table 1. The 1997 quality ratings for the fine fescue regional cultivar trial.

	Cultivar	Mean seedling vigor		Cultivar	Mean seedling vigor
1	Renegade	8.0	30	JTTFA-96	7.3
2	Titan 2	8.0	31	PC-AO	7.3
3	Safari	8.0	32	SRX 8084	7.3
4	Genesis	7.7	33	Apache II	7.3
5	Falcon II	7.7	34	Marksman	7.3
6	Southern Choice	7.7	35	Regiment	7.3
7	TMI-RBR	7.7	36	ISI-TF9	7.0
8	Shenandoah	7.7	37	WRS2	7.0
9	MB 28	7.7	38	ATF-257	7.0
10	CU9501T	7.7	39	SSDE31	7.0
11	Kentucky - 31 w/endo	7.7	40	PST-R5AE	7.0
12	PSII-TF-9	7.7	41	Mustang II	7.0
13	Tarheel	7.7	42	BAR FA 6LV	7.0
14	AA-989	7.3	43	TA-7	7.0
15	Alamo E+	7.3	44	TMI-FMN	7.0
16	Arid	7.3	45	DLF-1	7.0
17	PST-5RT	7.3	46	Pixie E+	7.0
18	WVPB-1C	7.3	47	Duster	7.0
19	AA-A91	7.3	48	SS45DW	7.0
20	DP-7952	7.3	49	MB 216	7.0
21	SR 8210	7.3	50	ATF-196	7.0
22	Pennington-1901	7.3	51	TMI-AZ	7.0
23	PST-R5TK	7.3	52	PST-5E5	7.0
24	EC-101	7.3	53	Shortstop II	7.0
25	MB 212	7.3	54	OFI-931	7.0
26	ISI-TF11	7.3	55	PSII-TF-10	7.0
27	MB 210	7.3	56	PST-523	7.0
28	R5AU	7.3	57	Gazelle	7.0
29	CU9502T	7.3	58	JTTFC-96	7.0

	Cultivar	Mean seedling vigor
59	SRX 8500	7.0
60	Koos 96-14	7.0
61	MB 214	7.0
62	Bullet	6.7
63	ZPS-5LZ	6.7
64	MB 29	6.7
65	BAR Fa6 US1	6.7
66	MB 213	6.7
67	MB 26	6.7
68	WX3-275	6.7
69	Tomahawk-E	6.7
70	BAR FA6 US6F	6.7
71	LTP-4026 E+	6.7
72	J-101	6.7
73	Tulsa	6.7
74	Pick FA 15-92	6.7
75	Leprechaun	6.7
76	OFI-96-31	6.7
77	Coyote	6.7
78	Finelawn Petite	6.5
79	BAR FA 6D	6.3
80	EA 41	6.3
81	WVPB-1D	6.3
82	AV-1	6.3
83	ATF-182	6.3
84	RG-93	6.3
85	BAR Fa6 US2U	6.3
86	Jaguar 3	6.3
87	ATF-253	6.3
88	Pick FA XK-95	6.3
89	JSC-1	6.3
90	TMI-TW	6.3
91	Lion	6.3
92	PST-5M5	6.3
93	J-98	6.3
94	Coronado	6.3

	Cultivar	Mean seedling vigor
95	OFI-96-32	6.3
96	MB 215	6.3
97	TMI-N91	6.3
98	ATF-188	6.3
99	DP 50-9011	6.3
100	PRO 8430	6.3
101	Empress	6.3
102	Bonsai	6.3
103	Pick FA 20-92	6.3
104	ATF-192	6.3
105	Pick FA 6-91	6.3
106	BAR Fa6D USA	6.3
107	OFI-FWY	6.3
108	Pick GA-96	6.0
109	Cochise II	6.0
110	MB 211	6.0
111	ATF-020	6.0
112	Pick FA B-93	6.0
113	AA-983	6.0
114	LTP-SD-TF	6.0
115	AFT-022	6.0
116	ZPS-2PTF	6.0
117	Pick FA N-93	6.0
118	OFI-951	6.0
119	Pick RT-95	6.0
120	BAR Fa6 US3	6.0
121	Crossfire II	6.0
122	ATF-038	5.7
123	J-5	5.7
124	WVPB-1B	5.7
125	PST-5TO	5.7
126	J-3	5.7
127	Pick FA UT-93	5.7
128	ISI-TF10	5.7
129	Sunpro	5.7
	$LSD_{0.05}$	

Regional Fine Fescue Cultivar Evaluation - Established 1993

Nick. E. Christians and James R. Dickson

This was the third 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 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Data on spring greenup are also included.

Table 1. The 1997 quality ratings for the fine fescue regional cultivar trial.

				Quality						
	Cultivar	Species	Greenup	May	June	July	Aug	Sept	Oct	Mean
1	Rondo	STC	5.0	7.7	8.0	8.0	7.7	7.7	8.3	7.9
2	Aruba	STC	6.0	7.0	7.7	7.7	8.0	8.0	7.7	7.7
3	PST-4VB endo.	STC	5.0	8.0	7.3	7.3	6.7	7.7	7.7	7.4
4	Shademaster II	STC	3.7	8.0	7.3	7.0	6.3	8.0	7.7	7.4
5	Shadow II (PST-44D)	CF	5.7	8.3	7.0	7.0	6.7	8.0	7.3	7.4
6	PST-4DT	STC	5.0	7.3	7.7	6.3	6.7	8.0	8.0	7.3
7	PST-4ST	STC	4.0	7.0	7.7	7.3	7.0	7.3	7.3	7.3
8	Jasper (E)	STC	4.7	7.3	7.3	6.7	7.0	7.3	7.7	7.2
9	Common Creeping	STC	5.0	7.0	7.7	7.7	7.0	6.7	6.0	7.0
10	K-2 (MB 65-93)	CF	6.0	7.3	6.7	6.7	6.7	7.3	7.0	6.9
11	Tiffany	CF	4.3	6.0	7.3	7.0	6.7	7.3	7.0	6.9
12	Flyer II (ZPS-4BN)	STC	5.3	8.3	6.3	6.0	6.3	7.3	6.7	6.8
13	Victory (E)	CF	5.7	7.3	6.7	6.7	6.3	7.0	6.7	6.8
14	Victory II (Pick 4-91W)	CF	4.7	7.0	6.3	6.0	6.3	7.7	7.7	6.8
15	BAR FRR 4ZBD	STC	5.0	7.3	7.0	6.0	6.3	6.0	7.3	6.7
16	BAR UR 204	STC	6.0	6.0	6.7	7.0	7.0	7.0	6.7	6.7
17	Molinda	CF	6.3	7.0	6.3	6.3	6.7	7.3	6.3	6.7
18	Banner III (MB 61-93)	CF	5.0	7.0	6.7	5.7	5.7	7.7	7.0	6.6
19	CAS-FR13	STC	5.7	7.0	7.0	6.7	6.7	6.0	6.0	6.6
20	Columbra (MB 64-93)	CF	5.3	7.7	6.3	6.7	6.7	6.0	6.3	6.6
21	Medina	CF	6.0	7.7	6.0	5.7	6.3	6.7	7.0	6.6
22	NJ F-93	CF	4.3	7.7	6.7	6.0	6.0	6.7	6.3	6.6
23	Sandpiper (PRO 92/20)	CF	5.0	6.7	7.0	6.0	6.3	7.0	6.7	6.6
24	Treazure (ZPS-MG)	CF	5.3	6.7	6.0	6.7	7.0	6.3	7.0	6.6
25	MB 66-93	CF	6.0	7.7	6.3	5.7	6.3	6.3	6.7	6.5
26	Seabreeze	SLC	5.0	6.7	6.3	7.0	6.3	6.3	6.3	6.5
27	SR 5100	CF	5.3	7.0	6.7	6.3	6.3	7.0	5.7	6.5
28	Bridgeport	CF	5.0	6.3	6.7	5.7	6.3	7.0	6.7	6.4
29	Brittany	CF	5.0	7.0	6.7	6.0	6.0	6.3	6.7	6.4
30	ISI-FC-62	CF	5.0	7.0	6.0	7.0	6.0	6.3	6.3	6.4
31	Jamestown II	CF	5.3	6.7	6.0	6.0	6.3	6.7	7.0	6.4

	Cultivar	Species	Greenup	Quality							
				May	June	July	Aug	Sept	Oct	Mean
32	WX3-FFG6	STC	5.3	6.3	7.3	6.0	6.3	6.7	6.0	6.4
33	Darwin	CF	4.3	6.7	6.7	6.3	6.7	5.7	5.7	6.3
34	ECO (MB 63-93)	CF	5.3	6.7	6.0	6.3	6.3	6.3	6.3	6.3
35	Osprey (PRO 92/24)	HF	3.7	6.7	7.0	5.7	6.0	6.7	6.0	6.3
36	WX3-FF54	CF	5.0	7.7	6.0	5.7	5.7	6.7	6.3	6.3
37	Banner II	CF	5.7	7.7	5.7	5.3	6.3	6.0	6.3	6.2
38	Discovery	HF	4.3	7.0	7.0	5.3	6.0	6.0	6.0	6.2
39	MB 82-93	HF	4.3	6.0	6.0	6.3	6.7	6.0	6.0	6.2
40	Shadow (E)	CF	5.7	8.0	5.7	5.3	5.7	6.7	6.0	6.2
41	Flyer	STC	4.7	5.7	5.3	6.7	5.7	6.3	6.3	6.0
42	TMI-3CE	CF	5.0	6.0	6.0	5.7	6.0	6.0	6.0	5.9
43	Jamestown	CF	5.7	7.0	6.0	5.3	5.7	5.7	5.3	5.8
44	Dawson	SLC	5.0	4.3	6.0	5.7	5.7	5.3	6.0	5.5
45	Silverlawn (WVPB-STCR-101)	HF	4.7	7.3	6.3	6.0	4.7	4.3	4.3	5.5
46	Reliant II	HF	4.7	6.3	6.7	4.7	5.0	4.7	5.3	5.4
47	SR 3100	HF	4.3	6.0	6.7	5.0	5.3	4.3	5.0	5.4
48	Ecostar	HF	4.3	7.0	5.7	4.3	4.3	4.7	5.0	5.2
49	Cascade	CF	6.0	5.3	6.0	5.0	5.3	4.0	4.7	5.1
50	Defiant (MB 81-93)	HF	5.0	6.7	5.3	5.0	4.3	4.3	5.0	5.1
51	Quatro (FO 143)	SF	4.3	6.7	5.3	4.7	4.3	4.3	5.0	5.1
52	Spartan	HF	5.3	6.0	5.3	4.3	4.3	5.3	4.7	5.0
53	Brigade	HF	4.7	6.0	5.7	4.7	4.3	4.0	4.0	4.8
54	Aurora W/Endo	HF	5.0	5.7	5.3	4.3	4.0	4.0	4.7	4.7
55	Nordic	HF	5.3	6.3	5.0	4.7	4.0	4.0	4.3	4.7
56	Pamela	HF	5.3	6.3	5.3	4.3	4.7	3.7	4.0	4.7
57	Vernon (MB 83-93)	HF	4.3	6.7	5.0	4.3	4.0	4.0	3.7	4.6
58	Scaldis	HF	4.7	5.7	5.3	3.7	3.7	4.0	4.0	4.4
59	67135	SF	8.7	4.7	4.7	3.7	3.7	3.3	3.3	3.9
	$LSD_{(0.05)}$	—	1.7	2.1	1.7	1.4	1.3	1.6	1.6	0.9

Species: CF = Chewings Fescue
HF = Hard Fescue
SF = Sheep Fescue
SLC = Slender Creeping Fescue
STC = Strong Creeping Fescue
Spring greenup (Greenup): 9 = dark green and 1 = light green.
Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Perennial Ryegrass Study - Established 1994

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 9 to 1 scale: 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. Data on genetic color (Gcolor), leaf texture (Ltex), and greenup (grnup) ratings also are included.

Table 1. The 1996 quality and other ratings for the national perennial ryegrass study established in 1994.

	Cultivar	Gcolor	Grnup	Ltex	May	June	July	Aug	Sept	Oct	Mean
1	J1706	6.7	5.3	4.3	5.7	7.3	8.0	7.3	7.3	7.7	7.2
2	Bar USA 94-II	7.3	6.0	4.7	5.7	7.0	7.7	7.3	7.3	7.3	7.1
3	Omega3 (ZPS-2DR-94)	7.0	6.0	3.7	5.7	6.7	7.7	7.0	7.7	7.3	7.0
4	Vivid	7.0	6.0	4.3	5.3	6.3	8.3	7.0	7.3	7.7	7.0
5	Line Drive (MB 47)	7.7	5.7	4.3	5.3	7.0	6.7	7.3	7.7	7.3	6.9
6	Excel (MB 1-5)	7.7	7.0	4.7	6.0	6.3	8.3	6.7	6.3	7.0	6.8
7	PST-2R3	7.0	5.3	4.3	5.3	6.7	7.7	7.3	7.0	7.0	6.8
8	RPBD	7.0	6.7	4.3	5.0	7.0	6.7	7.0	7.3	7.7	6.8
9	SR 4010 (SRX 4010)	6.3	6.0	4.0	5.7	6.3	7.3	6.7	7.3	7.3	6.8
10	TMI-EXFLP94	6.7	6.0	5.0	5.7	6.7	7.3	7.0	6.7	7.3	6.8
11	Accent	6.3	5.0	5.0	4.7	6.7	7.3	6.7	7.3	7.3	6.7
12	Express	7.0	6.7	4.0	6.0	7.0	7.0	5.7	7.0	7.3	6.7
13	ISI-R2	6.3	6.7	4.3	5.7	7.3	6.0	6.3	7.3	7.7	6.7
14	KOOS 93-6	6.7	5.3	4.3	5.3	6.7	7.0	6.3	7.3	7.7	6.7
15	LRF-94-MPRH	7.3	5.3	3.7	5.3	6.3	6.7	7.7	7.0	7.3	6.7
16	MB 45	7.7	5.7	3.7	4.7	7.0	8.0	7.3	6.3	6.7	6.7
17	MED5071	6.3	6.0	4.3	5.3	7.3	6.7	6.3	7.7	7.0	6.7
18	Nobility	7.3	5.0	4.7	5.3	6.7	7.7	6.3	7.0	7.3	6.7
19	SR 4400 (SRX 4400)	6.7	5.3	4.0	4.7	7.0	7.3	6.7	7.3	7.3	6.7
20	Wind Star (PST-28M)	6.7	5.7	4.3	5.3	6.7	7.3	6.7	7.3	7.0	6.7
21	WVPB 92-4	6.3	5.3	4.3	5.0	6.7	7.3	6.3	7.3	7.3	6.7
22	Dancer	7.3	4.0	4.7	5.0	6.7	7.0	7.0	6.7	7.0	6.6
23	Divine	7.0	6.0	3.7	5.0	7.0	8.0	6.0	6.3	7.0	6.6
24	Elf	6.0	6.3	4.3	5.0	7.0	7.3	7.0	6.3	6.7	6.6
25	Laredo	6.3	6.0	4.3	5.3	6.3	6.7	6.7	7.3	7.0	6.6

	Cultivar	Gcolor	Grnup	Ltex	May	June	July	Aug	Sept	Oct	Mean
26	Manhattan 3	6.3	6.3	4.3	5.0	6.0	7.0	6.7	7.3	7.3	6.6
27	Pennant II (MB 42)	8.0	4.7	4.0	4.7	6.7	7.3	6.7	7.3	7.0	6.6
28	PST-GH-94	7.7	4.7	3.7	4.7	6.7	7.3	6.7	6.7	7.3	6.6
29	ZPS-2NV	6.3	5.0	4.0	5.0	7.0	6.3	7.0	7.3	7.0	6.6
30	Advantage	7.7	4.7	4.3	5.0	7.0	6.3	6.3	7.0	7.3	6.5
31	Cutter	6.3	6.0	3.7	5.7	7.0	6.3	6.7	6.3	7.0	6.5
32	DLP 1305	6.7	5.3	3.7	5.3	6.7	6.3	6.7	7.0	7.0	6.5
33	MB 44	6.7	4.7	3.3	4.7	6.3	7.7	7.0	6.3	7.0	6.5
34	Panther (ZPS-PR1)	6.7	5.7	4.7	5.0	7.0	6.7	6.7	6.7	7.0	6.5
35	PS-D-9	6.7	4.7	4.3	5.0	6.7	6.7	6.7	6.7	7.3	6.5
36	Saturn II (ZPS-2ST)	7.0	6.3	4.3	5.3	7.0	6.7	6.3	7.0	6.7	6.5
37	Wizard (MB 41)	7.0	6.3	3.7	5.7	7.0	6.3	6.0	7.0	7.0	6.5
38	WVPB-93-KFK	6.0	5.7	4.3	5.0	6.7	6.3	6.7	7.0	7.3	6.5
39	Academy (PC-93-1)	6.3	6.0	5.0	5.3	6.7	7.0	6.0	6.7	7.0	6.4
40	Achiever	6.0	6.7	3.7	5.3	6.0	7.0	6.3	6.7	7.0	6.4
41	BAR ER 5813	6.7	5.0	3.7	4.7	6.7	6.7	6.3	7.0	7.0	6.4
42	ISI-MHB	7.0	5.0	3.7	4.7	7.0	6.7	6.3	7.0	6.7	6.4
43	MVF-4-1	7.0	5.7	4.0	5.0	6.0	7.0	6.0	7.0	7.7	6.4
44	PICK LP 102-92	7.7	5.7	4.0	4.7	7.0	7.3	6.7	6.3	6.7	6.4
45	PST-2DLM	7.7	5.7	3.7	4.7	7.0	6.3	6.7	7.0	6.7	6.4
46	SR 4200	6.3	5.7	4.7	5.3	6.3	6.3	6.3	7.0	7.0	6.4
47	APR 106	6.7	5.0	5.0	5.0	6.3	6.0	6.3	7.0	7.0	6.3
48	APR 124	6.7	5.7	4.7	5.7	6.3	6.3	6.3	6.3	7.0	6.3
49	Blazer III (PICK 928)	6.7	5.0	4.0	4.7	6.7	7.0	5.7	7.0	6.7	6.3
50	Calypso II	7.0	6.0	4.0	5.0	7.0	6.3	6.3	6.3	6.7	6.3
51	Edge	6.7	5.7	4.7	5.0	6.3	7.0	6.0	6.3	7.3	6.3
52	Majesty (MB 43)	7.0	5.0	4.3	4.7	7.0	6.7	6.0	6.7	7.0	6.3
53	PSI-E-1	6.3	5.7	4.0	4.7	6.3	7.0	6.7	6.3	7.0	6.3
54	PST-2CB	7.3	5.7	4.0	5.0	6.3	6.3	6.3	6.7	7.0	6.3
55	Roadrunner (PST-2ET)	6.7	6.3	4.3	4.7	6.3	7.0	6.7	6.0	7.0	6.3
56	WX3-93	7.0	5.0	4.3	4.7	7.0	7.0	6.3	6.3	6.3	6.3
57	Assure	6.3	6.0	4.3	5.0	6.3	6.7	6.0	6.3	6.7	6.2
58	CAS-LP23	7.3	5.3	4.0	5.0	6.0	6.7	6.0	6.7	6.7	6.2
59	Esquire	7.0	5.7	4.3	5.0	7.0	7.3	5.7	5.7	6.7	6.2
60	KOOS 93-3	6.3	5.3	4.3	5.3	6.3	6.0	6.0	6.7	7.0	6.2
61	Legacy II (Lesco-Twf)	7.3	5.3	5.0	5.3	6.3	6.7	6.0	6.3	6.7	6.2
62	Omni	6.3	5.3	4.0	4.3	6.3	7.0	5.7	7.0	6.7	6.2
63	Precision	6.3	4.7	4.3	5.0	6.7	6.3	6.3	6.7	6.3	6.2
64	Prizm	6.7	5.3	4.7	4.3	6.0	6.3	6.3	7.0	7.0	6.2
65	Quickstart	6.7	5.7	4.3	4.3	6.3	7.0	6.0	6.3	7.3	6.2
66	Riviera II	7.0	5.7	4.7	4.3	6.7	6.7	6.7	6.3	6.3	6.2
67	Stallion Select	7.0	5.7	4.0	5.3	6.0	6.7	6.0	6.7	6.7	6.5

	Cultivar	Gcolor	Grnup	Ltex	May	June	July	Aug	Sept	Oct	Mean
68	Williamsburg	6.0	6.0	4.7	5.3	6.3	6.7	5.7	6.7	6.7	6.2
69	WVPB-PR-C-2	7.0	6.3	4.7	5.3	5.7	6.3	6.3	6.7	6.7	6.2
70	Brightstar	7.3	5.7	4.7	4.7	6.3	6.7	6.3	6.3	6.3	6.1
71	Night Hawk	7.3	6.0	4.3	4.7	6.3	6.3	5.7	6.7	6.7	6.1
72	Passport (PST-2FF)	7.3	6.0	4.3	4.7	6.3	6.7	5.7	6.7	6.7	6.1
73	PICK PR 84-91	7.3	4.7	3.7	5.0	6.3	6.7	6.0	6.3	6.3	6.0
74	Saturn	6.7	4.7	4.7	4.7	6.7	6.0	5.7	6.7	6.7	6.1
75	PST-2FE	7.0	6.3	3.7	4.0	6.3	6.7	6.3	6.3	6.3	6.0
76	APR 066	6.3	5.0	4.3	4.3	6.0	6.0	6.0	6.7	6.7	5.9
77	APR 131	7.0	5.7	4.0	5.0	6.0	5.7	6.0	6.0	6.7	5.9
78	DSV NA 9402	6.0	4.3	4.3	4.3	5.7	5.7	6.0	7.0	7.0	5.9
79	Imagine	7.3	5.7	4.0	4.3	6.7	6.3	5.7	6.3	6.0	5.9
80	J-1703	6.3	5.7	4.3	4.0	6.3	6.3	5.7	6.3	6.7	5.9
81	Top Hat	7.3	6.3	3.7	4.0	6.7	6.3	6.3	5.7	6.3	5.9
82	Citation III (PST-2dgr)	6.7	5.0	3.3	3.7	6.3	6.0	6.0	6.3	6.7	5.8
83	Morning Star	7.0	4.3	4.3	4.7	6.0	5.3	5.3	6.3	7.0	5.8
84	Navajo	7.0	6.0	4.7	4.3	5.7	6.0	7.0	5.7	6.0	5.8
85	Pegasus	6.7	6.0	4.3	5.0	5.3	6.0	6.0	6.0	6.7	5.8
86	DSV NA 9401	6.0	3.7	4.7	4.3	6.0	5.0	4.3	6.7	7.0	5.6
87	Figaro	7.0	4.3	3.7	4.3	5.0	5.3	6.0	6.3	6.7	5.6
88	LRF-94-C8	7.7	5.3	3.0	4.0	5.7	5.7	5.7	6.3	6.0	5.6
89	Nine-O-Nine	7.7	4.7	4.3	4.0	4.7	6.3	6.0	6.0	6.0	5.5
90	Pennfine	7.0	5.3	2.3	4.7	6.3	5.3	4.7	5.7	6.3	5.5
91	LRF-94-B6	7.7	6.0	3.0	4.0	5.3	6.0	5.3	5.7	6.3	5.4
92	WX3-91	6.3	6.3	4.0	3.3	5.3	6.0	5.7	6.0	6.3	5.4
93	Brightstar II (PST-2M3)	7.7	5.3	2.7	3.0	5.7	5.7	5.7	5.7	6.0	5.3
94	MB 46	7.7	6.0	4.0	3.3	5.0	5.7	5.3	5.3	6.3	5.2
95	LRF-94-C7	7.7	6.3	3.0	3.7	5.7	5.7	5.7	5.0	5.0	5.1
96	Linn	5.7	3.7	2.0	3.0	4.3	4.0	4.0	5.3	5.3	4.3
	$LSD_{(0.05)}$	1.4	1.9	2.3	2.1	2.0	1.7	1.2	1.7	2.2	1.0

Gcolor (Genetic color): 9 = dark green and 1 = light green. Ltex (Leaf textrue): 9 = fine and 1 = coarse. Grnup (Greenup): 9 = best and 1 = poorest greenup.
Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Shade Adaptation Studies

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 is 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 drought periods.

Monthly quality data are collected from May through October (Table 1). Visual quality was based on a 9 to 1 scale: 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.

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.), and rough bluegrass (*Poa trivialis*), and *Poa supina*. The results from this trial appear in Table 2.

Table 3 contains a summary of data from the last eight years for this project.

Table 1. 1996 quality[1] ratings for turfgrass culitvars in the 1987 Shade Trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Atlanta (C.F.)	7.0	6.3	6.0	6.0	7.3	7.7	6.7
2	Victor (C.F.)	7.3	5.3	5.7	5.7	7.3	8.0	6.6
3	Mary (C.F.)	7.3	5.7	5.7	5.7	6.7	7.0	6.3
4	Banner (C.F.)	7.3	5.3	5.3	5.0	7.0	7.3	6.2
5	Waldorf (C.F.)	6.0	6.0	5.3	5.0	6.7	7.7	6.1
6	Wintergreen (C.F.)	5.7	6.0	5.7	5.3	6.3	7.0	6.0
7	Jamestown (C.F.)	7.7	5.0	5.0	4.7	6.3	7.0	5.9
8	Pennlawn (C.R.F.)	6.7	5.0	4.7	5.3	6.3	7.3	5.9
9	Shadow (C.F.)	7.0	4.7	4.3	5.0	6.7	7.7	5.9
10	Bar Fo 81-225 (H.F.)	4.7	5.3	5.3	5.7	6.3	7.0	5.7
11	Agram (C.F.)	6.7	4.7	4.3	4.7	6.0	6.7	5.5
12	St-2 (SR3000) (H.F.)	5.3	4.7	5.0	4.7	6.3	7.0	5.5
13	Ensylkva (C.R.F.)	5.7	4.0	3.7	4.7	6.3	7.3	5.3
14	Waldina (H.F.)	5.0	4.3	4.0	4.7	6.0	6.3	5.1
15	Spartan (H.F.)	4.7	4.7	4.3	4.7	5.3	6.3	5.0
16	Highlight (C.F.)	6.0	4.7	4.0	4.3	5.0	5.7	4.9
17	Sabre (*Poa trivialis*)	3.3	6.3	5.0	4.3	5.3	5.3	4.9
18	Reliant (H.F.)	4.3	4.3	4.3	4.7	5.7	6.3	4.9
19	Biljart (H.F.)	4.7	4.3	3.7	4.3	5.7	6.3	4.8
20	Koket (C.F.)	6.0	4.0	3.0	3.3	4.7	6.3	4.6
21	Rebel (T.F.)	4.0	4.0	4.3	4.3	5.0	5.7	4.6
22	Estica (C.R.F.)	4.0	3.3	3.0	3.3	5.7	6.7	4.3
23	Rebell II (T.F.)	4.3	3.7	3.3	4.3	5.0	5.3	4.3

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
24	Bonanza (T.F.)	3.7	3.7	3.7	4.0	4.7	5.3	4.2
25	Falcon (T.F.)	3.7	4.0	3.3	3.3	4.7	6.0	4.2
26	Scaldis (H.F.)	4.0	3.7	3.3	3.3	4.3	5.7	4.1
27	Midnight (K.B.)	2.7	4.3	3.7	4.7	4.0	4.7	4.0
28	Coventry (K.B.)	4.3	4.3	3.7	3.7	3.3	4.0	3.9
29	Apache (T.F.)	3.3	3.0	3.0	3.3	4.7	4.7	3.7
30	Arid (T.F.)	3.3	3.0	2.3	2.3	3.0	3.7	2.9
31	Bristol (K.B.)	2.3	2.7	2.0	3.0	3.0	3.7	2.8
32	Ram I (K.B.)	2.3	2.7	2.7	3.0	2.7	3.7	2.8
33	Glade (K.B.)	2.7	3.3	2.3	2.3	2.7	3.3	2.8
34	Chateau (K.B.)	2.0	2.0	2.3	2.0	2.0	2.7	2.2
35	Nassau (K.B.)	2.7	2.3	1.3	1.7	2.0	2.7	2.1
	$LSD_{0.05}$	1.7	2.1	1.9	1.9	2.3	2.0	1.7

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

Table 2. 1996 Visual quality[1] data for turfgrass culitvars in the 1994 Shade Trial.

	Cultivar	May	June	July	Aug	Sept	Oct	Mean
1	Saber	7.0	6.3	5.7	5.3	6.7	7.3	6.4
2	Cypress	6.7	6.7	5.3	5.0	7.0	6.7	6.2
3	Polder	6.7	6.3	5.3	5.7	6.7	6.7	6.2
4	SR 5100	6.3	5.3	4.7	5.0	6.3	6.7	5.7
5	Southport	5.0	4.0	4.3	3.7	5.7	6.0	4.8
6	Bridgeport	5.3	4.0	4.0	3.3	5.3	6.0	4.7
7	Banner	5.7	4.0	3.3	4.3	5.3	5.7	4.7
8	Silvana	4.3	4.0	4.0	4.0	5.0	6.3	4.6
9	Waldina	4.3	4.0	4.3	3.7	4.0	5.7	4.3
10	Midnight	4.7	4.7	4.0	4.0	3.7	4.3	4.2
11	Molinda	4.3	3.0	3.7	3.0	4.7	6.3	4.2
12	Ascot	3.0	4.3	3.7	3.7	4.3	5.3	4.1
13	Banner II	4.7	3.7	3.7	3.7	4.0	4.7	4.1
14	Nordic	4.0	3.0	3.0	4.0	4.3	5.3	3.9
15	Shadow	4.0	3.7	3.0	3.0	4.0	5.7	3.9
16	Bonanza	4.7	3.3	3.7	3.0	3.7	5.0	3.9
17	Spartan	3.3	3.0	3.7	3.3	4.0	5.3	3.8
18	Shenandoah	3.7	3.0	3.3	3.7	4.0	5.0	3.8
19	Victory	4.7	2.7	2.7	2.7	3.7	5.0	3.6
20	Flyer	4.0	3.3	3.3	2.7	3.7	4.7	3.6
21	Bonanza II	3.0	3.7	3.3	3.0	4.0	4.7	3.6
22	Coventry	5.0	3.3	2.7	3.0	3.0	3.3	3.4
23	Arid	3.3	3.3	3.7	2.7	3.7	3.7	3.4
24	Glade	4.3	3.0	2.7	3.0	3.0	4.0	3.3
25	Rebel II	3.3	2.3	3.0	3.3	3.7	4.3	3.3
26	Bristol	3.3	3.7	2.7	2.3	3.3	3.7	3.2
27	Buckingham	2.3	3.0	3.0	3.0	2.3	3.7	2.9
28	Brigade	3.7	2.0	2.3	2.3	2.7	4.3	2.9
29	Adobe	2.3	2.3	2.3	2.3	2.7	3.0	2.5
30	Mirage	3.0	2.0	2.0	2.0	2.3	3.0	2.4
31	Rebel	2.3	2.3	2.3	2.3	2.0	2.7	2.3
32	Falcon II	2.7	2.3	2.3	1.7	2.0	3.0	2.3
33	Bonsai	1.7	1.7	2.0	2.0	2.0	3.0	2.1
34	Aztec	2.0	2.0	2.3	1.7	2.7	2.0	2.1
35	Supranova	1.0	1.7	1.0	1.7	1.7	2.3	1.6
	$LSD_{0.05}$	2.2	1.7	2.0	2.0	2.3	2.1	1.7

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

Table 3. The average quality ratings for grasses in the Shade Trial: 1989 - 1996.

	Cultivar	1989	1990	1991	1992	1993	1994	1995	1996	Ave.*
1	Victor (C.F.)	6.3	6.1	4.3	5.9	7.2	7.1	6.6	6.6	6.38
2	ST-2 (SR 3000) (H.F.)	7.3	7.3	5.1	6.3	5.7	6.1	6.1	5.5	6.30
3	Mary (C.F.)	6.2	6.3	3.9	6.4	6.7	6.6	6.7	6.3	6.16
4	Waldorf (C.F.)	6.2	6.2	5.5	7.3	5.9	6.2	5.8	6.1	6.14
5	BAR FO 81-225 (H.F.)	6.9	7.1	4.9	6.5	5.5	6.1	6.5	5.7	6.10
6	Rebel (T.F.)	6.6	6.6	5.3	6.0	6.9	5.9	5.7	4.6	6.03
7	Jamestown (C.F.)	6.0	6.0	4.2	6.0	6.5	6.6	6.2	5.9	6.01
8	Estica (C.R.F.)	7.0	7.0	4.1	5.6	6.6	6.1	5.6	4.3	6.00
9	Bonanza (T.F.)	6.3	6.4	6.5	6.9	6.3	6.2	5.2	4.2	5.98
10	Sabre (Poa trivialis)	5.4	5.0	6.9	6.4	7.4	6.2	4.8	4.9	5.93
11	Shadow (C.F.)	5.5	5.2	4.7	6.0	6.6	6.6	5.9	5.9	5.92
12	Falcon (T.F.)	6.4	6.3	5.3	6.0	6.5	6.3	5.2	4.2	5.87
13	Apache (T.F.)	6.6	6.8	6.0	6.0	6.3	5.4	5.3	3.7	5.87
14	Atlanta (C.F.)	5.7	5.7	4.9	6.1	5.8	5.7	5.5	6.7	5.86
15	Waldina (H.F.)	6.8	6.8	4.1	5.5	5.5	5.8	5.8	5.1	5.83
16	Biljart (H.F.)	7.5	7.0	5.1	6.1	5.0	5.1	5.1	4.8	5.82
17	Pennlawn (C.R.F.)	5.8	5.6	4.7	6.2	6.3	5.5	5.5	5.9	5.80
18	Rebel II (T.F.)	6.6	6.8	5.3	5.6	6.1	6.2	5.1	4.3	5.78
19	Arid (T.F.)	6.3	6.3	6.0	7.1	6.7	5.6	4.7	2.9	5.71
20	Banner (C.F.)	5.6	6.0	4.5	5.0	6.0	5.6	5.3	6.2	5.68
21	Spartan (H.F.)	6.9	7.2	3.5	4.2	4.7	5.1	4.9	5.0	5.46
22	Wintergreen (C.F.)	5.6	5.5	4.6	5.9	5.0	5.0	5.0	6.0	5.41
23	Agram (C.F.)	5.6	5.3	3.9	5.9	5.4	5.3	5.1	5.5	5.41
24	Ensylva (C.R.F.)	5.4	5.2	4.0	5.1	5.9	5.4	4.4	5.3	5.31
25	Koket (C.F.)	5.4	4.9	4.2	5.2	5.2	5.7	4.6	4.6	5.12
26	Scaldis (H.F.)	6.5	5.8	3.7	5.2	4.6	4.4	4.8	4.1	5.07
27	Coventry (K.B.)	5.3	5.3	5.7	5.4	6.0	4.7	3.8	3.9	5.00
28	RAM I (K.B.)	6.1	5.2	5.0	5.0	5.9	4.3	3.3	2.8	4.87
29	Chateau (K.B.)	5.8	5.5	6.2	5.5	5.2	4.1	3.0	2.2	4.77
30	Highlight (C.F.)	4.9	4.8	3.5	4.6	5.0	4.8	4.7	4.9	4.70
31	Midnight (K.B.)	3.8	4.7	5.9	5.5	6.4	4.6	4.4	4.0	4.63
32	Glade (K.B.)	5.3	5.4	5.5	4.8	5.3	3.3	2.8	2.8	4.48
33	Reliant (H.F.)	3.7	3.9	3.1	3.5	4.2	4.9	4.8	4.9	4.26
34	Bristol (K.B.)	4.7	4.3	3.9	3.9	5.0	4.1	3.6	2.8	4.12
35	Nassau (K.B.)	4.1	3.7	3.4	3.8	4.3	3.3	2.4	2.1	3.49

Quality Based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
*Average includes 1988 data (not listed).
Compiled by Gary Peterson, ISU Extension Commercial Horticulture Field Specialist

Fairway Height Bentgrass Study - Established 1993

Nick E. Christians and James R. Dickson

This is the third 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-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 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 1996 season. Visual quality is based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Data on genetic color (Gcolor), leaf texture (Ltex), greenup, winter kill (Wkill), and (Grnup) ratings are also included.

The highest rated cultivar in 1996 was 18th Green followed by Trueline and Lopez. The first thirteen cultivars are statistically the same.

Table 1. The 1996 quality ratings for the fairway height bentgrass study.

						Quality						
	Cultivar	Gcolor	Ltex	Wkill	Grnup	May	June	July	Aug	Sept	Oct	Mean
1	18th Green	8.0	6.7	56.7	6.0	6.7	7.3	7.0	6.7	6.7	6.0	6.7
2	Trueline	6.7	6.3	50.0	5.3	6.3	7.0	6.7	6.3	7.3	6.3	6.7
3	Lopez	7.7	7.0	50.0	5.3	6.0	7.3	6.7	6.3	6.7	6.3	6.6
4	Penncross	7.0	5.7	50.0	5.3	5.3	6.7	7.3	5.7	6.7	6.3	6.3
5	Pro/Cup	7.3	6.7	63.3	5.3	5.0	7.0	7.0	6.3	6.3	6.0	6.3
6	Crenshaw	7.7	7.0	63.3	6.0	4.0	6.7	6.7	6.7	6.7	6.3	6.2
7	Seaside	6.7	6.0	23.3	7.7	6.7	5.7	5.7	5.3	7.0	6.7	6.2
8	OM-AT-90163	6.3	7.0	33.3	7.3	6.7	6.0	5.3	5.3	6.7	6.3	6.1
9	Providence	7.7	6.7	56.7	5.0	5.3	6.3	6.3	6.3	6.0	6.0	6.1
10	Southshore	6.7	6.7	70.0	4.7	3.3	6.0	6.3	6.3	7.3	7.0	6.1
11	ISI-AT-90162*	6.7	7.0	36.7	6.7	6.0	6.0	6.0	5.0	6.0	7.0	6.0
12	Penneagle	7.7	7.3	70.0	4.3	4.0	6.7	6.3	6.7	6.0	6.0	5.9
13	SR 7100	6.7	7.3	36.7	7.7	5.7	7.0	5.3	5.3	6.0	6.3	5.9
14	Cato	7.7	6.7	70.0	5.0	3.0	6.0	6.7	6.0	6.3	6.0	5.7
15	Bar WS 42102	7.0	8.0	76.7	4.7	3.0	5.3	6.3	5.3	7.0	6.3	5.6
16	Penn G-2 (G-2)	6.3	6.3	76.7	5.3	3.3	5.0	6.0	5.0	7.0	7.0	5.6
17	Seaside II (DF-1)	7.0	7.0	80.0	4.3	2.7	6.0	6.3	6.3	6.0	6.3	5.6
18	Tendenz	6.3	7.0	40.0	7.0	6.0	5.3	5.0	5.0	5.3	6.7	5.6
19	Bar AS 492	6.3	7.3	73.3	4.7	3.7	5.3	5.3	5.3	5.7	7.0	5.4
20	Penn G-6 (G-6)	6.7	6.7	80.0	4.3	2.7	5.7	6.0	6.0	5.3	6.7	5.4
21	Exeter	7.0	6.7	66.7	6.7	4.0	5.0	5.3	5.0	5.7	6.7	5.3
	$LSD_{(0.05)}$	2.2	NS	14.7	0.9	1.6	1.3	1.5	1.1	2.9	NS	0.9

* Colonial Bentgrass

Gcolor (Genetic color): 9 = dark green and 1 = light green. Ltex (Leaf texture): 9 = fine and 1 = coarse.

Wkill (Winter kill): numbers represent % area killed. Grnup (Greenup): 9 = best and 1 = poorest greenup.

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

NS = means are not significantly different at the 0.05 level.

Green Height Bentgrass Cultivar Trial (Native Soil) - Established 1993

Nick E. Christians and James R. Dickson

This is the third 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.

Pennlinks was the highest rated cultivar in 1996 (Table 1). The first 25 cultivars are statistically the same. Data on genetic color (Gcolor), leaf texture (Ltex), green up (Grnup), and winter kill (Wkill) ratings are also included in Table 1. Winter kill in the spring of 1996 was particularly bad. As can be seen from the data, some cultivars sustained much more damage than others.

Table 1. The 1996 ratings for the green height bentgrass trial.

						Quality						
	Cultivar	Gcolor	Ltex	Wkill	Grnup	May	June	July	Aug	Sept	Oct	Mean
1	Pennlinks	7.3	6.0	50.0	6.7	5.0	6.7	6.3	6.0	6.3	6.0	6.1
2	Providenc	7.7	6.3	70.0	6.0	3.7	6.7	7.0	6.0	6.7	6.3	6.1
3	Penn A-1(A-1)	7.7	8.0	63.3	6.7	4.3	6.0	6.7	6.7	6.3	6.0	6.0
4	18th Green	7.7	6.7	63.3	6.7	4.0	6.7	6.7	6.0	6.0	6.0	5.9
5	Regent	6.3	6.7	46.7	6.0	4.0	6.3	6.3	5.7	6.3	7.0	5.9
6	Southshore	7.3	7.0	56.7	7.0	4.3	5.7	6.0	6.3	7.0	6.3	5.9
7	Imperial (Syn 92-5)	7.3	8.0	63.3	6.3	4.0	5.3	6.0	6.0	6.3	7.3	5.8
8	Lofts L-93(1-93)	7.0	6.0	53.3	6.7	4.7	5.7	7.0	6.3	5.7	5.7	5.8
9	Century (Syn 92-1)	6.3	8.0	53.3	6.0	3.0	6.0	5.7	6.7	6.3	6.7	5.7
10	Msueb	6.0	6.0	46.7	6.3	4.7	6.0	6.0	5.3	6.0	6.3	5.7
11	Penncross	7.0	5.3	43.3	6.0	4.0	6.3	6.3	5.3	6.0	6.0	5.7
12	Cato	7.3	6.7	76.7	6.7	3.0	5.0	6.3	6.0	6.7	6.3	5.6
13	Crenshaw	7.3	7.3	73.3	6.3	3.0	5.3	6.3	6.3	6.0	6.3	5.6
14	DG-P	6.7	6.0	53.3	6.3	4.0	6.3	6.0	5.0	6.0	6.3	5.6
15	ISI-AP-89150	7.0	6.7	50.0	7.0	4.0	5.3	6.0	5.3	6.0	6.7	5.6
16	Penn G-2 (G-2)	7.0	7.0	76.7	7.0	3.0	4.7	6.3	5.7	7.0	7.0	5.6
17	Pro/Cup	6.7	6.0	46.7	6.3	3.7	6.0	6.0	5.7	6.3	6.0	5.6
18	SR 1020	7.0	6.3	73.3	5.7	3.7	5.3	6.0	5.7	6.3	6.7	5.6
19	Penn A-4(A-4)	7.0	7.3	70.0	6.0	3.0	5.3	6.3	6.0	6.0	6.3	5.5
20	Syn 92-2	6.7	7.0	70.0	6.0	3.3	5.3	5.3	6.0	6.0	7.0	5.5
21	Bar WS 42102	7.0	7.7	76.7	6.3	2.7	5.0	6.0	5.7	6.7	6.7	5.4
22	Mariner (Syn-1-88)	6.0	5.7	46.7	6.7	4.3	5.7	5.0	5.7	6.0	5.7	5.4
23	Trueline	6.3	5.3	60.0	6.7	3.7	5.3	5.7	5.3	6.7	6.0	5.4
24	Lopez	6.0	5.0	63.3	5.7	3.3	5.0	5.0	5.7	6.3	6.3	5.3
25	Penn G-6 (G-6)	6.0	7.0	76.7	5.7	2.3	5.0	5.7	6.3	6.3	5.7	5.2
26	Seaside	6.0	5.0	60.0	5.7	4.3	5.3	5.0	4.7	5.3	5.3	5.0
27	Bar AS 492	6.3	7.0	70.0	5.7	2.7	5.0	4.7	4.7	6.3	6.3	4.9
28	Tendenz	5.7	7.7	63.3	7.3	4.0	4.7	4.0	4.3	5.0	5.0	4.5
	$LSD_{(0.05)}$	2.1	1.1	22.2	2.5	2.0	1.0	1.1	1.0	2.6	3.0	0.9

Gcolor (Genetic color): 9 = dark green and 1 = light green.. Ltex (Leaf texture): 9 = fine and 1 = coarse. Wkill (Winter kill): numbers represent % area killed. Grnup(Green up): 9 = best and 1 = poorest greenup.
Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

Pre- and Postemergence Annual Weed Control Study - 1996

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

Herbicides from AgrEvo, DowElanco, Gowan, Rohm and Haas Company, and Sandoz were screened for efficacy as preemergence, early post-, and postemergence products for annual weed control in turfgrass. The study was conducted at the Iowa State University Horticulture Station north of Ames, Iowa. The experimental plot was an area of 'Nassau' Kentucky bluegrass established in 1994. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 4.5% organic matter, a pH of 6.2, 30 ppm P, and 133 ppm K.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with three replications and no barrier rows between replications. The assignment of treatments to plots was randomized.

There were a total of 46 treatments including two untreated control plots per replication (Table 1). Three experimental formulations and Pendimethalin, Team and Team/Gallery in combination with fertilizers were screened for DowElanco. NAF 191 was applied in split applications at 1.0 lb a.i./A, NAF 192 in a single application and split applications at 1.5 lb a.i./A, and NAF 193 in single applications at 2.0 lb a.i./A. Pendimethalin 0.86GR + fertilizer and Team 0.87GR + fertilizer were applied in split applications at 1.0 and 1.5 lb a.i./A. and in single applications at 1.5 and 2.0 lb a.i./A. Team/Gallery (Spring Valley) 1.09GR + fertilizer was applied in split applications at 2.04 lb a.i./A and in single applications at 2.720 lb a.i./A. The initial treatments were made preemergently before crabgrass germination and the sequential applications were made when the crabgrass was in the 1-3 tiller growth stage.

Betasan and Tupersan from the Gowan Company were applied as preemergence herbicides. Betasan 4LF was applied at 2 gal product/A and Tupersan 50WP at 20 lb product/A.

The Rohm and Haas products were applied in split applications of herbicide + fertilizer combinations. Each plot received the same amount of nitrogen when initial and sequential applications were made. Methylene urea fertilizer (39-0-0) was the fertilizer component of all formulations and also was used as the fertilizer 'blank' used to equalize the amount of applied N. Dimension 1EC was applied in single applications at 0.25 and 0.38 lb a.i./A and in split applications at 0.125 and 0.250 lb a.i./A. Three Dimension + fertilizer formulations (AD 442, AD 444, & AD 445) that contain different amounts of Dithiopyr and Dimension 1EC were used. AD 442 was applied in split applications at 0.060 lb a.i./A, AD 444 at 0.125 lb a.i./A in single and split applications, and AD 445 at 0.250 lb a.i./A in a single application. Barricade 65WG (Prodiamine) at 0.650 lb a.i./A, Pendimethalin 60WDG at 1.50 lb a.i./A in single applications, and a fertilized control were included for comparisons. Sequential applications were made 51 days after the initial application.

Barricade 65WG from Sandoz was applied as a preemergence herbicide at 0.32, 0.48, 0.65 and 0.50 lb a.i./A. The 0.50 lb treated plots received a sequential treatment 60 days after the initial treatment at a lower rate (0.25 lb a.i./A).

Acclaim Extra 68.5EW, Acclaim 120EC, and Preclaim 370.6EC were applied as early postemergence products at 0.060, 0.120, and 2.060 lb a.i./A, respectively, when the crabgrass was in the 1-3 leaf stage. These materials from AgrEvo also were applied postemergently at 0.090, 0.180, 3.090 lb a.i./A, respectively, when the crabgrass was tillering.

Dimension 1EC was applied at 0.250 lb a.i./A as a preemergence product and in split applications at 0.125 lb a.i/A and at 0.250 lb a.i./A in a single postemergence application. Dimension 1EC also was applied postemergently at 0.25 lb a.i./A with Trimec Plus at 3 fl oz product/1000 ft^2 and with

Preclaim at 3.09 lb a.i./A. Preclaim and Trimec Plus were applied alone at these same rates when the crabgrass was tillering.

Liquid formulations were applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles at 25-30 psi. The granular materials were applied using 'shaker dispensers'.

Preemergence treatments (treatments 1-32 and 39-40) were made on May 3 before crabgrass germination (Table 1). A pre-treatment survey of the plot confirmed that turf quality was uniform. The materials were 'watered in' with the irrigation system. On June 12, crabgrass plants were detected in the untreated control plots. The sequential application of granular treatments 22-32 was made on June 25 (51 days after initial application). The liquid formulations for treatments 22-32 and the early postemergence products (treatments 33-35) were applied on June 26 when the crabgrass was in the 1-3 leaf stage with no tillering. The sequential application of treatment 4 was made 60 days after the initial application on July 3. Postemergent applications (treatments 6, 8, 10, 12, 14, 15, 18, 36-38, and 40-45) were made on July 15 when the crabgrass was beginning to tiller.

The turf was examined for visual quality throughout the study. Data were taken May 9, May 22, June 13, June 26, July 3, July 22, and August 13. Turf quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 2). Kentucky bluegrass phytotoxicity was evaluated following herbicide applications using a 9 to 1 scale: 9 = no damage, 5 = uniform tip burning, 3 = severe burning & discoloration, and 1 = dead turf. Phytotoxicity data were taken July 10 following application of the early postemergence materials (Table 3). Crabgrass control was measured by counting the number of crabgrass plants in each plot on August 13 (Table 4). Crabgrass reductions were calculated by comparing crabgrass counts among the treated plots as compared with the untreated controls (treatments 1 and 46).

All data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference (LSD) test was used to compare means among the treatments.

Turf quality was equal in all treated and untreated plots in May and the first significant differences were detected on July 3 after the sequential applications for treatments 22-32 (Table 2). In these plots quality was significantly better than in the other treated and the untreated turf. By July 22, the quality improved in some plots receiving postemergence applications of herbicide + fertilizer formulations (treatments 6, 8, 15, and 18).

Mean turf quality was above the lowest acceptable rating (a '6') for all treatments including the untreated controls (Table 2). The best mean turf quality was achieved in Kentucky bluegrass treated with Pendimethalin 60WDG + fertilizer (treatment 23), Dimension 1EC + fertilizer (treatments 26 and 27), and the 'AD' experimental Dimension + fertilizer formulations (treatments 28-31).

The only bluegrass phytotoxicity was detected July 10 in plots treated with the early postemergence herbicides on June 26 (treatments 33, 34, and 35). The bluegrass had severe tip burning and was discolored (Table 3). By July 22, the turf had recovered somewhat and was given either the lowest acceptable quality rating or lower (5's and 6's). The temperatures during this period were quite high and there was only minimal rainfall. These factors probably contributed to the impact of the herbicides on the bluegrass. Turf quality in these plots did not improve by August 13.

Most herbicides significantly reduced the number of crabgrass plants when compared with the untreated controls and eighteen of the products provided ≥ 90% reductions (Table 3). Pre- and postemergence applications of some herbicides resulted in better crabgrass control than single applications (treatments 7 and 15).

Table 1. Materials, rates and timing of application for materials used in the 1996 Preemergence & Postemergence Annual Grass Control Study.

Materials	Rate lb a.i./A. (initial)	Amount of fertilizer lb/1000 ft^2 (initial)	Rate lb a.i/A (sequential)	Amount of fertilizer lb/1000 ft^2 (sequential)	Timing of applications
1. Untreated control	NA	none	NA	none	NA
2. Barricade 65WG	0.320	none	NA	none	PRE
3. Barricade 65WG	0.480	none	NA	none	PRE
4. Barricade 65WG	0.500	none	0.250	none	PRE & POST
5. Barricade 65WG	0.650	none	NA	none	PRE
6. NAF-191 0.57GR + fert	1.000	NA	1.000	NA	PRE & POST
7. NAF-192 0.86GR + fert	1.500	NA	NA	NA	PRE
8. NAF-192 0.86GR + fert	1.500	NA	1.500	NA	PRE & POST
9. NAF-193 1.15GR + fert	2.000	NA	NA	NA	PRE
10. Pendimethalin 0.86GR + fert	1.000	NA	1.000	NA	PRE & POST
11. Pendimethalin 0.86GR + fert	1.500	NA	NA	NA	PRE
12. Pendimethalin 0.86GR + fert	1.500	NA	1.500	NA	PRE & POST
13. Pendimethalin 0.86GR + fert	2.000	NA	NA	NA	PRE
14. Team 0.87GR + fertilizer	1.000	NA	1.000	NA	PRE & POST
15. Team 0.87GR + fertilizer	1.500	NA	1.500	NA	PRE & POST
16. Team 0.87GR + fertilizer	1.500	NA	NA	NA	PRE
17. Team 0.87GR + fertilizer	2.000	NA	NA	NA	PRE
18. Team 1.09GR & Gallery + fert	2.040	NA	2.040	NA	PRE & POST
19. Team 1.09GR & Gallery + fert	2.720	NA	NA	NA	PRE
20. Tupersan 50WP	20.0 lb/A	NA	NA	NA	PRE
21. Betasan 4LF	2.0 gal/A	NA	NA	NA	PRE
22. Barricade 65WG	0.650	4.0	none	4.0	PRE & POST
23. Pendimethalin 60WDG	1.500	4.0	none	4.0	PRE & POST
24. Dimension 1EC(& fertilizer)	0.250	4.0	none	4.0	PRE & POST
25. Dimension 1EC(& fertilizer)	0.380	4.0	none	4.0	PRE & POST
26. Dimension 1EC(& fertilizer)	0.125	4.0	0.125	4.0	PRE & POST
27. Dimension 1EC(& fertilizer)	0.250	4.0	0.250	4.0	PRE & POST
28. AD444 Dimension 0.072FG + fert	0.125	4.0	none	4.0	PRE & POST
29. AD445 Dimension 0.164FG + fert	0.250	3.5	none	3.5	PRE & POST
30. AD442 Dimension 0.035FG + fert	0.060	4.0	0.060	4.0	PRE & POST
31. AD444 Dimension 0.072FG + fert	0.125	4.0	0.125	4.0	PRE & POST
32. Fertilized control	NA	4.0	NA	4.0	NA
33. Acclaim Extra 68.5EW	0.060	none	NA	none	EARLY POST
34. Acclaim 120EC	0.120	none	NA	none	EARLY POST
35. Preclaim 370.6EC	2.060	none	NA	none	EARLY POST
36. Acclaim Extra 68.5Ew	0.090	none	NA	none	POST
37. Acclaim 120EC	0.180	none	NA	none	POST
38. Preclaim 370.6EC	3.090	none	NA	none	POST
39. Dimension 1EC	0.250	none	NA	none	PRE
40. Dimension 1EC	0.125	none	NA	none	PRE & POST
41. Dimension 1EC	0.250	none	NA	none	POST
42. Dimension 1EC	0.250				
+ Trimec Plus	+ 3 fl oz	none	NA	none	POST
43. Trimec Plus	3 fl oz	none	NA	none	POST
44. Dimension 1EC	0.250	none	NA	none	POST
+ Preclaim	+ 3.090				
45. Preclaim	3.090	none	NA	none	POST
46. Untreated control	NA	none	NA	none	NA

Treatments 1-32 and 39-40 were applied on May 3, trts 22-32 sequential on June 25, trt 4 sequential on July 3, and trts postemergence on 6, 8, 10, 12, 14, 15, 18, 36-38, and 40-45 on July 16.

Table 2. Visual quality[1] of Kentucky bluegrass treated with various herbicide formulations in the 1996 Preemergence & Postemergence Annual Grass Study.

	Materials	May 9	May 22	June 13	June 26	July 3	July 22	August 13	Mean quality
1.	Untreated control	9	9	8	8	7	6	6	8
2.	Barricade 65WG	9	9	8	8	7	6	5	8
3.	Barricade 65WG	9	9	8	8	7	7	6	8
4.	Barricade 65WG	9	9	8	8	7	7	6	8
5.	Barricade 65WG	9	9	8	8	7	7	7	8
6.	NAF-191 0.57GR + fert	9	9	9	8	7	8	7	8
7.	NAF-192 0.86GR + fert	9	9	9	8	7	6	6	8
8.	NAF-192 0.86GR + fert	9	9	9	8	7	8	7	8
9.	NAF-193 1.15GR + fert	9	9	8	8	7	7	6	8
10.	Pendimethalin 0.86GR + fert	9	9	8	8	7	7	6	8
11.	Pendimethalin 0.86GR + fert	9	9	9	8	7	6	6	8
12.	Pendimethalin 0.86GR + fert	9	9	8	8	7	6	7	8
13.	Pendimethalin 0.86GR + fert	9	9	9	8	7	7	6	8
14.	Team 0.87GR + fert	9	9	8	8	7	7	6	8
15.	Team 0.87GR + fert	9	9	9	8	7	8	7	8
16.	Team 0.87GR + fert	9	9	8	8	7	6	6	8
17.	Team 0.87GR + fert	9	9	8	8	7	7	6	8
18.	Team 1.09GR & Gallery + fert	9	9	8	8	7	8	6	8
19.	Team 1.09GR & Gallery + fert	9	9	8	8	7	6	6	8
20.	Tupersan 50WP	9	9	8	8	7	6	6	8
21.	Betasan 4LF	9	9	8	8	7	7	6	8
22.	Barricade 65WG (& fert)	9	9	9	8	9	8	8	8
23.	Pendimethalin 60WDG (& fert)	9	9	9	8	9	8	8	9
24.	Dimension 1EC (& fert)	9	9	9	8	9	7	7	8
25.	Dimension 1EC (& fert)	9	9	9	8	9	8	7	8
26.	Dimension 1EC (& fert)	9	9	9	8	9	9	7	9
27.	Dimension 1EC (& fert)	9	9	9	8	9	9	7	9
28.	AD444 0.072FG + fert	9	9	9	8	9	9	7	9
29.	AD445 0.164FG + fert	9	9	9	8	9	9	8	9
30.	AD442 0.035FG + fert	9	9	9	8	9	9	8	9
31.	AD444 0.072FG + fert	9	9	9	8	9	9	8	9
32.	Fertilized control	9	9	9	8	9	8	7	8
33.	Acclaim Extra 68.5EW	9	9	8	8	6	5	5	7
34.	Acclaim 120EC	9	9	8	8	6	6	6	7
35.	Preclaim 370.6EC	9	9	8	8	6	6	5	7
36.	Acclaim Extra 68.5EW	9	9	8	8	7	6	6	7
37.	Acclaim 120EC	9	9	8	8	7	5	5	7
38.	Preclaim 370.6EC	9	9	8	8	7	6	6	7
39.	Dimension 1EC	9	9	8	8	7	7	6	8
40.	Dimension 1EC	9	9	8	8	7	5	5	7
41.	Dimension 1EC	9	9	8	8	6	6	5	7
42.	Dimension 1EC + Trimec Plus	9	9	8	8	7	5	6	7
43.	Trimec Plus	9	9	8	8	7	7	6	8
44.	Dimension 1EC + Preclaim	9	9	8	8	7	6	5	7
45.	Preclaim	9	9	8	8	7	6	6	8
46.	Untreated control	9	9	8	8	7	6	6	8
	$LSD_{0.05}$	NS	NS	1	NS	1	1	1	0.3

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

NS = means are not significantly different at the 0.05 level.

Treatments 1-32 and 39-40 were applied on May 3, trts 22-32 sequential on June 25, trt 4 sequential on July 3, and trts postemergence on 6, 8, 10, 12, 14, 15, 18, 36-38, and 40-45 on July 16.

Table 3. Kentucky bluegrass phytotoxicity[1] in the 1996 Preemergence & Postemergence Annual Grass Study.

	Materials	Rate (lb a.i./A) initial / sequential	Timing of application	Phytotoxicity on July 10
1.	Untreated control	NA	NA	9
2.	Barricade 65WG	0.320 / NA	PRE	9
3.	Barricade 65WG	0.480 / NA	PRE	9
4.	Barricade 65WG	0.500 / 0.250	PRE & POST	9
5.	Barricade 65WG	0.650 / NA	PRE	9
6.	NAF-191 0.57GR + fertilizer	1.000 / 1.000	PRE & POST	9
7.	NAF-192 0.86GR + fertilizer	1.500 / NA	PRE	9
8.	NAF-192 0.86GR + fertilizer	1.500 / 1.500	PRE & POST	9
9.	NAF-193 1.15GR + fertilizer	2.000 / NA	PRE	9
10.	Pendimethalin 0.86GR + fertilizer	1.000 / 1.000	PRE & POST	9
11.	Pendimethalin 0.86GR + fertilizer	1.500 / NA	PRE	9
12.	Pendimethalin 0.86GR + fertilizer	1.500 / 1.500	PRE & POST	9
13.	Pendimethalin 0.86GR + fertilizer	2.000 / NA	PRE	9
14.	Team 0.87GR + fertilizer	1.000 / 1.000	PRE & POST	9
15.	Team 0.87GR + fertilizer	1.500 / 1.500	PRE & POST	9
16.	Team 0.87GR + fertilizer	1.500 / NA	PRE	9
17.	Team 0.87GR + fertilizer	2.000 / NA	PRE	9
18.	Team 1.09GR & Gallery + fertilizer	2.040 / 2.040	PRE & POST	9
19.	Team 1.09GR & Gallery + fertilizer	2.720 / NA	PRE	9
20.	Tupersan 50WP	20.0 lb/A / NA	PRE	9
21.	Betasan 4LF	2.0 gal/A / NA	PRE	9
22.	Barricade 65WG (& fertilizer)	0.650 & fert	PRE & POST	9
23.	Pendimethalin 60WDG (& fertilizer)	1.500 & fert	PRE & POST	9
24.	Dimension 1EC (& fertilizer)	0.250 & fert	PRE & POST	9
25.	Dimension 1EC (& fertilizer)	0.380 & fert	PRE & POST	9
26.	Dimension 1EC (& fertilizer)	0.125 / 0.125	PRE & POST	9
27.	Dimension 1EC (& fertilizer)	0.250 / 0.250	PRE & POST	9
28.	AD444 0.072FG + fertilizer	0.125 / fert	PRE & POST	9
29.	AD445 0.164FG + fertilizer	0.250 / fert	PRE & POST	9
30.	AD442 0.035FG + fertilizer	0.060 / 0.060	PRE & POST	9
31.	AD444 0.072FG + fertilizer	0.125 / 0.125	PRE & POST	9
32.	Fertilized control	fert / fert	PRE & POST	9
33.	Acclaim Extra 68.5EW	0.060 / NA	EARLY POST	3
34.	Acclaim 120EC	0.120 / NA	EARLY POST	3
35.	Preclaim 370.6EC	2.060 / NA	EARLY POST	3
36.	Acclaim Extra 68.5EW	0.090 / NA	POST	9
37.	Acclaim 120EC	0.180 / NA	POST	9
38.	Preclaim 370.6EC	3.090 / NA	POST	9
39.	Dimension 1EC	0.250 / NA	PRE	9
40.	Dimension 1EC	0.125 / 0.125	PRE & POST	9
41.	Dimension 1EC	0.250/ NA	POST	9
42.	Dimension 1EC + Trimec Plus	0.250 + 3 fl oz/ NA	POST	9
43.	Trimec Plus	3 fl oz / NA	POST	9
44.	Dimension 1EC + Preclaim	0.250 + 3.090/ NA	POST	9
45.	Preclaim	3.090 / NA	POST	9
46.	Untreated control	NA	NA	9
	$LSD_{0.05}$			NS[2]

[1] Kentucky bluegrass phytotoxicity was determined following herbicide applications using a 9 to 1 scale: 9 = no damage, 5 = tip burning, 3 = severe burning & discoloration, and 1 = dead turf.
Treatments 1-32 and 39-40 were applied on May 3, trts 22-32 sequential on June 25, trt 4 sequential on July 3, and trts postemergence on 6, 8, 10, 12, 14, 15, 18, 36-38, and 40-45 on July 16.
[2] NS = LSD test is not valid for these data because there is no error among the replications.

Table 4. Number of crabgrass plants and percentage reductions[1] in crabgrass numbers in Kentucky bluegrass in the 1996 Preemergence & Postemergence Annual Grass Study on August 13.

	Materials	Rate (lb a.i./A) initial / sequential	Timing of application	Number of crabgrass plants per plot	Percent reduction in crabgrass plants per plot[1]
1.	Untreated control	NA	NA	83	0
2.	Barricade 65WG	0.320 / NA	PRE	6	94
3.	Barricade 65WG	0.480 / NA	PRE	6	95
4.	Barricade 65WG	0.500 / 0.250	PRE & POST	0	100
5.	Barricade 65WG	0.650 / NA	PRE	2	98
6.	NAF-191 0.57GR + fert	1.000 / 1.000	PRE & POST	66	38
7.	NAF-192 0.86GR + fert	1.500 / NA	PRE	92	13
8.	NAF-192 0.86GR + fert	1.500 / 1.500	PRE & POST	24	77
9.	NAF-193 1.15GR + fert	2.000 / NA	PRE	15	86
10.	Pendimethalin 0.86GR + fert	1.000 / 1.000	PRE & POST	33	69
11.	Pendimethalin 0.86GR + fert	1.500 / NA	PRE	37	65
12.	Pendimethalin 0.86GR + fert	1.500 / 1.500	PRE & POST	67	37
13.	Pendimethalin 0.86GR + fert	2.000 / NA	PRE	32	70
14.	Team 0.87GR + fert	1.000 / 1.000	PRE & POST	39	64
15.	Team 0.87GR + fert	1.500 / 1.500	PRE & POST	22	80
16.	Team 0.87GR + fert	1.500 / NA	PRE	70	34
17.	Team 0.87GR + fert	2.000 / NA	PRE	16	85
18.	Team 1.09GR & Gallery + fert	2.040 / 2.040	PRE & POST	36	66
19.	Team 1.09GR & Gallery + fert	2.720 / NA	PRE	45	58
20.	Tupersan 50WP	20.0 lb/A / NA	PRE	110	0
21.	Betasan 4LF	2.0 gal/A / NA	PRE	5	96
22.	Barricade 65WG (& fert)	0.650 & fert	PRE & POST	1	99
23.	Pendimethalin 60WDG (& fert)	1.500 & fert	PRE & POST	31	71
24.	Dimension 1EC (& fert)	0.250 & fert	PRE & POST	26	75
25.	Dimension 1EC (& fert)	0.380 & fert	PRE & POST	3	97
26.	Dimension 1EC (& fert)	0.125 / 0.125	PRE & POST	3	97
27.	Dimension 1EC (& fert)	0.250 / 0.250	PRE & POST	0	100
28.	AD444 0.072FG + fert	0.125 / fert	PRE & POST	18	83
29.	AD445 0.164FG + fert	0.250 / fert	PRE & POST	5	96
30.	AD442 0.035FG + fert	0.060 / 0.060	PRE & POST	1	99
31.	AD444 0.072FG + fert	0.125 / 0.125	PRE & POST	1	99
32.	Fertilized control	fert / fert	PRE & POST	58	45
33.	Acclaim Extra 68.5EW	0.060 / NA	EARLY POST	33	69
34.	Acclaim 120EC	0.120 / NA	EARLY POST	43	59
35.	Preclaim 370.6EC	2.060 / NA	EARLY POST	1	99
36.	Acclaim Extra 68.5EW	0.090 / NA	POST	8	92
37.	Acclaim 120EC	0.180 / NA	POST	5	95
38.	Preclaim 370.6EC	3.090 / NA	POST	2	98
39.	Dimension 1EC	0.250 / NA	PRE	29	72
40.	Dimension 1EC	0.125 / 0.125	PRE & POST	94	11
41.	Dimension 1EC	0.250 / NA	POST	40	62
42.	Dimension 1EC + Trimec Plus	0.250+3 fl oz/NA	POST	0	100
43.	Trimec Plus	3 fl oz / NA	POST	85	19
44.	Dimension 1EC + Preclaim	0.250+3.090/NA	POST	1	99
45.	Preclaim	3.090 / NA	POST	44	58
46.	Untreated control	NA	NA	128	0
	$LSD_{0.05}$			46	43

[1] Percent reduction in crabgrass counts were calculated as the mean number of crabgrass plants per plot compared with the mean number in the untreated controls (treatments 1 and 46).

Treatments 1-32 and 39-40 were applied on May 3, trts 22-32 sequential on June 25, trt 4 sequential on July 3, and trts postemergence on 6, 8, 10, 12, 14, 15, 18, 36-38, and 40-45 on July 16.

Postemergence Annual Weed Control Study - 1996

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

Herbicides from AgrEvo and Rohm and Haas Company were screened for efficacy as early post- and postemergence annual weed control products in turfgrass. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was an area of 'common' Kentucky bluegrass. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 2.5% organic matter, a pH of 6.9, 7 ppm P, and 87 ppm K. Supplemental irrigation was used to keep the turf in good growing condition.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with three replications and 12 treatments. The assignment of treatments to plots was randomized. There were 11 herbicide treatments and an untreated control. Acclaim Extra 68.5EW, Acclaim 120EC, and Preclaim 370.6EC were applied as early postemergence products at 0.06, 0.12, and 2.06 lb a.i./A, respectively, and as postemergence products at 0.09, 0.18, and 3.09 lb a.i./A, respectively. Dimension 1EC was applied as a postemergence herbicide alone at 0.25 lb a.i./A and at this same rate in combination with Trimec Plus at 3 fl oz/1000 ft^2 and Preclaim at 3.09 lb a.i./A. Trimec Plus and Preclaim also were applied alone at these same rates (Table 1).

A pre-treatment survey of the experimental plot indicated that there was a large crabgrass population. The Kentucky bluegrass was uniform in quality throughout the plot. Early post- applications were made June 4. The crabgrass was in the 1-3 leaf stage and there was no evidence of tillering. The postemergence treatments were made July 12 when the crabgrass was in the 1-2 tiller growth stage.

The plot was periodically examined for turf quality and phytotoxicity. Turf quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Visual quality data were taken June 7, June 25, July 3, July 15, July 23, July 30, and August 8 (Table 1). The plot was checked for phytotoxicity following the early post- and postemergence applications.

Effectiveness of the herbicides was measured by estimating the percentage of crabgrass cover in each plot on July 23, July 30, and August 8 (Table 2). Percentage reductions in crabgrass cover were calculated by comparing crabgrass counts from treated turf with those from the untreated controls.

In addition, broadleaf weed populations were examined even though the distribution was sporadic. The number of spurge and oxalis plants per plot was counted on August 8 (Table 3).

All data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means comparisons were made using Fisher's Least Significant Difference test (LSD).

There were no quality differences among the treated and untreated plots and turf quality remained above the lowest acceptable rating (a '6'). throughout the duration of the study (Table 1). Following the early post- and postemergence applications, the turf treated with Preclaim had a yellow coating. This coloration was not evident when the turf was checked for phytotoxicity three days after application (June 7 and July 15). There were no phytotoxic symptoms on any treated bluegrass.

All of the herbicides provided significant crabgrass control when compared with the untreated controls. Six of the products reduced crabgrass cover by > 95% (Table 2).

The oxalis and spurge data do not indicate significant control by any herbicides when compared with the untreated controls because of low numbers of these plants in the control plots (Table 3).

Table 1. Visual quality[1] of Kentucky bluegrass treated with early post- and postemergence herbicide products for the Postemergence Annual Weed Control Study.

	Material	Rate lb a.i./A.	Timing of application	June 7	June 25	July 3	July 15	July 23	July 30	Aug 8
1.	Untreated control	NA	NA	7	7	6	7	7	7	7
2.	Acclaim Extra 68.5EW[1]	0.06	EARLY POST	7	7	6	7	7	7	7
3.	Acclaim 120EC	0.12	EARLY POST	7	7	6	7	7	7	7
4.	Preclaim 370.6EC	2.06	EARLY POST	7	7	6	7	7	7	7
5.	Acclaim Extra 68.5EW	0.09	POST	7	7	6	7	7	7	7
6.	Acclaim 120EC	0.18	POST	7	7	6	7	7	7	7
7.	Preclaim 370.6EC	3.09	POST	7	7	6	7	7	7	7
8.	Dimension 1EC	0.25	POST	7	7	6	7	7	7	7
9.	Dimension 1EC	0.25								
	+ Trimec Plus	+ 3 fl oz	POST	7	7	6	7	7	7	7
10.	Trimec Plus	3 fl oz	POST	7	7	6	7	7	7	7
11.	Dimension 1EC	0.25								
	+ Preclaim	+ 3.09	POST	7	7	6	7	7	7	7
12.	Preclaim	3.09	POST	7	7	6	7	7	7	7
	$LSD_{0.05}$			NS	NS	NS	NS	NS	NS	NS

[1]Visual quality was assessed on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
EARLY POST applications were made on June 4 and POST on July 12, 1996.
NS = means are not significantly different at the 0.05 level.

Table 2. Percent crabgrass cover[1] and mean percentage reduction in crabgrass cover in Kentucky bluegrass treated with early post- and postemergence herbicides for the Postemergence Annual Weed Control Study.

	Material	Rate lb a.i./A.	Timing of application	Percentage crabgrass cover July 23	July 30	Aug 8	Mean cover	Mean reduction
1.	Untreated control	NA	NA	48	65	65	59	0
2.	Acclaim Extra 68.5EW	0.06	EARLY POST	10	18	18	16	74
3.	Acclaim 120EC	0.12	EARLY POST	10	15	15	13	77
4.	Preclaim 370.6EC	2.06	EARLY POST	1	2	1	1	98
5.	Acclaim Extra 68.5EW	0.09	POST	1	1	1	1	98
6.	Acclaim 120EC	0.18	POST	1	1	1	1	98
7.	Preclaim 370.6EC	3.09	POST	1	1	1	1	99
8.	Dimension 1EC	0.25	POST	30	40	52	41	31
9.	Dimension 1EC + Trimec Plus	0.25 + 3 fl oz	POST	18	12	15	15	74
10.	Trimec Plus	3 fl oz	POST	27	17	20	21	64
11.	Dimension 1EC + Preclaim	0.25 + 3.09	POST	4	1	1	2	97
12.	Preclaim	3.09	POST	1	1	2	1	98
	$LSD_{0.05}$			13	12	9	11	18

[1]These values represent the area per plot covered by crabgrass.
EARLY POST applications were made on June 4 and POST on July 12, 1996.

Table 3. Number of oxalis and spurge plants[1] in Kentucky bluegrass treated with early post- and postemergence herbicide products for the Postemergence Annual Weed Control Study.

	Material	Rate lb a.i./A.	Timing of application	Number of Oxalis	Number of Spurge
1.	Untreated control	NA	NA	2	1
2.	Acclaim Extra 68.5EW	0.06	EARLY POST	5	5
3.	Acclaim 120EC	0.12	EARLY POST	6	7
4.	Preclaim 370.6EC	2.06	EARLY POST	0	0
5.	Acclaim Extra 68.5EW	0.09	POST	11	3
6.	Acclaim 120EC	0.18	POST	7	2
7.	Preclaim 370.6EC	3.09	POST	0	0
8.	Dimension 1EC	0.25	POST	2	0
9.	Dimension 1EC + Trimec Plus	0.25 + 3 fl oz	POST	0	0
10.	Trimec Plus	3 fl oz	POST	0	0
11.	Dimension 1EC + Preclaim	0.25 + 3.09	POST	0	0
12.	Preclaim	3.09	POST	2	1
	$LSD_{0.05}$			5	4

[1]These values represent the number of plants per plot.
EARLY POST applications were made on June 4 and POST on July 12, 1996.

1995 *Poa annua* Control in Creeping Bentgrass Greens - Year 2

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

Several herbicides were evaluated throughout the fall of 1995 and the spring of 1996 for their efficacy in controlling *Poa annua* in green height creeping bentgrass. The plot was located on an established 'Penncross' creeping bentgrass practice green at Veenker Memorial Golf Course in Ames, Iowa with 60-80% infestation of *Poa annua.*

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft and three replications were conducted. There were six treatments including an untreated control, Turf Enhancer 2SC [Paclobutrazol (TGR)], Proturf high K fertilizer (15-0-29) + Prograss, High K fertilizer (15-0-29) + Turf Enhancer, Prograss 1EC (Ethofumesate) at two rates, and Primo 1EC (Table 1). Liquid formulations were applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles at 25-30 psi.. The granular materials were applied using cardboard containers as 'shaker dispensers'.

Weather conditions were highly variable during this study. Rainfall was sporadic and temperature fluctuations were large. Supplemental irrigation was used to keep the bentgrass in good growing condition.

In September and October of 1995, Turf Enhancer 2SC was applied at 8 fl oz/A and Proturf fertilizer + Turf Enhancer at 0.125 lb a.i./A. Spring 1996 applications were on April 22, June 4, and July 10. Prograss 1.5EC was applied at 0.380 and 0.560 lb a.i./A and Proturf fertilizer + Prograss at 0.380 lb a.i./A in September, October, and November 1995 and April 1996. Primo 1EC was applied in the fall of 1995 at the rate of 0.3 fl oz/1000 ft^2, in April 1996 at 0.25 fl oz/1000 ft^2 and in June and July at 0.30 fl oz/1000 ft^2. On May 9 the plot was fertilized with Nutralene at 1/2 lb N/1000 ft^2. Potassium also was applied at 1/2 lb/1000 ft^2. Proturf fertilizer (15-0-30) was not applied to the untreated control plots.

The first spring treatments were made April 22. Sequential applications were made June 4. The last 1996 applications were made July 10. The materials were watered in with the irrigation following each application.

On April 12, green up had occurred and *Poa annua* germination was observed. There were obvious differences in quality among the plots on April 16. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Subsequent visual quality data were taken on May 9 and May 30.

Poa annua control was measured by determining percentage of *Poa annua* cover per plot (Table 2). The first *Poa annua* data were taken April 16 and subsequent data were taken May 9, May 30, June 12, July 3, July 31, and August 29.

Data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

Several treatments significantly reduced turf quality on April 16, 1996 (Table 1). These reductions were likely due to loss of *Poa annua* during the winter in treated plots (Table 2). No other reductions of turf quality below acceptable levels were observed during the rest of the season with the exception of Primo 1EC on June 10 (Table 1).

Primo was the only treatment that did not significantly reduce *Poa annua* during the 1996 season (Table 2). Prograss 1.5EC at 0.56 lb a.i./A was the most effective treatment with an average reduction of 81% as compared to the untreated control (47% to 9%). Turf Enhancer 2SC reduced *Poa annua* an average 45% without added K fertilizer and 57% with added K fertilizer.

Table 1. Visual quality[1] of Kentucky bluegrass treated with herbicide and herbicide + fertilizer formulations in the 1995-1996 Green Height Bentgrass *Poa annua* Control Study.

Material	Rate lb a.i./A	Spring applications[2]	April 16	May 9	June 10	Mean quality
1. Untreated control	NA	NA	7	9	7	8
2. Turf Enhancer 2SC	0.125	April, June, July	4	7	7	6
3. Proturf fertilizer + Prograss	0.380	April	5	8	8	7
4. High K fertilizer + Turf Enhancer	0.125	April, June, July	4	6	8	6
5. Prograss 1.5EC	0.380	April	5	7	7	6
6. Prograss 1.5EC	0.560	April	6	8	9	7
7. Primo 1EC	0.300[3]	April, June, July	7	8	5	7
$LSD_{0.05}$			1	1	1	1

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

[2] Applications were made on April 22, June 4, and July 10.

[3] The rate for the April applications was 0.25 fl oz product/1000 ft^2 and the rate for June and July was 0.30 fl oz product/1000 ft^2.

Table 2. Percent *Poa annua* cover[1] in Kentucky bluegrass treated with herbicide and herbicide + fertilizer formulations in the 1995-1996 Green Height Bentgrass *Poa annua* Control Study.

Material	Rate lb a.i./A	Apr 16	May 9	May 30	June 12	July 3	July 31	Aug 29	Mean % cover
		% cover							
1. Untreated control	NA	57	52	60	53	60	25	23	47
2. Turf Enhancer 2SC	0.125	20	10	48	53	17	12	22	26
3. Proturf fertilizer + Prograss	0.380	32	13	13	17	35	25	17	22
4. High K fertilizer + Turf Enhancer	0.125	17	13	22	42	22	13	15	20
5. Prograss 1.5EC	0.380	15	18	12	18	23	12	8	15
6. Prograss 1.5EC	0.560	10	12	5	7	7	8	12	9
7. Primo 1EC	0.300	60	38	57	38	53	23	20	41
$LSD_{0.05}$		14	15	19	33	21	NS	NS	11

[1] These percentages represent the area per plot covered by *Poa annua*.

NS = means are not significantly different at the 0.05 level.

Effects of Trinexapac Ethyl on Sod Production - 1996

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

The impact of the growth regulator, Trinexapac ethyl, on sod production and post-harvest establishment was assessed. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was 'Vantage' Kentucky bluegrass. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.6% organic matter, a pH of 7.0, 2 ppm P, and 85 ppm K.

The experiment was designed as a randomized complete block. There were four replications with 5 x 5 ft. individual plots and no barrier rows between replications. There were three Primo 1EC treatment regimes and an untreated control. All applications were made at 0.75 oz/1000 ft^2 (the label rate for Kentucky bluegrass). Primo was applied two weeks prior to sod harvest, two weeks after sod establishment, and both two weeks prior and two weeks after (Table 1). A carbon dioxide backpack sprayer equipped with #8006 nozzles at 20-25 psi was used to apply the Primo 1EC.

On June 4, the 'two weeks before sod cutting' treatments were applied. On June 19, the turf on the entire experimental plot was cut using a sod cutter. The sod had approximately 1.5 - 2.0 in. of soil/root mass. Sod pieces were transplanted into 12 x 12 in. wooden frames. A piece of sod the size of the outside diameter of the frame was cut and the frames were placed into the resulting hole so that the frames were flush with the soil surface. The sod piece was then trimmed to fit inside the frame. The frames had 18 mesh fiberglass screen bottoms so the roots could grow through. The frames were placed back into the experimental plots so the sod would establish. Four frames were used in each plot, one in each of four quadrants. One frame from each plot was randomly chosen and 'pulled' on each of four data collection dates. The plot was watered thoroughly upon completion and watered as needed to prevent the sod from drying.

On July 3, the 'two weeks after sod establishment' treatments were made and the first set of sod frames were sampled. Steel cables attached to a special hydraulic sod pulling apparatus were attached to screw hooks placed on each side of the frames. Pressure was applied to the lifting apparatus and the frames were 'pulled'. The tensile strength required to pull the roots from the soil was measured in foot pounds and recorded on a gauge. The remaining three sets of frames were harvested at 2-week intervals on July 19, July 31, and August 15.

Turf quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Visual quality data were taken on July 3, July 19, July 25, July 31, and August 15 (Table 1). Sod establishment and root 'knitting' were measured as tensile strength in foot pounds using a hydraulic sod pulling apparatus (Table 2).

Data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference test (LSD).

Significant differences in turf quality were found on July 25 and August 15. The untreated controls and bluegrass treated with Primo two weeks before sod cutting (treatment 2) had significantly better mean quality than turf treated with Primo two weeks after sod cutting and turf treated two weeks before and after cutting.

On July 3, the tensile strength of sod treated with Primo two weeks before sod cutting was significantly higher than the untreated controls and sod treated with Primo two weeks after establishment (Table 3). On July 19, the tensile strengths were similar for treated and untreated sod. On July 31, the strengths were not significantly different and were almost equal for sod treated with Primo two weeks before, sod treated two weeks before and after, and untreated sod. On August 15, sod treated with Primo two weeks before and after had significantly higher tensile strength than the other treated and untreated sod.

Table 1. Visual quality[1] of Kentucky bluegrass sod growing in frames in the 1996 Primo Sod Production Study.

Materials	Rate [oz product]	Timing of application	July 3	July 19	July 25	July 31	Aug. 15	Mean quality
1. Untreated control	NA	NA	7	7	8	7	6	7
2. Primo 1EC	0.75	2 wks before	7	7	8	7	7	7
3. Primo 1EC	0.75	2 wks after	7	6	6	6	6	6
4. Primo 1EC	0.75	2 wks before & 2 wks after	7	6	6	6	7	6
$LSD_{0.05}$			NA	NA	0.5	NA	0.4	0.1

Two weeks prior to sod cutting treatments were applied June 4. Sod was cut and put into frames on June 19. Two weeks after sod establishment treatments were applied July 3.

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

NA = LSD test not applicable because there is no mean square error (no variance among reps).

Table 2. Root tensile strength and knitting of Kentucky bluegrass sod growing in frames in the 1996 Primo Sod Production Study measured by the number of pounds (PSI) required to pull 1 ft^2 frames.

			Tensile strength (PSI)				
Materials	Rate [oz product]	Timing of application	July 3	July 19	July 31	Aug 15	Mean strength
1. Untreated control	NA	NA	146	273	335	274	257
2. Primo 1EC	0.75	2 wks before	188	271	333	333	281
3. Primo 1EC	0.75	2 wks after	129	243	263	303	234
4. Primo 1EC	0.75	2 wks before & 2 wks after	178	280	320	460	309
$LSD_{0.05}$			40	NS	NS	133	NS

Two weeks prior to sod cutting treatments were applied June 4. Sod was cut and put into frames on June 19. Two weeks after sod establishment treatments were applied July 3.

NS = means are not significantly different at the 0.05 level.

Effects of Trinexapac Ethyl (Primo) on Perennial Ryegrass Seedlings - 1996

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

The effects of the growth regulator, trinexapac ethyl, were evaluated on the establishment and early growth of seedling perennial ryegrass. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental plot was an area where Kentucky bluegrass sod was cut. The soil in this plot was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 2.8% organic matter, a pH of 6.9, 5 ppm P, and 71 ppm K.

The experiment was designed as a randomized complete block. There were three replications with 5 x 5 ft individual plots laid out a single row measuring 90 x 5 ft. Primo 1EC was applied at the same rate five different times throughout the growth and establishment of the ryegrass. All Primo applications were made at 1.0 oz/1000 ft^2, the requested rate for perennial ryegrass. Treatments included an application of Primo at seeding, 1 week after seeding (1 WAS), and subsequent treatments at 2, 3, and 4 weeks after seeding. An untreated control was included for comparisons (Table 1).

To prepare the plot for seeding, it was sprayed with Roundup, tilled and raked. Phosphorous was applied at 1 lb P_2O_4/1000 ft^2 and nitrogen was applied at 1/2 lb/1000 ft^2 prior to seeding. Perennial ryegrass was seeded at 4 lbs/1000 ft^2. A PAR 3 ryegrass blend from D & K Products, Des Moines, IA was used. It contained 33.6% Palmer II, 33.6% Prelude II, and 28.8% Repell II. The origin of these cultivars was Oregon and the germination was rated at 90%. It was tested 1/96 and was lot 40024-1. Seeding was performed on June 26, 1996. Following seeding, the plot was rolled and watered. Supplemental irrigation was employed to keep the plot moist for good germination.

Ryegrass emergence was observed on July 3. On this same date the 1 WAS treatment was made. Rainfall occurred on July 7 (Table 2). The 2 WAS application was made on July 10, the 3 WAS on July 19, the 4 WAS on July 25 (delayed because of adverse weather and 1996 Turfgrass Field Day).

The initial fresh clipping weight, visual quality, and percent ryegrass cover data were taken on July 30. Subsequent data were taken on August 8, August 23, and September 5. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Clipping weights were measured as grams fresh tissue (Table 2). Mowing height for collecting clippings was 2 inches. Ryegrass cover was determined by a visual estimation of the percentage of ryegrass cover in each plot (Table 3).

Data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means were compared with the Fisher's Least Significant Difference (LSD) test.

Primo had no detrimental effects on either quality (Table 1) or percentage cover (Table 3) of perennial ryegrass. There were no significant reductions in growth of the seedling ryegrass (Table 2) although the 4 WAS treatment did numerically reduce clipping weights from 137 g in the control to 93 g in the treated plots.

Table 1. Visual quality[1] of perennial ryegrass treated with Primo 1EC in the 1996 Primo Seedling study.

	Materials	July 30	August 8	August 23	September 5	Mean Quality
1.	Untreated control	8	8	7	7	7.5
2.	Primo 1EC at seeding	8	8	7	7	7.5
3.	Primo 1EC 1 WAS[2]	8	8	7	7	7.5
4.	Primo 1EC 2 WAS[2]	8	8	7	7	7.5
5.	Primo 1EC 3 WAS[2]	8	8	7	7	7.5
6.	Primo 1EC 4 WAS[2]	8	8	7	7	7.5
	$LSD_{0.05}$	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.
[2] WAS = weeks after seeding.
Perennial ryegrass was seeded and treatment 2 was applied on June 26, treatment 3 on July 3, treatment 4 on July 10, treatment 5 on July 19, and treatment 6 on July 25, 1996.
NS = means are not significantly different at the 0.05 level.

Table 2. Clipping weights[1] of perennial ryegrass treated with Primo 1EC in the 1996 Primo Seedling study.

	Materials	July 30	August 8	September 5	Mean Weight	Total Weight
		grams fresh tissue				
1.	Untreated control	27	6	74	46	137
2.	Primo 1EC at seeding	31	40	74	48	145
3.	Primo 1EC 1 WAS[2]	31	35	70	46	137
4.	Primo 1EC 2 WAS[2]	24	34	78	45	135
5.	Primo 1EC 3 WAS[2]	34	34	53	40	121
6.	Primo 1EC 4 WAS[2]	31	15	47	31	93
	$LSD_{0.05}$	NS	NS	NS	NS	NS

[1] Clipping weights are expressed as grams fresh tissue.
[2] WAS = weeks after seeding.
Perennial ryegrass was seeded and treatment 2 was applied on June 26, treatment 3 on July 3, treatment 4 on July 10, treatment 5 on July 19, and treatment 6 on July 25, 1996.
NS = means are not significantly different at the 0.05 level.

Table 3. Percentage of perennial ryegrass cover in plots treated with Primo 1EC in the 1996 Primo Seedling study.

	Materials	July 30	August 8	August 23	September 5[1]	Mean ryegrass cover
		% cover				
1.	Untreated control	80	83	90	83	84
2.	Primo 1EC at seeding	80	83	90	92	86
3.	Primo 1EC 1 WAS[2]	80	85	90	83	85
4.	Primo 1EC 2 WAS[2]	80	82	90	77	82
5.	Primo 1EC 3 WAS[2]	80	87	90	90	87
6.	Primo 1EC 4 WAS[2]	80	85	90	92	87
	$LSD_{0.05}$	NS	NS	NS	NS	NS

[1] Differences in ryegrass cover are attributable to the percentage of weed cover.
[2] WAS = weeks after seeding.
Perennial ryegrass was seeded and treatment 2 was applied on June 26, treatment 3 on July 3, treatment 4 on July 10, treatment 5 on July 19, and treatment 6 on July 25, 1996.
NS = means are not significantly different at the 0.05 level.

The Effect of Betasan on Four Creeping Bentgrass Cultivars Maintained at Green Height

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

Betasan 4LF was evaluated for phytotoxicity on green height creeping bentgrass. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experiment was located in creeping bentgrass grown in native soil with a pH of 7.25, 5 lb/acre P, and 60 lb/acre K.

Four experimental plots were set up, one in each of four creeping bentgrass cultivars (Penncross, Penneagle, SR-1019, and SR-1020) mowed at 0.3 in. Each experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with three replications. There were three treatments including an untreated control. Betasan 4LF was applied at 20 pt. product/A initially and sequentially at 15 pt. product/A (Table 1). Double applications at these same rates and with the same timing were included to simulate overlap. The assignment of treatments to plots was randomized. Betasan 4LF was applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles and a spray pressure of 30 psi.

The plots were irrigated with 0.5 - 1.0 inch of water immediately after applications. Supplemental irrigation was used to maintain the bentgrass in good growing condition.

The initial treatments were made May 29, 1996. Sequential applications were made on August 29. The plots were checked for turf quality and phytotoxicity periodically beginning June 3. Subsequent data were taken on June 10, June 26, July 3, July 18, August 8, August 29, September 5, and September 11. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Phytotoxicity data were assessed using a 9 to 1 scale: 9 = no damage, 8 = 10% brown, 7 = 20% brown, and 6 = 30% brown turf within the plot (Table 2).

Data were analyzed with the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

There were no signs of phytotoxicity on any of the treated bentgrass plots following the initial applications (Table 1). On September 5, seven days after the sequential treatments, there was some general browning on the entire green height bentgrass area including the experimental plots and surrounding areas. In the Penneagle plot, a more pronounced browning appeared to correspond with individual plots and to be a treatment effect. These symptoms were considered as possible phytotoxicity (Table 2). By September 11, the quality of the Penneagle was uniform among the treated and untreated plots. No other phytotoxicity was detected.

Table 1. Visual quality[1] of green height creeping bentgrass treated with Betasan 4LF in the 1996 Green Height Bentgrass Phytotoxicity Study.

Material	Rate (pts product/A) initial/sequential	June 3	June 10	June 26	July 3	July 18	Aug 8	Sept 5	Sept 11	Mean quality
SR-1019										
1. Untreated control	NA	9	8	8	8	9	9	6	7	8
2. Betasan 4LF	20/15	9	8	8	8	9	9	6	7	8
3. Betasan 4LF	40/30[2]	9	8	8	8	9	9	6	7	8
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
SR-1020										
1. Untreated control	NA	9	8	8	8	9	9	6	7	8
2. Betasan 4LF	20/15	9	8	8	8	9	9	6	7	8
3. Betasan 4LF	40/30[2]	9	8	8	8	9	9	6	7	8
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
Penncross										
1. Untreated control	NA	9	8	8	8	9	9	6	7	8
2. Betasan 4LF	20/15	9	8	8	8	9	9	6	7	8
3. Betasan 4LF	40/30[2]	9	8	8	8	9	9	6	7	8
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
Penneagle										
1. Untreated control	NA	9	8	8	8	9	9	6	7	8
2. Betasan 4LF	20/15	9	8	8	8	9	9	6	7	8
3. Betasan 4LF	40/30[2]	9	8	8	8	9	9	6	7	8
$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
[2]Twice the Betasan and water were applied to plots receiving treatment 3
Initial applications were made on May 29 and sequential on August, 29, 1996.
NS = means are not significantly different at the 0.05 level.

Table 2. Possible phytotoxicity[1] detected September 5 in green height creeping bentgrass treated with Betasan 4LF in the 1996 Green Height Bentgrass Phytotoxicity Study.

	Material	Rate (pts product/A) initial/sequential[2]	September 5
SR-1019			
1.	Untreated control	NA	9
2.	Betasan 4LF	20/15	9
3.	Betasan 4LF	40/30	9
	$LSD_{0.05}$		NS
SR-1020			
1.	Untreated control	NA	9
2.	Betasan 4LF	20/15	9
3.	Betasan 4LF	40/30	9
	$LSD_{0.05}$		NS
Penncross			
1.	Untreated control	NA	9
2.	Betasan 4LF	20/15	9
3.	Betasan 4LF	40/30	9
	$LSD_{0.05}$		NS
Penneagle			
1.	Untreated control	NA	8
2.	Betasan 4LF	20/15	6
3.	Betasan 4LF	40/30	6
	$LSD_{0.05}$		NS

[1] Phytotoxicity was assessed using a 9 to 1 scale: 9 = no phyto, 8 = 10% brown, 7 = 20% brown, 6 = 30% brown turf per plot.
[2] Twice the Betasan and water were applied to plots receiving treatment 3.
NS = means are not significantly different at the 0.05 level.

The Effect of Tupersan on Four Creeping Bentgrass Cultivars Maintained at Fairway Height

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

Tupersan 50WP was evaluated for phytotoxicity on creeping bentgrass maintained at fairway height. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The soil in this area up was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with a pH of 7.25, 5 lb/acre P, and 60 lb/acre K.

Four experimental plots were set up, one in each of four creeping bentgrass cultivars (Penncross, Penneagle, SR-1019, and Dominant) mowed at 0.5 in. Each experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with three replications. There were three treatments including an untreated control. Tupersan 50WP was applied at 24 lb product/A and in double applications at 24 lb product/A per application to simulate overlap (Table 1). The assignment of treatments to plots was randomized. Tupersan was applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles and a spray pressure of 30 psi. The plots were irrigated with 0.5 - 1.0 inch of water immediately after application. Supplemental irrigation was used to maintain the bentgrass in good growing condition.

The initial treatments were made May 29, 1996. The plots were checked for turf quality and phytotoxicity periodically beginning June 3. Subsequent data were taken June 10, June 26, July 3, July 18, August 8, August 29, September 5, and September 11. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1).

Data were analyzed with the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

May 30, the plots treated with Tupersan still retained a slight whitish color from the material. This color was still visible on June 3 but by June 10 was no longer evident. At no time during the study were there any signs of phytotoxicity on any of the treated plots (Table 1).

Table 1. Visual quality[1] of fairway height creeping bentgrass in the 1996 Bentgrass Phytotoxicity Study.

	Material	Rate (lbs product/A[2])	June 3	June 10	June 26	July 3	July 18	Aug 8	Sept 5	Sept 11	Mean quality
	SR-1019										
1.	Untreated control	NA	7	7	8	8	9	9	8	8	8
2.	Tupersan 50WP	24	7	7	8	8	9	9	8	8	8
3.	Tupersan 50WP	48[1]	7	7	8	8	9	9	8	8	8
	$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dominant										
1.	Untreated control	NA	7	7	8	8	9	9	8	8	8
2.	Tupersan 50WP	24	7	7	8	8	9	9	8	8	8
3.	Tupersan 50WP	48[1]	7	7	8	8	9	9	8	8	8
	$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
	Penncross										
1.	Untreated control	NA	7	7	8	8	9	9	8	8	8
2.	Tupersan 50WP	24	7	7	8	8	9	9	8	8	8
3.	Tupersan 50WP	48[1]	7	7	8	8	9	9	8	8	8
	$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS
	Penneagle										
1.	Untreated control	NA	7	7	8	8	9	9	8	8	8
2.	Tupersan 50WP	24	7	7	8	8	9	9	8	8	8
3.	Tupersan 50WP	48[1]	7	7	8	8	9	9	8	8	8
	$LSD_{0.05}$		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.
[2] Twice the Tupersan and water were applied to plots receiving treatment 3.
NS = means are not significantly different at the 0.05 level.

Non-selective Herbicide Demonstration Study

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

Finale from AgrEvo, Roundup from Monsanto, and Reward from Zeneca were screened in a non-replicated study for efficacy of non-selective herbicides 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 1996 Turfgrass Field Day.

The experimental area consisted of Kentucky bluegrass surrounding permanent ornamental grass beds. Finale, Roundup, and Reward were applied to approximately 6-inch wide border strips around individual ornamental plantings. Finale was applied at a rate of 4.0 oz a.i./A, Roundup at 2.7 oz a.i./A, and Reward at the label rate of 20 ml product/gal water. The materials were applied with a carbon dioxide backpack sprayer equipped with #8006 nozzles at 25-30 psi. Applications were made July 3, July 12, and July 15. These dates correspond with 14, 5, and 2 days, respectively, before Field Day on July 18.

A survey of the experimental area was made prior to treatment and the bluegrass in the border areas was uniform in color and overall quality. Data on the overall condition of the plants within the treated area and the evenness of the border areas were taken on July 10, July 15, July 25, and August 20 (Table 1).

All materials worked satisfactorily and produced even border strips with brown, dead grass in approximately 12 days (Table 1). Even, brown, dead borders were observed on July 15 in all plots treated on July 3 (Table 1). The herbicides produced different phytotoxic symptoms. Finale treated bluegrass exhibited severe chlorosis before turning orange-brown and dying. Grass treated with either Roundup or Reward turned from healthy green to shades of brown.

Border areas treated with Reward were not as persistent as those treated with either Finale or Roundup. By July 25 (five days after Field Day), regrowth of green turf was present in the border areas treated with Reward on July 3. On August 20, (33 days after Field Day) all grass in the Reward treated border areas had regrown but there was no regrowth of either turfgrass or weeds in the areas treated with either Finale or Roundup (Table 1).

Table 1. Phytotoxic symptoms on Kentucky bluegrass in ornamental border areas treated with non-selective herbicides in the 1996 Non-selective Herbicide Demonstration Study.

Treatment	Days before Field Day	Date applied	Border area Kentucky bluegrass symptoms			
			July 10	July 15	July 25	August 20
Untreated Control	NA	NA	green, healthy plants	green, healthy plants	green, healthy plants	green, healthy plants
Finale - 120 SC	14	July 3	most plants orange-brown, 90% dead, even border	all plants dead, even border	all plants dead, even border	all plants dead, even border
	5	July 12		moderate to severe browning, some dead plants, even border	all plants dead, even border	all plants dead, even border
	2	July 15			all plants dead, even border	all plants dead, even border
Roundup - 356SN	14	July 3	plants grayish-brown, 90% dead, even border	all plants dead, even border	all plants dead, even border	all plants dead, even border
	5	July 12		moderate, uneven browning, some dead plants, even border	all plants dead, even border	all plants dead, even border
	2	July 15			all plants dead, even border	all plants dead, even border
Reward	14	July 3	most plants light brown, 75% dead, even border	all plants dead, even border	50% green plants, even border	border area green
	5	July 12		moderate to severe browning, some dead plants, even border	25% green plants, even border	border area green
	2	July 15			most plants light brown, 80% dead, even border	border area green

Nutrient Salts and Toxicity of Black-layer

Clinton F. Hodges and Douglas A. Campbell

Black-layer or black-plug layer is a common disorder of high-sand-content golf greens characterized by development of an interrupted or continuous subsurface blackened layer in the sand (2, 4, 5, 6). The layer is typically associated with noxious odors, and the turf may show symptoms of chlorosis, wilting, thinning, and eventual death. The layer may be initiated by a consortium of bacteria or by cyanobacteria that produce biofilms in the sand that impede the drainage of water (4, 6). The biofilm creates anaerobic conditions and provides organic matter that support the proliferation of sulfate-reducing bacteria and the subsequent development of the black-layer.

The precise cause of death of creeping bentgrass growing on black-layered sand is unknown. The potential production of hydrogen sulfide by sulfate-reducing bacteria may be one of the toxic components of black-layer development (1, 7). It is not uncommon, however, to find healthy grass growing on black-layered sand. This suggests that the toxicity of the layers may be variable. It has also been observed that the roots of *A. palustris* can grow through and clear the black-layer formed by the interaction of cyanobacteria and sulfate-reducing bacteria (5). Studies on the physical structure of black-layer have revealed vertical cavities in the layer through which grass roots grow with at least 3-mm of clear sand between the root and the blackened sand (2).

There are two primary prerequisites for the formation of black-layer by sulfate-reducing bacteria in high-sand-content greens: anaerobic sites in the sand and metabolizable organic matter. The nature of the toxicity of black-layer is unclear and may be variable and/or dependent on factors associated with the site or the management practices applied to the turf. Preliminary research has been initiated to determine if various elemental substances commonly used on golf greens can influence the toxicity of black-layer formed by the interaction of cyanobacteria and sulfate-reducing bacteria.

Nutrients and Toxicity

Black-layered sand was produced from the combination of cyanobacteria of the genera *Nostoc, Oscillatoria,* or *Phormidium* combined with the sulfate-reducing bacterium *Desulfovibrio desulfuricans*. All black-layered sand columns and the non-black-layered control columns received the same standard salt solution (3) supplemented with iron, sulfur, or lime.

Salts. Dry weight loss in the black-layered sand was 51% of the no-organism salts control in response to the combinations of *Nostoc* + *D. desulfuricans*, 59% for *Phormidium* + *D. desulfuricans*, and 79% for *Oscillatoria* + *D. desulfuricans*. These observations suggest that the toxicity of black-layered sand formed from the interaction of different species of cyanobacteria and *D. desulfuricans* can differ. These preliminary observations indicate that the cyanobacterium *Nostoc* in combination with *D. desulfuricans* produces a more toxic black-layer than that resulting from other cyanobacteria. *D. desulfuricans* alone failed to produce a black-layer and had no effect on plant growth relative to the no-organism salts control.

Salts + sulfur. Dry weight of plants from the salts + sulfur no-organism control did not differ from that from the no-organism salts control. All combinations of cyanobacteria and *D. desulfuricans* moderately decreased dry weight relative to the no-organisms sulfur control. All decreases were less than that in response to the same organism combinations in the salts control. The combination of *Nostoc* + *D. desulfuricans* stilled caused the greatest decrease at 78% of the no-organisms sulfur control. *D. desulfuricans* alone in nonblack-layered sand responded to the sulfur by decreasing dry weight to 55% of the no-organism sulfur control. This observation suggests that *D. desulfuricans* can damage turfgrasses long before there is any visible sign of black-layer formation in the sand.

Salts + iron. Dry weight of plants from the salts + iron no-organism control increased dramatically relative to that of the no-organism salts control and salts + sulfur control. Dry weight of the grasses in the no-organism salts + iron control were about 140% greater than that in the no-organisms salts control and salts + sulfur control. The various combinations of cyanobacteria and *D. desulfuricans* decreased dry weight relative to the stimulated plants in the no-organisms salts + iron control. *Nostoc* + *D. desulfuricans* caused the greatest decrease in dry weight (54%). *D. desulfuricans* alone in nonblack-layered sand responded to the iron by decreasing dry weight to 54% of the no-organism salts + iron control. Iron also increased the intensity of the black coloration of the black-layer; the intensity of blackening, however, was not necessarily correlated with an increase in toxicity of the layer.

Salts + lime. Dry weight of plants from the salts + lime no-organism control was less than that from any of the other no-organism controls (salts, sulfur, and iron). This response was believed due to a pH that reach 9.0 or higher. Plant dry weight increased in black-layered sand produced by the combinations of *Oscillatoria*, *Phormidium*, or *Nostoc* with *D. desulfuricans* to 149, 142, and 138%, respectively, of the no-organisms salts + lime control. However, these increases in dry weight were still substantially lower than that of the same organism combinations in the salts, sulfur, and iron no organisms controls. Hence, the effect of the lime on the dry weight of plants growing in black-layer was equal to or less than those growing in sulfur or iron treatments.

Root Growth and Black-layer Persistence

All plants transplanted into black-layered sand columns survived. Roots of plants growing in blackened sand that received the salts control, salts + sulfur, salts + iron, and salts + lime produced clear channels in the sand that surrounded roots as they grew downward in the column. By the end of the 10-wk growing period the only blackened sand occurred in the bottom of the sand columns below the tips of the extending roots. The blackened region below the root tips in sand columns receiving salts + iron remained intensely black as compared with the sand columns receiving the salts control, salts + sulfur, or salts + lime.

The clearing of blackened sand by *A. palustris* roots has been observed in previous studies (2, 5). Cullimore et al. (2) showed that the physical structure of black-layer consisted of a series of vertical columnar structures and lateral plates. It was further observed that vertical cavities were present, through which roots grew with at least a 3-mm zone of clear sand between the root and the blackened sand. The observations of roots growing through black-layer or clearing black-layered sand suggest that the toxicity of black-layers may be variable.

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Evaluation of Fungicides for Control of Brown Patch in Creeping Bentgrass - 1996

Mark L. Gleason

Trials were conducted at Veenker Memorial Golf Course on the campus of Iowa State University. 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 four replications. All plots measured 4 ft x 5 ft. All plots were surrounded by 1-ft-wide strips of untreated turf in order to help create uniform disease pressure.

Fungicide applications began on June 12. Subsequent applications were made at specified intervals on June 25 and July 3, 10, and 24.

Brown patch symptoms were first observed on June 22. Disease development, expressed as percent diseased area per plot, increased gradually in the untreated check during July, becoming moderate by the end of the month. Because of plot-to-plot variability, no fungicide treatments exhibited significantly (LSD, $P \leq 0.05$) more or less disease than the untreated check. However, significant differences among various sprayed treatments were observed on each rating date. No phytotoxicity symptoms were observed during the trial.

Table 1. 1996 Brown Patch Trial, Veenker Memorial Golf Course, Iowa State University

			Rate per	Interval	Diseased area (% of plot)			
Trt#	Company	Product	1000 ft^2	(days)	6/22	7/10	7/16	7/30
1	none	untreated check			5.0	5.5	10.5	16.3
2	AgrEvo	ProStar 50 WP	3 oz	21	0.5	3.0	7.8	8.8
3	AgrEvo	ProStar Plus 50 WP	2.5 oz	28	8.0	6.0	5.3	10.0
		(pkg w/Bayleton 50 WP)						
4	AmVac	Amv 41 F	2 fl oz	14	4.0	1.5	11.0	11.3
5	AmVac	Amv 41 F	4 fl oz	14	2.0	2.5	14.5	18.8
6	AmVac	Amv 53 WDG	2 oz	14	3.0	1.3	8.8	12.5
7	AmVac	Amv 53 WDG	4 oz	14	3.5	5.5	14	23.8
8	AmVac	ParFlo 6 F	3 fl oz	14	0.8	1.8	1.3	12.0
9	Zeneca	Heritage 50 WDG	0.2 oz	14	0.8	1.8	1.3	12.0
10	Zeneca	Heritage 50 WDG	0.3 oz	21	2.5	2.0	6.3	11.3
11	Zeneca	Heritage 50 WDG	0.4 oz	28	2.5	1.8	5.0	12.5
12	Rhone-Poulenc	EXP 10715A 80 WG	4 oz	14	1.8	7.8	5.8	12.5
		+ Dithane 75 WG (Dithane DF)	8 oz					
13	Rhone-Poulenc	EXP 10715A 80 WG	8 oz	14	0.8	2.8	6.5	11.3
		+ Dithane 75 WG (Dithane DF)	8 oz					
14	Rhone-Poulenc	EXP 10704A 80 WP	4 oz	14	3.3	3.3	3.0	6.3
		+ Dithane 75 WG (Dithane DF)	4 oz					

Trt#	Company	Product	Rate per 1000 ft²	Interval (days)	Diseased area (% of plot) 6/22	7/10	7/16	7/30
15	Rhone-Poulenc	EXP 10715A 80 WG	8 oz	14	2.3	2.5	10	15.5
16	Rhone-Poulenc	Chipco Aliette 80 WDG	4 oz	14	1.0	7.8	9.5	8.3
		+ Fore 50 WP	8 oz					
17	Rhone-Poulenc	Chipco 26019 FLO	3 fl oz	14	1.3	1.3	3.0	11.3
18	Rhone-Poulenc	Chipco 26019 FLO	4 fl oz	14	0.3	1.0	6.5	22.5
19	Rhone-Poulenc	Chipco 26019 WDG	1.5 oz	14	1.8	2.5	14.5	20
20	Rhone-Poulenc	Chipco 26019 WDG	2.0 oz	14	1.0	4.5	5.3	17.5
21	Terra	Thalonil 90 DF	3.5 oz	14	1.5	2.3	6.8	7.5
22	Terra	Thalonil 4 L	6 fl oz	14	2.0	1.0	3.3	7.5
23	Terra	TRA 0106 (Thalonil 6)+C48	4 fl oz	14	0.5	3.0	3.0	6.3
24	Bayer	Lynx 25 DF	1 oz	21	1.3	5.5	9.5	21.3
25	Bayer	Lynx 250 EW	28.4 ml	21	2.5	5.5	9.5	21.3
26	Bayer	Bayleton 25 DF	1 oz	21	1.8	3.8	6.8	6.3
		(Bayleton 25% T/O)						
27	ISK Biotech	Daconil Ultrex	3.8 oz	14	3.5	2.8	4.3	7.5
28	ISK Biotech	Daconil Weather Stik	4.1 fl oz	14	1.0	2.5	5.0	11.3
29	ISK Biotech	Daconil Zn (Bravo Zn)	6.0 fl oz	14	2.0	7.8	9.0	22.5
30	ISK Biotech	IB 11522	4.0 oz	14	0.3	3.0	5.3	11.3
31	ISK Biotech	IB 12231	4.7 oz	14	2.3	10	10.8	18.8
32	ISK Biotech	Daconil Ultrex	3.8 oz	14	1.5	4.5	6.0	7.5
		+ Aliette 80 WDG	4.0 oz					
33	ISK Biotech	Daconil Zn	6.0 fl oz	14	0.3	2.5	8.5	11.3
		+ Aliette 80 WDG	4.0 oz					
34	ISK Biotech	Daconil Ultrex	3.8 oz	14	1.3	3.8	7.8	13.8
		+ IB 10813	0.5% v/v					
35	Rohm & Haas	Eagle (RH 3866 40 WP)	0.6 oz	14	0.8	2.0	2.8	8.8
		+ Fore	6.0 oz					
36	Rohm & Haas	Fore	6.0 oz	21	0.3	1.3	3.7	5.0
		+ Prostar 50 WP	2.0 oz					
37	Rohm & Haas	Eagle (RH 3866 40 WP)	0.6 oz	21	0.8	4.0	11.5	13.8
38	Rohm & Haas	Eagle (RH 3866 40 WP)	1.2 oz	28	8.5	4.3	4.0	13.8
	MSE[1]				14.6	19.8	49.2	141.2
	LSD[2]				5.4	6.2	9.8	16.6

[1]Mean square error. df = 111 on 6/22 and 7/10, df = 110 on 7/16 and 7/30. n = 4.
[2]Least significant difference. $P \leq 0.05$.

Evaluation of Fungicides for Control of Dollar Spot in Penncross Creeping Bentgrass - 1996

Mark L. Gleason

Trials were conducted at the Turfgrass Research Area of Iowa State University's 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 ft x 5 ft.

After inoculation of the entire plot with pathogen-infested rye grain on June 10, spray applications began on June 18. Subsequent applications were made at specified intervals on July 2, 9, 16, and 30.

Dollar spot symptoms appeared in the plot within nine days after the first spray treatment. Disease development was moderate during July. On July 10, the only treatments that did not exhibit significantly (LSD, $P \leq 0.05$) fewer infection centers than the untreated control were AMV 53 WDG at 4 oz rate and Daconil Zn (6 fl oz) + Aliette 80 WDG (4 oz). On July 24, the only treatments that did not exhibit significantly fewer infection centers than the untreated control were AMV 53 WDG at 4, 6, and 8-oz rates, Rizolex 75 WP at 2.5 oz, Thalonil 4L at 6 fl oz, and two combination treatments: Chipco 26019 FLO (2 fl oz) + Heritage 50 WG (0.2 oz) and Chipco 26019 FLO (2 fl oz) + Daconil 2787 (3 fl oz). No phytotoxicity symptoms were observed during the trial.

Table 1. 1996 Dollar Spot Trial, Iowa State University Horticulture Research Station

Trt#	Company	Product	Rate per 1000 ft^2	Interval (days)	# of infection centers/plot 6/27	7/10	7/24
1	none	untreated check			36.8	62.8	115.5
2	AmVac	Amv 41 F	8 fl oz	14	8.3	10.3	17.0
3	AmVac	Amv 41 F	10 fl oz	14	25.8	12.5	19.3
4	AmVac	Amv 41 F	12 fl oz	14	12.8	7.5	14.3
5	AmVac	Amv 53 WDG	4 oz	14	41.3	37.5	110.0
6	AmVac	Amv 53 WDG	6 oz	14	32.5	30.8	67.5
7	AmVac	Amv 53 WDG	8 oz	14	31.3	20.0	76.3
8	AmVac	ParFlo 6 F	8 fl oz	14	7.5	11.5	49.0
9	Rhone-Poulenc	EXP 10702A 2 SC	4 fl oz	14	6.3	3.0	9.8
		+ Chipco Aliette WDG	4 oz				
10	Rhone-Poulenc	EXP 10715A 80 WG	4 oz	14	0.5	1.5	1.3
		+ EXP 10702A 2 SC	4 fl oz				
11	Rhone-Poulenc	Daconil Ultrex 82.5 WG	3 oz	14	10.0	5.8	10.8
		+ EXP 10715A 80 WG	4 oz				
12	Rhone-Poulenc	EXP 10715A 80 WG	4 oz	14	20.0	26.3	43.8
13	Rhone-Poulenc	Chipco 26019 FLO	4 fl oz	14	9.3	20.0	31.3
14	Sandoz	Sentinel 40 WG,	0.167 oz	14	8.8	1.5	3.3
		Daconil Ultrex 82.5 WDG[1]	3.8 oz				
15	Sandoz	Sentinel 40 WG	0.167 oz	21	3.8	2.8	3.0
		+ Rizolex 75 WP	2.5 oz				

Trt#	Company	Product	Rate per 1000 ft^2	Interval (days)	# of infection centers/plot 6/27	7/10	7/24
16	Sandoz	Sentinel 40 WG	0.167 oz	21	5.5	1.8	2.5
		+ Daconil Ultrex 82.5 WDG	3.8 oz				
17	Sandoz	Rizolex 75 WP	2.5 oz	14	43.8	32.3	65.5
18	Sandoz	Sentinel 40 WG	0.167 oz	21	6.3	1.8	1.5
19	Sandoz	Heritage 50 WDG	0.2 oz	14	22.5	8.8	47.5
20	Sandoz	Banner 1.24 MEC	1 fl oz	14	3.8	1.8	1.5
21	Terra	Thalonil 90 DF	3.5 oz	14	8.8	8.0	8.8
22	Terra	Thalonil 4 L	6 fl oz	14	27.5	30.3	75.8
23	Terra	TRA 0106	4 fl oz	14	14.3	6.5	27.5
24	Ciba Geigy	CGA-BMP WP	0.56 oz	21	4.8	1.8	2.3
25	Ciba Geigy	Banner Maxx	1 fl oz	21	9.5	7.8	1.3
26	Bayer	Lynx 25 DF	1 oz	28	6.3	8.0	1.8
27	Bayer	Lynx 250 EW	28.4 ml	28	5.3	3.0	2.5
28	Bayer	Bayleton 25 DF	1 oz	28	7.8	7.3	1.8
29	ISK Biotech	Daconil Ultrex	3.8 oz	14	16.3	8.3	11.5
30	ISK Biotech	Daconil Weather Stik	4.1 fl oz	14	4.5	2.5	6.3
31	ISK Biotech	Daconil Zn	6.0 fl oz	14	7.5	4.8	11.3
32	ISK Biotech	IB 11522	4.0 oz	14	9.3	5.0	13.8
33	ISK Biotech	IB 12231	4.7 oz	14	22.5	11.5	28.8
34	ISK Biotech	Daconil Ultrex	3.8 oz	14	4.3	1.8	4.8
		+ Aliette 80 WDG	4.0 oz				
35	ISK Biotech	Daconil Zn	6.0 fl oz	14	35.0	37.5	28.8
		+ Aliette 80 WDG	4.0 oz				
36	ISK Biotech	Daconil Ultrex	3.8 oz	14	5.0	5.3	1.3
		+ IB 10813	0.5% v/v				
37	Rhone-Poulenc	Chipco 26019 FLO	2.0 fl oz	14	11.3	2.3	1.8
		+ Banner 1.24 MEC	0.5 fl oz				
38	Rhone-Poulenc	Chipco 26019 FLO	2.0 fl oz	14	3.0	4.0	3.3
		+ Bayleton 25 % DF	0.5 oz				
39	Rhone-Poulenc	Chipco 26019 FLO	2.0 fl oz	14	4.0	1.3	1.3
		+ Cleary 3336 F	1.0 fl oz				
40	Rhone-Poulenc	Chipco 26019 FLO	2.0 fl oz	14	13.0	2.8	58.8
		+ Heritage 50 WG	0.2 oz				
41	Rhone-Poulenc	Chipco 26019 FLO	2.0 fl oz	14	13.8	9.3	75.0
		+ Daconil 2787	3.0 fl oz				
42	Rhone-Poulenc	Chipco 26019 FLO	4.0 fl oz	14	11.5	3.8	12.8
	MSE[2]				412.2	373.6	1917.0
	LSD[3]				28.1	26.8	60.7

[1] Sentinel + Daconil at first application date, Daconil alone at second application date, then repeat.
[2] Mean square error. df = 129. n = 4.
[3] Least significant difference. $P \leq 0.05$.

Evaluation of Fungicides for Control of Metalaxyl-resistant Pythium Blight on Creeping Bentgrass, 1994-1995

Michael W. Daly (Novartis Corporation), Nick E. Christians, and Mark L. Gleason

The object of the trial was to evaluate the efficacy of various fungicide applications on turf that was typed resistant to metalaxyl in 1991. The trial was conducted on the fairway of hole #11 at Elmcrest Country Club, Cedar Rapids, Iowa. The fairway is composed of 80% "Penncross" creeping bentgrass (*Agrostis palustris*) and 20% *Poa annua*, and has had severe outbreaks of pythium blight over the last 12 years. The fairway is a lightly modified native soil, the soil type is a Tama silty clay loam. Drainage is average to poor. Nutrient levels are average to high. The fairway is maintained at a height of 0.5 inches. The thatch level is less than 0.5 inches.

From 1986 through 1990, the fairway received six Banol applications at 2 oz/1000 ft^2, six applications of Aliette at 4 oz/1000 ft^2, and eight applications of Subdue at 2 oz/1000 ft^2. Rick Tegtmeier, course superintendent, noticed decreased intervals of control after the Subdue applications in 1990; from 14-21 days of control down to 7-14 days. Control of Pythium in 1990 required six fungicide applications due to the shortened control interval. The decision was made to switch to a tank mix of Subdue at 2 oz. and Mancozeb at 6 oz/1000 ft^2 for 1991 to try and maximize control intervals. An application was made on 6/5/91 and breakthrough was noticed by 6/11. A sample of diseased turf was taken on 6/12/91 and sent to the Novartis research lab in Vero Beach, FL. The sample arrived on 6/13 in very good condition and one fast-growing Pythium was recovered and typed as *Pythium aphanidermatum.* A sensitivity test was done comparing this sample to a known sensitive *P. Aphanidermatum* control. The EC 50 of the sample to metalaxyl was greater than 100 ppm versus an EC 50 of 0.53 for the control. The sample was classified as resistant to Subdue.

In 1994, the superintendent expressed an interest in finding out what his control options would be after three years of no Subdue applications. An experimental plot was designed using a randomized series of treatment strips down the fairway with the most pressure historically. The size of each strip was 7 ft x 100 ft (the width of the fairway), and the treatments were replicated four times. The applications were made with a "Grounds Wheelie" push sprayer with 2 gallons/1000 ft^2 of carrier using flat fan nozzles. An application was made on 7/1/94 with a second application on 8/5/94. Cool weather during this time frame resulted in no disease pressure.

The trial was continued in 1995 with an application made on 7/15. The temperature was 89° F with winds of 5-10 mph and full sun. Hot, humid weather developed subsequently and *Pythium* was noticed in the plots on 7/31. Data was taken on 8/1 by counting the number of disease centers in each plot by the superintendent and his assistant, Jeff Schmidt. A separate rating of the phytotoxicity to the turf by the various fungicide treatments was made at the same time when differences were noticed while counting the disease centers. The individuals doing the rating did not know which products had been applied to each plot. Results are compiled below.

Treatment	Rate/1000 ft^2	Mean number of disease centers/treatment	
Subdue 2E	2 oz	5.25	a
Banol	2 oz	5.13	a
Untreated check		4.63	a
Aliette	4 oz	3.75	ab
Subdue 2E + Banol	2 oz. + 2 oz.	3.00	ab
Subdue + Mancozeb	2 oz. + 6 oz.	1.38	b

Mean of 4 replications. Mean with the same letter are not significantly different. (LSD = 2.43, P=0.05)

It is interesting that the best treatment was a tank mix that included Subdue. That tank mix has been included in the Pythium disease program during the summers of 1995 and 1996 and seems to be performing well, as the data would indicate. It would also be interesting to take a sample of disease off the fairways now and run the same sensitivity trial on it to see if there has been any change in the pathogen since 1991. More research is necessary to determine if these results would be applicable to any other sites with metalaxyl resistance. The results would seem to confirm the theory that tank mixes are an appropriate strategy in response to resistance concerns.

Below is the data rating the damage to the turf from the various applications to the fairway. It should be noted again that the temperature was 89° F and sunny during the applications. The rating used was 10 for no phyto down to 1 for dead turf. The superintendent expected that Subdue 2E would cause the most damage due to the xylene inert (carrier) and was surprised that Aliette wettable powder actually caused the most phyto problem.

Treatment	Rate 1000 ft^2	Rating	
Untreated check		9.75	a
Subdue 2E + Banol	2 oz. + 2 oz.	9.50	ab
Banol	2 oz.	9.50	ab
Subdue + Mancozeb	2 oz. + 6 oz.	9.13	b
Subdue 2E	2 oz.	8.50	c
Aliette	4 oz.	7.88	d

Mean of 4 replications. Mean with the same letter are not significantly different. (LSD=0.54, P=0.05)

Kentucky Bluegrass Fertilizer Study

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

The purpose of this study was to evaluate the response of Kentucky bluegrass to several turf fertilizer formulations. The experimental plot was an established area of 'Park' Kentucky bluegrass at the Iowa State University Horticulture Research Station north of Ames, Iowa. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.5% organic matter, a pH of 7.3, 6 ppm P and 85 ppm K. Irrigation was used to supplement rainfall and maintain the turf in good growing condition.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft and three replications were conducted. Three-foot barrier rows were placed between replications to facilitate taking clippings.

Natural fertilizers and commercial mixtures were included in this study in single and split applications (Table 1). There were 11 treatments including eight different fertilizers and an untreated control. Two Turfgo fertilizer formulations from Viridian Inc. containing ESN #2003 mini coated material were used (23-5-10 and 22-5-10). They were applied at an annual rate of 4 lb N/1000 ft^2 in split applications. Two Renaissance products from Renaissance Fertilizers Inc. were included. The 6-0-6 formulation was applied at a yearly rate of 4 lbs N/1000 ft^2 in split applications. The 8-2-6 mixture was applied at 2 and 3 lbs N/1000 ft^2 in single applications and at 4 lbs N/1000 ft^2 in split applications. Corn gluten meal from Grain Processing Inc., sustane (turkey manure), milorganite (processed sewage sludge), and Poly Plus sulfur coated urea (39-0-0) from LESCO Inc. also were included. They were applied at 4 lbs N/1000 ft^2 in split applications.

Prior to treatment the plot was mowed to a uniform height of 2 inches. A survey of the area was made before application and the bluegrass was found to be uniform in color and overall quality. The fertilizers were applied using plastic coated containers as 'shaker dispensers'. Initial applications were made June 3. Sequential applications were made August 8.

Fresh clipping weight and visual quality data was taken weekly beginning eight days after initial treatment. Turf quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Tables 2 and 3). Clipping weights were measured as grams fresh tissue and mowing height for the clippings was 2 inches (Tables 4 and 5).

Data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means comparisons were made with Fisher's Least Significant Difference (LSD) test.

There were significant differences in turf quality among the treatments on each of the 15 data collection dates. All fertilizers produced significantly higher quality bluegrass than the untreated controls from June 19 through September 12. During this period, the quality of all fertilized turf was above the lowest acceptable rating of '6' (Tables 3 and 4). Renaissance at 3 lbs N/1000 ft^2 consistently produced very good turf quality through August 8. Bluegrass treated with the two ESN #2003 products, corn gluten meal, and Renaissance (6-0-6) also exhibited good quality through August 8.

All bluegrass that received a sequential fertilizer treatment on August 8 had significantly higher quality than the untreated controls through October 3. Sulfur coated urea, the two ESN #2003 products, corn gluten meal, Renaissance (8-2-6) in split applications, and Renaissance (6-0-6) produced the best quality bluegrass (Table 2 and 3). Turf quality declined after August 8 in those plots that did not receive sequential applications.

Mean turf quality for all fertilized bluegrass was significantly better than the untreated controls. The two ESN #2003 products, sulfur coated urea, corn gluten meal and Renaissance (6-0-6) produced bluegrass with the best overall quality (Table 3).

Fresh clipping weights from treated bluegrass were significantly different from the untreated control for 13 weeks of the 15-week study (Tables 4 and 5). Significant differences among the fertilizer treatments also were found on each of these dates. Growth response to most of the products was maintained from June 11 through August 8 as shown by the clipping weights. On August 15, the clipping weights reflect a rapid growth response to the sequential applications of some of the materials including the two ESN #2003 formulations, sulfur coated urea, and Renaissance (6-0-6). By August 23, all turf receiving a sequential application exhibited substantial clipping increases as compared with the untreated controls and those not treated on August 8 (Table 3 and 4). This trend continued through the late summer and early fall.

Mean and total clipping weights for all of the fertilizers were significantly higher than the untreated controls (Table 5). ESN #2003 (22-5-10) produced the most clippings followed by ESN #2003 (23-5-10), sulfur coated urea, corn gluten meal, Renaissance (8-2-6) (treatment 7), and Renaissance (6-0-6).

Table 1. Rates and number of applications for fertilizer formulations used in the 1996 Kentucky Bluegrass Fertilizer Trial.

	Materials[1]	Yearly 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	2	2
3.	Sustane (5-2-4)	4	2	2
4.	Renaissance (6-0-6)	4	2	2
5.	Renaissance (8-2-6)	2	2	0
6.	Renaissance (8-2-6)	3	3	0
7.	Renaissance (8-2-6)	4	2	2
8.	Milorganite (6-2-0)	4	2	2
9.	ESN #2003 (23-5-10)	4	2	2
10.	ESN #2003 (22-5-10)	4	2	2
11.	Sulfur coated urea(39-0-0) (LESCO Poly Plus™)	4	2	2

[1] Initial applications were made on June 3 and sequential on August 8.

Table 2. Visual quality[1] of Kentucky bluegrass treated with fertilizer materials in the 1996 Kentucky Bluegrass Fertilizer Trial (data through August 15).

	Materials[2]	Rate[3] lbs N/1000 ft^2	June 11	June 19	June 25	July 2	July 12	July 23	July 30	Aug 8	Aug 15
1.	Untreated control	NA	6	5	5	5	6	6	6	6	6
2.	Corn gluten meal (10% N)	4-split	6	7	9	8	8	8	8	8	8
3.	Sustane (5-2-4)	4-split	7	7	7	6	7	7	7	7	8
4.	Renaissance (6-0-6)	4-split	7	9	8	7	7	8	8	8	9
5.	Renaissance (8-2-6)	2	7	8	8	7	7	8	8	8	6
6.	Renaissance (8-2-6)	3	7	9	9	9	9	9	9	9	7
7.	Renaissance (8-2-6)	4-split	7	7	8	7	7	8	8	7	8
8.	Milorganite (6-2-0)	4-split	7	7	7	6	7	7	7	7	8
9.	ESN #2003 (23-5-10)	4-split	8	8	8	7	8	8	8	8	9
10.	ESN #2003 (22-5-10)	4-split	9	9	8	8	8	9	8	8	9
11.	Sulfur coated urea (39-0-0)	4-split	8	8	7	7	7	7	7	7	9
	$LSD_{0.05}$		1	1	1	1	1	1	1	1	1

[1] Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2] Initial applications were made on June 3 and sequential on August 8.
[3] Treatments 5 and 6 received only 1 application of fertilizer, the other treatments were made in split applications of 2 lbs.

Table 3. Visual quality[1] of Kentucky bluegrass treated with fertilizer materials in the 1996 Kentucky Bluegrass Fertilizer Trial (data from August 23 through October 3).

	Materials[2]	Rate[3] lbs N/1000 ft^2	Aug 23	Aug 29	Sept 5	Sept 12	Sept 19	Oct 3	Mean quality
1.	Untreated control	NA	6	6	5	5	5	5	6
2.	Corn gluten meal (10% N)	4-split	9	9	9	8	7	8	8
3.	Sustane (5-2-4)	4-split	9	8	7	7	7	7	7
4.	Renaissance (6-0-6)	4-split	9	8	8	7	7	7	8
5.	Renaissance (8-2-6)	2	7	7	6	6	6	6	7
6.	Renaissance (8-2-6)	3	7	7	6	6	5	5	8
7.	Renaissance (8-2-6)	4-split	9	9	8	8	7	7	8
8.	Milorganite (6-2-0)	4-split	8	8	8	7	7	7	7
9.	ESN #2003 (23-5-10)	4-split	9	9	9	8	7	8	8
10.	ESN #2003 (22-5-10)	4-split	9	9	9	9	8	9	8
11.	Sulfur coated urea (39-0-0)	4-split	9	9	9	9	8	9	8
	$LSD_{0.05}$		1	1	1	1	1	1	0.3

[1] Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2] Initial applications were made on June 3 and sequential on August 8.
[3] Treatments 5 and 6 received only 1 application of fertilizer, the other treatments were made in split applications of 2 lbs.

Table 4. Clipping weights[1] of Kentucky bluegrass treated with fertilizer materials in the 1996 Kentucky Bluegrass Fertilizer Trial (data from June 11 through August 23).

	Materials[2]	Rate[3] lbs N/ 1000 ft[2]	June 11	June 19	June 25	July 2	July 12	July 23	July 30	Aug 8	Aug 15	Aug 23
1.	Untreated control	NA	171	105	102	69	40	66	63	65	61	72
2.	Corn gluten meal (10% N)	4-split	184	172	203	107	94	198	146	157	163	305
3.	Sustane (5-2-4)	4-split	199	180	155	68	56	121	109	112	134	239
4.	Renaissance (6-0-6)	4-split	206	263	207	88	75	170	130	128	172	348
5.	Renaissance (8-2-6)	2	236	223	209	108	81	188	140	154	114	118
6.	Renaissance (8-2-6)	3	183	238	261	110	93	260	179	166	135	133
7.	Renaissance (8-2-6)	4-split	207	198	183	94	66	152	126	128	155	292
8.	Milorganite (6-2-0)	4-split	223	196	152	80	71	140	114	133	142	246
9.	ESN #2003 (23-5-10)	4-split	241	302	197	94	84	211	144	153	233	377
10.	ESN #2003 (22-5-10)	4-split	279	303	204	86	101	224	151	150	235	415
11.	Sulfur coated urea (39-0-0)	4-split	267	273	138	78	73	161	124	135	188	360
	$LSD_{0.05}$		NS	51	59	NS	17	30	18	32	24	40

[1] Clipping weights are expressed as grams fresh weight.
[2] Initial applications were made on June 3 and sequential on August 8.
[3] Treatments 5 and 6 received only 1 application of fertilizer, the other treatments were made in split applications of 2 lbs.
NS = means are not significantly different at the 0.05 level.

Table 5. Clipping weights[1] of Kentucky bluegrass treated with fertilizer materials in the 1996 Kentucky Bluegrass Fertilizer Trial (data from August 29 through October 3).

	Materials[2]	Rate[3] lbs N/1000 ft[2]	Aug 29	Sept 5	Sept 12	Sept 19	Oct 3	Mean weight	Total clipping weight
1.	Untreated control	NA	48	46	48	25	24	67	1003
2.	Corn gluten meal (10% N)	4-split	187	153	120	63	72	155	2325
3.	Sustane (5-2-4)	4-split	126	108	85	46	49	119	1786
4.	Renaissance (6-0-6)	4-split	173	137	101	50	57	154	2304
5.	Renaissance (8-2-6)	2	73	77	66	35	42	124	1864
6.	Renaissance (8-2-6)	3	76	82	73	47	41	138	2076
7.	Renaissance (8-2-6)	4-split	167	152	118	55	62	144	2154
8.	Milorganite (6-2-0)	4-split	135	123	92	54	58	131	1959
9.	ESN #2003 (23-5-10)	4-split	182	166	130	69	83	178	2666
10.	ESN #2003 (22-5-10)	4-split	201	170	145	71	83	188	2818
11.	Sulfur coated urea (39-0-0)	4-split	184	166	136	71	87	163	2438
	$LSD_{0.05}$		20	23	14	9	8	16	247

[1] Clipping weights are expressed as grams fresh weight.
[2] Initial applications were made on June 3 and sequential on August 8.
[3] Treatments 5 and 6 received only 1 application of fertilizer, the other treatments were made in split applications of 2 lbs.
NS = means are not significantly different at the 0.05 level.

Vigoro Kentucky Bluegrass Fertilizer Study - 1996

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The purpose of this study was to screen two fertilizer products from Vigoro for longevity and safety on Kentucky bluegrass. The study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The experimental area was 'Park' Kentucky bluegrass that was not fertilized this spring. The soil in this plot was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.5% organic matter, a pH of 7.3, 6 ppm P, and 85 ppm K.

The experiment was designed as a randomized complete block with three replications. Individual plots were 5 x 5 ft with 3 ft barrier strips between replications. There were four fertilizer treatments plus an untreated control. ParEx (24-4-12) and Experimental (21-4-12) were applied at 0.5 and 1.0 lb N/1000 ft^2 in single applications (Table 1). In addition, ParEx and Experimental were applied at 2.0 lb N/1000 ft^2 to nonreplicated 5 x 5 ft plots to evaluate the potential for fertilizer burn.

Applications were made June 13, 1996 using plastic coated containers as 'shaker dispensers'. A pre-treatment survey of the plot confirmed that turf quality was uniform. Irrigation was used to 'water in' the materials.

Visual quality and fresh clipping weight data were taken weekly beginning June 19. Subsequent data were taken on June 19, June 24, July 2, July 12, July 23, July 30, August 8, August 15, and August 23. Visual quality data also were taken on these days for the two nonreplicated demonstration plots. In some cases, slow turf growth and weather conditions necessitated changes in the collection dates. Turf quality was assessed with visual ratings using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Clipping weights were recorded in grams fresh weight and the mowing height for collecting clippings was 2 inches (Table 2). The nonreplicated plots were mowed at the same height but clippings were not collected. The plot was surveyed for phytotoxicity throughout the duration.

Data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Means comparisons were made using Fisher's Least Significant Difference test (LSD). The quality data from the nonreplicated demonstration plots were not included in the analyses.

Among the replicated plots, there were significant quality differences on June 19 and August 8. The higher rates of ParEx and Experimental produced the best quality when compared with the other treatments and untreated controls. Turf quality was consistently better for the bluegrass treated with ParEx and Experimental at 2.0 lb N/1000 ft^2 than for the other treated and untreated turf. By August 23, the fertilizer effects were gone and turf quality was uniform among all treated and untreated turf (Table 1).

No phytotoxicity was detected on the fertilized plots throughout the duration of the test. The nonreplicated, demonstration plots treated at 2 lb N/1000 ft^2 also were monitored and there were no burn symptoms on these plots.

Clipping weights were significantly higher for all treated bluegrass when compared with the untreated controls on July 2, July 12, and July 23. Bluegrass receiving the higher rates of the fertilizers had significantly more clippings than the untreated controls on June 25, July 2, July 12, July 23, and August 15 (Table 2).

Table 1. Visual quality[1] of Kentucky bluegrass treated with various herbicide fertilizer formulations in the 1996 Vigoro Kentucky Bluegrass Study.

Materials	Yearly N/ 1000 ft^2	June 19	June 25	July 2	July 12	July 23	July 30	August 8	August 15	August 23	Mean quality
1. Untreated control	NA	6	6	6	7	7	7	7	7	7	7
2. ParEx (24-4-12)	0.5	7	7	7	7	8	8	7	7	7	7
3. ParEx (24-4-12)	1.0	8	8	7	8	8	8	8	7	7	8
4. Experimental (21-4-12)	0.5	7	7	7	7	8	8	7	7	7	7
5. Experimental (21-4-12)	1.0	8	8	8	8	8	8	8	7	7	8
6. ParEx (24-4-12)[2]	2.0	9	9	9	9	9	9	9	8	7	---
7. Experimental (21-4-12)[2]	2.0	9	9	9	9	9	9	9	8	7	---
$LSD_{0.05}$		1	NS	NS	NS	NS	NS	0.6	NS	NS	0.2

[1] Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2] These 2 treatments were in nonreplicated demonstration plots and their data were not included in the analysis.
NS = means are not significantly different at the 0.05 level.

Table 2. Clipping weights[1] of Kentucky bluegrass treated with various herbicide fertilizer formulations in the 1996 Vigoro Kentucky Bluegrass Study.

Materials	Yearly N/ 1000 ft^2	June 19	June 25	July 2	July 12	July 23	July 30	August 8	August 15	August 23	Mean weight	Total weight
1. Untreated control	NA	169	78	52	64	99	79	86	67	69	85	764
2. ParEx (24-4-12)	0.5	216	107	79	84	136	103	100	78	88	110	991
3. ParEx (24-4-12)	1.0	203	152	87	98	182	126	114	95	87	127	1145
4. Experimental (21-4-12)	0.5	233	113	74	89	141	109	96	86	80	113	1020
5. Experimental (21-4-12)	1.0	193	128	81	98	167	114	118	87	90	120	1076
$LSD_{0.05}$		NS	34	8	7	19	21	NS	16	NS	5	48

[1] Clipping weights are reported in grams fresh tissue.
NS = means are not significantly different at the 0.05 level.

Response of Kentucky Bluegrass to Potassium - 1996

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The responses of Kentucky bluegrass to a standard potassium and a coated (T-60) potassium material (from Viridian Inc.) were compared. This study was conducted on an established 'Park' Kentucky bluegrass at the Iowa State University Horticulture Research Station north of Ames, Iowa. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 4.1%, a pH of 7.2, 3 ppm P, and 80 ppm K as of May 1996. This plot was not fertilized in the spring of 1996.

Individual plots were 5 x 5 ft and three replications were conducted. Three-foot barrier rows were placed between replications. There were five treatments including an untreated control. Potassium was applied in a standard formulation of K_2SO_4 (0-0-50) and in the experimental coated formulation T-60 (0-0-48.5) from Viridian Inc. Both materials were applied at an annual rate of 1 lb K/1000 ft^2 in a single application and at 2 lb K/1000 ft^2 in split applications with the sequential being applied 30 days after the initial application (Table 1). The potassium materials were applied with 'shaker dispensers'.

Initial treatments were made on May 30. A pre-application survey of the plot showed uniform turf quality. Thirty-day sequential applications for treatments 4 and 5 were made July 3. Because of dry conditions, supplemental irrigation was used to maintain the turf in good growing condition.

The duration of the experiment was 11 weeks. The plot was mowed weekly beginning June 11. Fresh clippings were collected and weighed. Bi-weekly, the clippings were dried to determine dry weights and to analyze tissue potassium.

Fresh clipping weights and turf quality data were taken on June 11, June 19, June 25, July 12, July 23, July 30, August 8, and August 15. Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Fresh clipping weights were measured as grams fresh tissue (Table 2). Mowing height for collecting clippings was 2 inches.

The clippings from June 19, July 12, July 30, and August 15 were dried and dry weights were measured in grams dry weight (Table 3). The dry tissue was ground to pass through 40 mesh screen using a Wiley Mill Grinder and analyzed for potassium content.

Potassium analyses were conducted by the Plant Nutrition Lab in the Department of Horticulture at Iowa State University. Potassium content was determined using an IRIS - AP - Duo, Inductively Coupled Argon Plasma Analyzer (ICAP). The dry tissue samples were ashed at 490° C and the ash was dissolved in 1 N aqua regia solution (a 3:1 solution of hydrochloric acid and nitric acid). The aqua regia and ash solution was filtered with Whatman #42 paper prior to ICAP analysis. A calibration curve (K range 10 - 800 ppm) was constructed and potassium content was determined in ppm and converted to percent in tissue (Table 4). The results of the ICAP analyses were confirmed by checking one representative sample for each treatment using the Flame Atomic Absorption (FAA) analyzer.

The soil in each individual plot was tested for a standard profile and for potassium content at the end of the study. These tests were conducted at the Soil Test Lab in the Department of Agronomy at Iowa State University. Soil samples were taken August 30 and one sample per treatment was taken and analyzed for percent organic matter, pH, phosphorous, and potassium (Table 5).

Data were analyzed using the Statistical Analysis System (SAS) version 6.09 and the Analysis of Variance (ANOVA) procedure. Mean quality ratings and clipping weights were compared using Fisher's Least Significant Difference (LSD) test.

There were no differences in visual quality among the treated and untreated plots (Table 1). There also were no differences in either fresh or dry clipping weights of the grass on plots treated with the potassium materials as compared with the untreated controls throughout the study (Tables 2 and 3).

The 1-lb K rate did not increase soil test amounts of K but the 2-lb rate increased soil test levels to 100 ppm (Table 4). Surprisingly, no increase in K tissue levels was observed with increasing K application rates (Table 5). The data were double checked and backup samples were examined with the Flame Atomic Absorption analyzer to verify the results. We are uncertain as to the reason why K tissue levels showed no increases at these relatively low K soil test levels. Additional research will be needed to evaluate K uptake under these conditions.

Table 1. Visual quality[1] of Kentucky bluegrass treated with potassium formulations in the 1996 Potassium Response Study.

	Materials	Annual amount of K/1000 ft^2	June 11	June 19	June 25	July 12	July 23	July 30	Aug 8	Aug 15	Mean Quality
1.	Untreated control	NA	8	8	8	8	8	7	7	6	7.5
2.	K_2SO_4 (0-0-50)	1	8	8	8	8	8	7	7	6	7.5
3.	Sherritt coated T-60 (0-0-48.5)	1	8	8	8	8	8	7	7	6	7.5
4.	K_2SO_4 (0-0-50)	2	8	8	8	8	8	7	7	6	7.5
5.	Sherritt coated T-60 (0-0-48.5)	2	8	8	8	8	8	7	7	6	7.5
	$LSD_{0.05}$		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.
1st application of materials was made on May 30 and 2nd on July 3, 1996.
NS = means are not significantly different at the 0.05 level.

Table 2. Fresh clipping weights[1] of Kentucky bluegrass treated with potassium formulations in the 1996 Potassium Response Study.

	Materials	Annual amount of K/1000 ft^2	June 11	June 19	June 25	July 12	July 23	July 30	Aug 8	Aug 15	Mean fresh weight	Total fresh weight
1.	Untreated control	NA	491	160	103	150	129	62	57	52	150	1203
2.	K_2SO_4 (0-0-50)	1	498	177	104	155	126	27	63	65	157	1259
3.	Sherritt coated T-60 (0-0-48.5)	1	411	150	89	127	101	55	51	45	129	1029
4.	K_2SO_4 (0-0-50)	2	425	149	95	126	99	56	53	47	131	1050
5.	Sherritt coated T-60 (0-0-48.5)	2	467	150	93	141	110	61	55	53	141	1129
	$LSD_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Clipping weights are expressed as grams fresh weight.
1st application of materials was made on May 30 and 2nd on July 3, 1996.
NS = means are not significantly different at the 0.05 level.

Table 3. Dry clipping weights[1] of Kentucky bluegrass treated with potassium formulations in the 1996 Potassium Response Study.

	Materials	Annual amount of K/1000 ft^2	June 19	July 12	July 30	August 15	Mean dry weight	Total dry weight
1.	Untreated control	NA	52.3	55.2	20.5	19.9	37.0	147.9
2.	K_2SO_4 (0-0-50)	1	56.5	58.0	23.3	26.5	41.0	164.2
3.	Sherritt coated T-60 (0-0-48.5)	1	49.5	48.0	19.2	18.2	33.7	134.8
4.	K_2SO_4 (0-0-50)	2	49.9	48.0	19.2	18.3	33.9	135.5
5.	Sherritt coated T-60 (0-0-48.5)	2	49.3	53.6	20.8	21.6	36.3	145.3
	$LSD_{0.05}$		NS	NS	NS	NS	NS	NS

[1]Dry clipping weights are expressed as grams dry weight.
1st application of materials was made on May 30 and 2nd on July 3, 1996.
NS = means are not significantly different at the 0.05 level.

Table 4. Tissue potassium[1] of Kentucky bluegrass treated with potassium formulations in the 1996 Potassium Response Study.

	Materials	Annual amount of K/1000 ft^2	June 19	July 12	July 30	August 15	Mean dry weight
1.	Untreated control	NA	1.73	1.31	1.67	1.48	1.55
2.	K_2SO_4 (0-0-50)	1	1.75	1.30	1.67	1.50	1.56
3.	Sherritt coated T-60 (0-0-48.5)	1	1.71	1.27	1.59	1.39	1.49
4.	K_2SO_4 (0-0-50)	2	1.71	1.27	1.64	1.40	1.51
5.	Sherritt coated T-60 (0-0-48.5)	2	1.69	1.28	1.64	1.47	1.52
	$LSD_{0.05}$		NS	NS	NS	NS	NS

[1]Tissue potassium values were determined with ICAP analysis and are expressed as percent potassium/tissue.
1st application of materials was made on May 30 and 2nd on July 3, 1996.
NS = means are not significantly different at the 0.05 level.

Table 5. Soil analysis[1] from the Kentucky bluegrass plot used in the 1996 Potassium Response Study from samples taken on August 30, 1996.

	Materials	Annual amount of K/1000 ft^2	Organic matter content (%)	Soil pH	Phosphorous content (ppm)	Potassium content (ppm)
1.	Untreated control	NA	4.3	6.7	5	
2.	K_2SO_4 (0-0-50)	1	4.3	6.7	4	83
3.	Sherritt coated T-60 (0-0-48.5)	1	4.9	6.8	5	88
4.	K_2SO_4 (0-0-50)	2	4.4	6.7	4	100
5.	Sherritt coated T-60 (0-0-48.5)	2	4.7	6.8	4	100

[1]Soil analyses were conducted by the Soil Testing Lab of the Agronomy Department at Iowa State University.
1st application of materials was made on May 30 and 2nd on July 3, 1996.

Toro Bentgrass Establishment Trial 1996-1997

Michael B. Faust and Nick E. Christians

1996

This bentgrass establishment trial was initiated in September, 1996 at the Iowa State University Horticulture Research Station. It is sponsored by the Toro Company. The project was designed to study the effects of Toro products on the establishment of creeping bentgrass on a new sand-based golf green.

The study is being conducted on a 100% sand green which was seeded in September, 1996 with 'Crenshaw' creeping bentgrass. This trial uses a total surface area of 900 ft^2, with individual treatment plots having an area of 50 ft^2. Six treatments with three replications are being used.

Five of the treatments used in the study are a combination of products supplied by the Toro Company (Table 1). The final treatment is the control which contains elemental N, P, and K. Application of the treatments followed a 4-week cycle in the fall of 1996. Week one was a 1:1:1 (N,P,K) application with 0.5 lb N, P, and K being applied to the turf. Weeks 2-4 used a 2:0:1 (N,P,K) application with 0.5 lb N, zero P, and 0.25 lb K.

Treatments 1-5 were applied to the turf using a hand-spray boom sprayer. Treatment 6, a granular, was applied using a hand-held shaker. The first 1:1:1 application was made September 25, with the 2:0:1 applications following for the next three weeks. Treatments were irrigated after application. A single 4-week cycle was completed in 1996.

One set of visual quality data was taken October 15, 1996 (See below). This data rated the percentage of ground cover during the fall 1996 grow-in period. Initially, the plots receiving the granular treatments were slightly behind the other liquid treatments. This was demonstrated in turf color and percent cover shown by the emergence of the new bentgrass seedlings.

Percent Cover Data 1996

Treatment #	1	2	3	4	5	6
Rating (Mean)	5	4	4	5	4	3

*Ratings are 9 = Best and 1 = Worst

1997

The treatments were resumed in the spring of 1997 with the following changes. The plots were split into two 25 ft^2 sections, doubling the number of individual plots in the trial. The first application was a 1:1:1 starter fertilizer containing 0.5 lb N, 0.5 lb P, and 0.5 lb K. This application was made to both sections of the plot on May 1. Application frequency and product quantity changes were initiated two weeks following the 1:1:1 application. At that time, a switch was made to a 2:0:1 material (Table 1). These applications will be used for the remainder of the season. Half of the experimental plots will receive one 0.5 lb N/1000 ft^2 application every two weeks; (2 applications per month). The other half of the plots will receive two 0.125 lb N/1000 ft^2 applications per week; (eight applications per month). A total of 1 lb. N/1000 ft^2 and 0.5 lb K/1000 ft^2 will be applied to each plot in a one-month period.

Visual quality data will be taken weekly throughout the spring, summer, and fall months. Sampling of clippings are scheduled every two weeks once the grass on the plots has matured. Rooting will be measured in July and September. Clipping tissue samples will be analyzed every two weeks with the IRIS--AP--DUO, Inductively Coupled Argon Plasma Analyzer (ICAP). The analysis by (ICAP) will occur on all plots for a total of eight sampling dates.

Table 1. Toro Bentgrass Establishment Trial 1996 and 1997

- Objective

  - Compare the effects of five different combinations of Toro products and control on the establishment of bentgrass on USGA spec. soil mix maintained under putting green conditions.

- Post Germination Treatments (1996)

  - Weekly applications at a rate of 0.5 lb N/1000 ft^2
  - Week 1- 1:1:1 N, P, & K
  - Weeks 2, 3, and 4 - 2:0:1 N, P, & K
  - Repeat on a four (4) week cycle through establishment period

- Post Germination Treatments (1997)

  - Initial 1:1:1 treatment application with 0.5 lb N, 0.5 lb P, and 0.5 lb K/1000 ft^2
  - 2:0:1 treatment applications to be used for the remainder of the season
  - Half of the plots will receive one 0.5 lb N/1000 ft^2 application every two weeks (2 applications/month)
  - The other half of the experimental plots will receive two 0.125 lb N/1000 ft^2 applications per week (8 applications/month)
  - All experimental plots will receive 1.0 lb N/1000 ft^2 and 0.25 lb K/1000 ft^2 per month

- 1:1:1 Treatments

  1. 7-24-0 *w/5% humic acid* as P source; KNO_3 as K source; remaining N from NH_3NO_4
  2. 8-16-4 *w/compost-derived organic acids* as P source; KNO_3 as K source; and remaining N from NH_4NO_3
  3. 15% *humic acid* ; H_3PO_4 as primary P source; KNO_3 as primary K source; and remaining N from NH_4NO_3
  4. 5-3-2 *w/molasses* ; H_3PO_4 as primary P source; KNO_3 as primary K source; remaining N from NH_4NO_3
  5. (Control) H_3PO_4 as P source; KNO_3 as K source; remaining N from NH_4NO_3.
  6. 12-16-8 *granular* & 12-3-9 *granular* at 0.5 lb N/1000 ft^2

- 2:0:1 Treatments

  1. 22% *humic acid* ; KNO_3 as K source; remaining N from NH_4NO_3
  2. 6-0-0 *w/compost derived organic acids* ; KNO_3 as K source; remaining N from NH_4NO_3
  3. 15% *humic acid* ; KNO_3 as K source; remaining N from NH_4NO_3
  4. 5-3-2 *w/molasses* ; KNO_3 as primary K source; remaining N from NH_4NO_3
  5. (Control) KNO_3 as K source; remaining N from NH_4NO_3
  6. 12-3-9 *granular* at 0.5 lb and 0.125 lb N/1000 ft^2

- Response Measurements

  1. Clipping dry weight on a g/m^2/day basis
  2. Root mass
  3. Quality

1991 Corn Gluten Meal Crabgrass Control Study - Year 6

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

A study screening corn gluten meal (CGM) for efficacy as a natural product herbicide and fertilizer in turf was begun in 1991 and has been continued on the same plot for six consecutive 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 'Parade' Kentucky bluegrass. The soil in this experimental area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.5% a pH of 6.4, 11.2 ppm P, and 220 ppm K.

Individual experimental plots are 5 x 5 ft and there are five treatments with three replications. The experimental design is a randomized complete block. Corn gluten meal was applied at 0, 20, 40, 60, 80, 100, and 120 lbs/1000 ft^2 (Table 1). Because corn gluten meal is 10% N, these rates are equivalent to 0, 2, 4, 6, 8, and 10 lbs N/1000 ft^2. All treatments were made to the same plots as in previous years. The CGM was applied in a single early spring preemergence application on April 24, 1996 using 'shaker dispensers'. The materials were watered-in with the irrigation system. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

The plot was evaluated for phytotoxicity on April 25 and periodically throughout the growing season. Visual quality data were taken on June 7, July 10, July 30, and August 23. 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 counting the number of crabgrass plants per individual plot. Control data were taken on August 23 (Tables 2 & 3). Crabgrass populations were quite low in 1996 (Table 2). The cool, wet spring delayed crabgrass germination and the grass and broadleaf weeds were able to become well established before the crabgrass emerged. There were only a few crabgrass plants on August 23 and they were quite small with only one to two tillers.

To determine the level of broadleaf weed control, dandelion and clover populations were surveyed. Overall estimations of percentage of broadleaf cover (dandelion and clover were the only broadleaf species present) were made on June 7, July 10, and July 30 (Table 3). On August 23, counts were made of the number of dandelions per plot and percentage of clover cover per plot were estimated (Table 4).

Data were analyzed with the Statistical Analysis System version 6.10 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Least Significant Difference (LSD) means comparison tests were used to assess CGM effects on bluegrass quality and weed control. Weed control data also were expressed as percent reductions (Tables 3, 4, & 8). These values were calculated as percentage reductions compared with the untreated controls.

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

There were significant reductions in the number of crabgrass plants in the treated as compared with the untreated turf (Table 2). Crabgrass reductions were $\geq$ 59% in all corn gluten meal-treated turf except at 20 lbs /1000 ft^2. At this CGM level, there were more crabgrass plants than in the untreated controls. Reductions were 97, 79, 59, 83, and 97% for 40, 60, 80, 100, and 120 lbs/1000 ft^2 CGM, respectively.

Crabgrass control data for 1991-1995 were compared with data from 1996 (Table 5). Percentage reductions in 1996 were generally higher than those recorded in 1995.

There were significant reductions in the percentage of broadleaf weed cover in the treated as compared with the untreated bluegrass plots (Table 3). Percent cover was significantly lower in all CGM treated plots as compared to the untreated controls.

Percentage of clover cover was significantly reduced by all CGM levels (Table 4). Mean percent cover data also indicated large reductions in treated versus untreated control turf. Reductions in percent clover cover from 1996 were similar to those from 1994 at 20, 40, 60, 80, 100, and 120 lbs/1000 ft^2 and larger than those reported for 1995 at 20, 40, 80, and 100 lbs/1000 ft^2 (Table 6).

The number of dandelions was significantly reduced by all CGM levels except 20 lbs/1000 ft^2 (Table 5). In 1994, dandelion was controlled better than in 1995 and 1996 at 20, 40, and 60 lbs/1000 ft^2 (Table 6). Reductions were similar for all three years at 80, 100, and 120 lbs/1000 ft^2.

Table 1. Visual quality[1] of Kentucky bluegrass treated with granular corn gluten meal in the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs CGM /1000 ft^2	lbs N /1000 ft^2	June 7	July 10	July 30	Aug 23	Mean quality
1.	Untreated control	0	0	6	7	7	7	7
2.	Corn gluten meal	20	2	7	7	7	7	7
3.	Corn gluten meal	40	4	8	8	8	8	8
4.	Corn gluten meal	60	6	9	8	8	8	8
5.	Corn gluten meal	80	8	9	9	8	8	9
6.	Corn gluten meal	100	10	9	9	9	9	9
7.	Corn gluten meal	120	12	9	9	9	9	9
	$LSD_{0.05}$			1	1	1	1	1

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

Table 2. Number of crabgrass plants[1] in Kentucky bluegrass plots treated with granular corn gluten meal for the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs CGM /1000 ft^2	lbs N /1000 ft^2	August 23	% Reduction in Numbers[2]
1.	Untreated control	0	0	13	0
2.	Corn gluten meal	20	2	11	15
3.	Corn gluten meal	40	4	1	97
4.	Corn gluten meal	60	6	2	85
5.	Corn gluten meal	80	8	4	69
6.	Corn gluten meal	100	10	2	87
7.	Corn gluten meal	120	12	1	97
	$LSD_{0.05}$			8	60

[1] These values represent the actual number of crabgrass plants per plot.
[2] These values represent the percentage reductions in crabgrass plants per plot as compared with the untreated controls.

Table 3. Percentage of broadleaf cover[1] in Kentucky bluegrass treated with granular corn gluten meal in the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs N /1000 ft^2	June 7	July 10	July 30	Mean % cover	Percent reduction[2]
1.	Untreated control	0	43	53	58	52	0
2.	Corn gluten meal	2	23	23	28	25	52
3.	Corn gluten meal	4	10	7	10	9	83
4.	Corn gluten meal	6	4	2	4	3	94
5.	Corn gluten meal	8	4	1	7	4	93
6.	Corn gluten meal	10	4	4	7	5	91
7.	Corn gluten meal	12	1	4	4	3	95
	LSD0.05		18	10	13	10	20

[1] Dandelion and clover were the only broadleaf species detected in the plots. These percentages represent the amount of area per plot covered by dandelion and clover.
[2] These values represent the percentage reductions in crabgrass plants per plot as compared with the untreated controls.

Table 4. Percentage clover cover[1] and dandelion counts per plot[2] in Kentucky bluegrass treated with in the 1991 Corn Gluten Meal Weed Control Study.

			Percentage clover cover (%)[1]			Dandelion counts per plot[2]		
	Material	lbs N /1000 ft^2	May 9	August 23	Mean % cover	May 9	August 23	Mean number
1	Untreated control	0	15	27	21	19	20	19
2	Corn gluten meal	2	7	5	6	10	16	13
3	Corn gluten meal	4	5	2	4	4	5	5
4	Corn gluten meal	6	1	2	2	2	6	4
5	Corn gluten meal	8	4	1	2	1	1	1
6	Corn gluten meal	10	2	1	2	0	1	1
7	Corn gluten meal	12	1	2	2	0	0	0
	$LSD_{(0.05)}$		7	14	6	12	11	11

[1]Percentage clover cover represents the area per plot covered by clover.
[2]Dandelion counts are the actual number of dandelion per plot.

Table 5. Comparisons of the percentage crabgrass reductions[1] in Kentucky bluegrass treated with granular corn gluten meal in the 1991 Corn Gluten Meal Weed Control Study through 1996.

	Material	lbs N/1000 ft^2	Percent crabgrass reduction (%) 1991	1992	1993	1994	1995	1996
1	Untreated control	0	0	0	0	0	0	0
2	Corn gluten meal	2	58	85	91	70	36	15
3	Corn gluten meal	4	86	98	98	97	88	97
4	Corn gluten meal	6	97	98	93	98	93	85
5	Corn gluten meal	8	87	93	93	87	75	69
6	Corn gluten meal	10	79	94	95	86	75	87
7	Corn gluten meal	12	97	100	100	98	84	97
	$LSD_{0.05}$		26	44	31	39	40	60

[1] These values represent the percentage reductions in crabgrass plants per plot as compared with the untreated controls.

Table 6. Reductions in percentages clover cover[1] and number of dandelions per plot[2] for 1994-1996 in Kentucky bluegrass treated with corn gluten meal in the 1991 Corn Gluten Meal Weed Control Study.

			Percentage clover cover reduction[3]			Reduction in dandelion numbers[3]		
	Material	lbs N/1000 ft^2	1994	1995	1996	1994	1995	1996
1	Untreated control	0	0	0	0	0	0	0
2	Corn gluten meal	2	81	56	71	71	49	33
3	Corn gluten meal	4	90	64	82	100	77	75
4	Corn gluten meal	6	98	93	93	100	89	79
5	Corn gluten meal	8	100	76	90	98	96	95
6	Corn gluten meal	10	94	84	92	100	98	96
7	Corn gluten meal	12	90	93	93	100	100	100
	$LSD_{(0.05)}$		NS	48	29	50	65	60

[1] Percentage clover cover represent the area per plot covered by clover.
[2] Dandelion counts are the actual number of dandelions per plot.
[3] These values represent the percentage reductions in plants per plot as compared with the untreated controls.
NS = not significantly different at the 0.05 level.

1995 Corn Gluten Meal Rate Weed Control Study - Year 2

Barbara R. Bingaman and Nick E. Christians

Corn gluten meal (CGM) was screened for efficacy as a natural product 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 area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.7%, a pH of 7.1, 4 ppm P, and 100 ppm K. The initial broadleaf weed population exceeded 50% cover on most of the test area.

Individual experimental plots are 10 x 10 ft and there are five treatments with three replications. The experimental design is a randomized complete block. Corn gluten meal was applied at a yearly rate of 40 lb CGM/1000 ft^2 (equivalent to 4 lb N/1000 ft^2) using four different regimes of single and split applications (Table 1). Four applications of 10 lb/1000 ft^2, split applications of 20 lb/1000 ft^2, an initial application of 30 lbs plus a sequential of 10 lb/1000 ft^2, and a single application of 40 lb/1000 ft^2 were included with an untreated control.

Initial applications were made April 24. The second application for treatment 2 was made May 28. On August 8, the third application of treatment 2, and the sequential applications of treatments 3 and 4 were made. The final application for treatment 2 was made September 5.

The experimental plot was checked for phytotoxicity after applications. Visual quality data were taken May 22, June 10, June 26, July 10, July 30, August 23, and September 5. 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 counting the number of crabgrass plants per individual plot. Crabgrass control data were taken August 23 (Table 2). The first broadleaf control data for this study were taken in the spring of 1996. Broadleaf weed control was assessed by estimating the percentage of area in each plot covered by dandelion and clover. These data were taken June 10, June 26, July 10, and July 30 (Table 3). In addition, the percent cover of dandelion and clover were determined separately May 9, August 23, and September 5 (Tables 4 and 5).

Data were analyzed with the Statistical Analysis System version 6.10 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference test (LSD) was used to compare means.

There were no phytotoxic symptoms detected on the treated bluegrass. Visual turf quality was better in bluegrass treated with CGM than in the untreated controls for the entire season (Table 1).

Broadleaf weed species were well established when the crabgrass was emerging especially in the untreated controls. Competition from the broadleaves and the mature turf probably prevented the establishment of large crabgrass populations within the untreated plots. Consequently crabgrass numbers were quite low in all of the plots and when crabgrass data were taken August 23, the plants were still quite small with only two or three tillers. Corn gluten meal did not significantly reduce the number of crabgrass plants per plot (Table 2).

In 1996, there were fewer crabgrass plants in turf treated with CGM in split applications at 20 lb CGM and at 30 lb followed by 10 lb CGM/1000 ft^2 (treatments 3 and 4) than in the untreated controls (Table 2). In turf receiving the other CGM treatments, there were more crabgrass plants than in the untreated controls. Crabgrass numbers were much higher in 1995 than in 1996 and all CGM treatments reduced crabgrass numbers when compared with the untreated controls. In 1996, crabgrass control was better in turf receiving 30 lb followed by 10 lb CGM/1000 ft^2 than in 1995.

Percent broadleaf cover was significantly reduced by corn gluten meal throughout the season (Table 3). The best broadleaf control was provided at 40 lb CGM/1000 ft^2 in a single, spring application but this level was not different from the other CGM rates.

Dandelion and clover cover were reduced in turf treated with CGM but the reductions were not significantly different than the untreated controls (Table 4 and 5). Treatment at all CGM rates except the split application of 30 lb followed by 10 lb CGM/1000 ft^2 (treatment 4) resulted in 50% dandelion cover reductions (Table 4). Reduction in percentage cover was 28% in turf treated with 30 lb followed by 10 lb CGM/1000 ft^2. The best clover control was in turf treated with 3 lb followed by 10 lb CGM/1000 ft^2 and with 40 lb/1000 ft^2 in a single application (Table 5).

Table 1. Visual quality[1] of Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

	Material	CGM treatments (lb/1000 ft^2)[2]	Application timing[2]	May 22	June 10	June 26	July 10	July 30	Aug 23	Sept 5	Mean quality
1.	Untreated control	0	NA	6	5	7	6	6	6	6	6
2.	Corn gluten meal	10 fb 10 fb 10 fb 10	4 sequential	8	8	8	8	7	8	9	8
3.	Corn gluten meal	20 fb 20	split	8	8	8	7	8	9	9	8
4.	Corn gluten meal	30 fb 10	30 + 10 lb split	9	8	8	8	7	8	8	8
5.	Corn gluten meal	40	1 single	9	8	9	9	8	8	8	8
	$LSD_{0.05}$			1	1	NS	1	1	1	1	1

[1] Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2] All treatments were at an annual rate of 4 lbs N/1000 ft^2. Initial applications were made on April 24; 2nd application of trt 2 on May 28; 3rd application of trt 2 and 2nd of trt 3 & 4 on August 8; and final application of trt 2 on September 5.
NS = means are not significantly different at the 0.05 level

Table 2. Crabgrass counts per plot[1] and crabgrass reductions[2] in Kentucky bluegrass treated with corn gluten meal (CGM) in the 1995 Corn Gluten Meal Rate Weed Control Study.

	Material	Application timing[3]	Crabgrass counts[1]	Percent crabgrass reduction[2]	
			August 23	1995	1996
1.	Untreated control	NA	4	0	0
2.	Corn gluten meal	sequential	7	28	0
3.	Corn gluten meal	split	3	45	33
4.	Corn gluten meal	split	1	44	67
5.	Corn gluten meal	single	5	54	0
	$LSD_{0.05}$		NS	NS	NS

[1] These data represent the number of crabgrass plants per plot.
[2] These values represent the percentage reductions in plants per plot as compared with the untreated controls.
[3] All treatments were at an annual rate of 4 lbs N/1000 ft^2. Initial applications were made on April 24; 2nd application of trt 2 on May 28; 3rd application of trt 2 and 2nd of trt 3 & 4 on August 8; and final application of trt 2 on September 5.
NS = means are not significantly different at the 0.05 level.

Table 3. Percent broadleaf cover[1] in Kentucky bluegrass treated with corn gluten meal for the 1995 Corn Gluten Meal Rate Weed Control Study.

	Material	Application timing[2]	June 10	June 26	July 10	July 30	Mean % cover	% cover reduction[3]
1.	Untreated control	NA	58	40	50	62	53	0
2.	Corn gluten meal	sequential	20	25	23	27	24	55
3.	Corn gluten meal	split	20	15	20	20	19	65
4.	Corn gluten meal	split	17	15	23	22	19	64
5.	Corn gluten meal	single	13	15	22	18	17	68
	$LSD_{0.05}$		18	13	20	13	14	26

[1]Percent cover represents the area per plot covered by broadleaf species.
[2]All treatments were at an annual rate of 4 lbs N/1000 ft^2. Initial applications were made on April 24; 2nd application of trt 2 on May 28; 3rd application of trt 2 and 2nd of trt 3 & 4 on August 8; and final application of trt 2 on September 5.
[3]These values represent the percentage reductions in plants per plot as compared with the untreated controls.

Table 4. Percentage dandelion cover[1] in Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

	Material	Application timing[2]	May 9	August 23	September 5	Mean % cover	% Cover reduction
1.	Untreated control	NA	20	27	23	23	0
2.	Corn gluten meal	sequential	10	15	12	12	48
3.	Corn gluten meal	split	13	10	12	12	50
4.	Corn gluten meal	split	15	15	20	17	28
5.	Corn gluten meal	single	13	10	12	12	50
	$LSD_{0.05}$		NS	NS	NS	NS	NS

[1] Percentage cover represents the amount of area per plot covered by dandelion.
[2] Initial applications were made on April 24; 2nd application of trt 2 on May 28; 3rd application of trt 2 and 2nd of trt 3 & 4 on August 8; and final application of trt 2 on September 5.
NS = means are not significantly different at the 0.05 level.

Table 5. Percent clover cover[1] in Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

	Material	Application timing[2]	May 9	August 23	September 5	Mean % cover	% Cover reduction
1.	Untreated control	NA	12	22	27	20	0
2.	Corn gluten meal	sequential	8	12	13	11	45
3.	Corn gluten meal	split	5	7	7	6	69
4.	Corn gluten meal	split	2	4	1	3	90
5.	Corn gluten meal	single	2	1	2	2	92
	$LSD_{0.05}$		NS	NS	NS	NS	NS

[1] Percentage cover represents the amount of area per plot covered by dandelion.
[2] All treatments were at an annual rate of 4 lbs N/1000 ft^2. Initial applications were made on April 24; 2nd application of trt 2 on May 28; 3rd application of trt 2 and 2nd of trt 3 & 4 on August 8; and final application of trt 2 on September 5.
NS = means are not significantly different at the 0.05 level.

1995 Corn Gluten Hydrolysate Weed Control Study - Year 2

Barbara R. Bingaman and Nick E. Christians

Corn gluten hydrolysate (CGH) was screened for efficacy as a natural herbicide in turf. This trial is a long-term study started in 1995 that will be continued in the same experimental 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 3.7% a pH of 7.1, 4 ppm P, and 100 ppm K.

The experimental design is a randomized complete block with three replications. Individual experimental plots are 5 x 5 ft with 3 ft barrier rows between replications. Corn gluten hydrolysate was applied at 5, 10, 15, and 20 lbs product/1000 ft^2 (Table 1). These rates are equivalent to 0.5, 1.0, 1.5, and 2.0 lbs N/1000 ft^2 as CGH contains 10% N. The CGH was dissolved in water and the volumes applied were 700, 1400, 2100, and 2800 ml for the 5, 10, 15, and 20 lb rates, respectively. An untreated control was included for comparisons. The CGH was applied using a carbon dioxide backpack sprayer equipped with #8006 nozzles at 20 psi.

All treated plots received a single application on May 14. Supplemental irrigation was used to provide adequate moisture to maintain the grass in good growing condition.

Visual quality data were taken May 22 and June 10. Visual quality was measured using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality (Table 1). Data for individual weed species were not taken because weed populations were very high especially in the untreated controls. The cool, wet spring delayed crabgrass germination until the broadleaf weed species (i.e. dandelion and clover) were well established. Weed control was assessed by making visual estimations of the percent of area per plot covered by broadleaf and grass weed species (Table 2). Representative species included dandelion, clover, black medic, and spurge. Weed control data were taken May 22, June 10, July 10, July 30, and August 23.

Data were analyzed with the Statistical Analysis System version 6.10 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference (LSD) means comparison tests were used to assess CGH effects on bluegrass quality and weed control.

No phytotoxic symptoms were detected in any of the treated plots. Turf quality was improved by CGH as compared with the untreated control plots through June 10. After this date, there were no quality differences among the plots (Table 1).

Weed populations were not significantly reduced by CGH (Table 2). On some of the data collection dates, percentage weed cover was higher in bluegrass treated with CGH than in the untreated controls. The majority of the weed cover consisted of dandelion and clover with only small sporadic populations of black medic and spurge. The absence of crabgrass could possibly be explained by the competition at the time of germination from dense populations of dandelion and clover.

Table 1. Visual quality[1] of Kentucky bluegrass treated with corn gluten hydrolysate for the 1995 Corn Gluten Hydrolysate Weed Control Study.

	Material	lbs product /1000 ft²	May 22	June 10	Mean Quality
1.	Untreated control	NA	6	5	6
2.	Corn gluten hydrolysate	5	7	6	7
3.	Corn gluten hydrolysate	10	8	7	8
4.	Corn gluten hydrolysate	15	8	8	8
5.	Corn gluten hydrolysate	20	9	8	8
	$LSD_{0.05}$		1	1	1

[1] Visual quality was assessed using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
Corn gluten hydrolysate was applied on May 14, 1996.

Table 2. Percentage of weed cover[1] in Kentucky bluegrass treated with corn gluten hydrolysate for the 1995 Corn Gluten Hydrolysate Weed Control Study.

	Material	lbs product /1000 ft²	May 22	June 10	July 10	July 30	Aug 23	Mean % cover	Percent cover reduction
1.	Untreated control	NA	53	47	60	58	67	57	--
2.	Corn gluten hydrolysate	5	63	55	65	55	65	61	0
3.	Corn gluten hydrolysate	10	60	53	72	58	65	62	0
4.	Corn gluten hydrolysate	15	53	47	45	40	55	48	16
5.	Corn gluten hydrolysate	20	53	47	65	55	60	56	2
	$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS

[1]Percent cover is the percentage of area per plot covered by all broadleaf and grass weed species.
Corn gluten hydrolysate was applied on May 14, 1996.
NS = not significantly different at the 0.05 level.

Pendimethalin and Corn Gluten Meal Combinations for Weed Control in Turfgrass

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

These field experiments were conducted at the Iowa State University Horticulture Research Station in an area of common Kentucky bluegrass (*Poa pratensis* L.) that had been established in 1968. The soil was a Nicollet with a pH of 6.2, 6.5 mg P kg^{-1}, 77 mg K kg^{-1}, and 22 g kg^{-1} of organic matter. Twenty treatments consisting of four rates of corn gluten meal combined in a factorial arrangement with five rates of pendimethalin 60 DG were applied individually to 20 plots. Each plot was 5 x 5 ft, and plots were arranged in a randomized complete block design with two rows of ten plots per block and 2.5 ft barrier rows between each of the three blocks.

Powdered corn gluten meal was hand-applied on 13 April 1995 and 24 April 1996, at single application rates of 0, 49, 98, or 147 g m^{-2}. A carbon dioxide backpack sprayer, with a pressure of 30 psi using 8006 nozzles, was used to apply pendimethalin on 25 April 1995 and 1 May 1996 at single application rates of 0, 29, 59, 88, or 117 mg ai m^{-2}. The rates of pendimethalin tested were 1/6, 1/3, 1/2, and 2/3 of the minimum recommended application rate, and the rates of corn gluten meal tested were 1/2, 1, and 2 times the recommended application rate of corn gluten meal. The test plots were mowed and supplemental irrigation was used as necessary throughout the summer so that the turfgrass did not go dormant. No other fertilizer was applied during the study.

In both years, data were collected as average visual estimates of two researchers as combined percentage cover of smooth crabgrass and large crabgrass 15 weeks after application of corn gluten meal. Estimates of turfgrass visual quality were made 5, 7, 11, and 15 weeks after application of corn gluten meal. Turfgrass visual quality was evaluated on a 9 to 1 scale: 9 = best quality, 6 = acceptable quality, and 1 = poorest quality based on overall color, density, and uniformity.

Data were analyzed by using the Statistical Analysis System (SAS) and the general linear models (GLM) procedure. Data collected from the two years of field data were pooled. Fisher's least significant difference (LSD) test was used to compare main effect means and means over all treatments.

The analysis showed differences among studies at the $P_{0.05}$ level between years and replications. An additive effect on crabgrass cover was observed when corn gluten meal and pendimethalin were applied in combination to turfgrass in the field. Each 49 g m^{-2} increase in applied corn gluten meal reduced crabgrass cover but the level of reduction over the previous rate decreased as rate increased (Table 1). Analysis of the main effects showed that there was no increase in crabgrass control at rates higher than 59 mg ai m^{-2} pendimethalin.

The application of 49 g m^{-2} corn gluten meal and 88 mg ai m^{-2} pendimethalin provided 75-85% control as did either 98 g m^{-2} corn gluten meal and 59 mg ai m^{-2} pendimethalin or 147 g m^{-2} corn gluten meal and 29 mg ai m^{-2} pendimethalin. There was no increase in crabgrass control in plots that received larger amounts of corn gluten meal and pendimethalin. Crabgrass reduction in plots that received 49 g m^{-2} corn gluten meal and 59 mg ai m^{-2} pendimethalin were not different from the plots that received 49 g m^{-2} corn gluten meal and 88 mg ai m^{-2} pendimethalin. However, they were different from the plots that received 98 g m^{-2} corn gluten meal and 59 mg ai m^{-2} pendimethalin.

For each increase of 49 g m^{-2} corn gluten meal, turfgrass visual quality was improved by approximately one unit on the 9 to 1 scale after 5 and 7 weeks (Table 2). The fertilizer effects of corn gluten meal application were visible for 11 weeks. After 11 weeks, turfgrass quality did not differ among plots that received different rates of corn gluten meal. Pendimethalin did not affect turfgrass visual quality.

The results the field experiments suggest that crabgrass control may be improved by applying a sublethal rate of pendimethalin in combination with corn gluten meal. Crabgrass control was improved over that of corn gluten meal applied alone by using the three combinations of corn gluten meal and pendimethalin. There was no difference in crabgrass control among these rate combinations (Table 1). The previously documented fertilizer effect caused by corn gluten meal (Christians, 1993) was also observed in our field experiment. Increased turfgrass vigor caused by the fertilizer effect may contribute to the reduction in crabgrass observed on plots treated with corn gluten meal (Christians, 1993).

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Table 1. Percentage reduction in crabgrass cover compared with the control by using different combinations of corn gluten meal and pendimethalin tested in the field during 1995 and 1996[1].

Corn gluten meal applied	Pendimethalin applied (mg ai m^{-2}) 0	29	59	88	117	Mean[2]
– (g m^{-2}) –	% Reduction					
0	0§	15	45	54	53	33
49	25	40	61	77	75	56
98	42	57	84	84	86	71
147	55	79	84	87	95	80
Mean[3]	31	48	69	76	77	

ANOVA

Source	d.f.	M.S.	Pr > F
Year	1	1864.4	0.0007
Year*Rep	4	2429.3	0.0001
Treatment	19	1863.8	0.0001
Corn Gluten Meal (CGM)	3	5554.9	0.0001
Pendimethalin (Pend)	4	4400.7	0.0001
CGM x Pend	12	95.4	0.8080
Year*Treatment	19	114.2	0.7474
Year*CGM	3	54.0	0.7833
Year*Pend	4	96.3	0.6365
Year*CGM*Pend	12	135.2	0.5537
Error	76	150.7	

[1] Values are the average of visual estimates of two researchers.
[2] Corn gluten meal means are the average of three replications of five rates of pendimethalin applied in combination with each rate of corn gluten meal observed over two years (n=30). $LSD_{(0.05)}$ = 9% for the comparison of corn gluten meal means according to Fisher's least significant difference test.
[3] Treatment means are the average of three replications observed over two years (n=6). $LSD_{(0.05)}$ = 21% for the comparison of all treatments according to Fisher's least significant difference test.
[3] Pendimethalin means are the average of three replications of four rates of corn gluten meal in combination with each rate of pendimethalin observed over two years (n=24). $LSD_{(0.05)}$ = 11% for the comparison of pendimethalin means according to Fisher's least significant difference test.

Table 2. Mean weekly turfgrass visual quality ratings during 1995 and 1996 for Kentucky bluegrass in response to increasing corn gluten meal rates (n=30)[1].

Corn gluten meal applied	Time after corn gluten meal application (wk) 5	7	11	15
– (g m^{-2}) –	Turfgrass Visual Quality Rating[2]			
0	5	5	6	6
49	7	7	7	6
98	8	8	7	6
147	9	9	8	6
$LSD_{(0.05)}$[3]	1	1	1	1

[1] Means are the average of three replications of five rates of pendimethalin applied in combination with each rate of corn gluten meal observed over two years. Values given are the average of visual estimates of two researchers.
[2] Turfgrass visual quality was evaluated on a 9 to 1 scale: 9 = best quality, 6 = acceptable turfgrass, and 1 = poorest quality based on overall color, density, and uniformity.
[3] According to Fisher's least significant difference test.

The Effects of De-icing Chemicals on Turfgrass - 1996 Trial

David D. Minner and Barbara R. Bingaman

Runoff from de-icing products applied to walkways and other hard surfaces results in damaged and dead turfgrass borders. The purpose of this study was 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 Horticulture 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-foot 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. Application rates of 2, 4, and 8 oz/yd^2 were used to simulate typical amounts of product used in the ice melt industry (Table 1). 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 fifth 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. This non-replicated evaluation was used for preliminary injury data half-way through the treatment period.

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-foot 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. Application 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). Compared to the brine solution study, the granular study covered a broader range of application rates. 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 on 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 10 to 1 scale: with 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 10 to 1 scale: 10 = best recovery and 1 = no living plants (Table 1).

Percent turf cover, percent weed cover, percent bare soil, turf quality, and turf color data were taken July 1 and August 28 for the brine (Tables 3 and 4) and the granular studies (Tables 5 and 6). Percent turf cover was assessed as the percentage of area per plot covered by turfgrass species and percent weed cover as the percentage of area per plot covered by weed species (broadleaf and grass species). Any areas devoid of turf or weeds were recorded as the percentage of bare soil per plot. Turf quality was measured using a 10 to 1 scale: 10 = best quality, 2 = weeds only, and 1 = no green material. Turf color was determined using a 9 to 0 scale: 9 = best, 1 = worst color, and 0 = no turf present.

In the summer of 1996, the brine and de-icer experimental plots were sprayed with Roundup. The dead plant material was removed and the plots were seeded with perennial ryegrass at 2 lb/1000 ft^2 using a drop spreader. Ryegrass seedling vigor and percentage ryegrass cover data were taken October 10 for the brine and granular studies (Tables 7 and 8). Ryegrass seedling vigor was assessed using a 10 to 1 scale: 10 = best and 1 = worst vigor. Percent ryegrass cover was determined as the percentage of area per plot covered by ryegrass.

Results:

Two separate experiments, brine spray and granular, were conducted to produce seven de-icer application rates: 0, 1, 2, 4, 6, 8, and 12 oz/yd^2. Repeated applications from the brine spray study combined with the single application from the granular study resulted in total winter application rates of 0, 10, 18, 36, 60, 72, and 120 oz/yd^2.

De-icer treatments applied during the winter caused a bleaching and light tan appearance to the dormant turf. This appearance remained visible for some treatments during spring green-up and was rated as phytotoxicity. The average of phytotoxicity on April 10 and May 9 indicated that all treatments had significantly more turf injury than the untreated control (Table 1). Urea-$CaCl_2$ 30/70 at 18 oz/yd^2 had significantly less phytotoxicity than all other treatments except KCl.

Percent turf cover and weed cover (Table 3) and turf quality and color (Table 4) were evaluated to determine recovery following de-icer affects. The average percent turf cover for July and August indicated that at the 18 oz/yd^2 rate urea-$CaCl_2$ 67/33, urea, and $MgCl_2$ had significantly less turf cover than the untreated control.

De-icer treatments that resulted in poor turf cover also had higher weed cover. Treatments with high rates of urea (trts 7, 9, 10, 15, and 16) substantially reduced both turf and weed cover and resulted in plots with mostly bare soil showing (Table 3).

Average turf quality and color for July and August, 1996 are presented in Table 4. At 18 oz/yd^2 all urea + $CaCl_2$ combinations, KCl, rock salt, Safe Step, and $CaCl_2$ were statistically similar to the untreated control. Urea and $MgCl_2$ had inferior turf quality.

At 36 oz/yd^2 all de-icer treatments had significantly poorer turf quality than the untreated control, however, urea + $CaCl_2$, 30/70, KCl, and Safe Step were superior to urea + $CaCl_2$ 50/50 or 67/33, urea, rock salt, and $MgCl_2$.

At 72 oz/yd^2 all de-icer treatments were similar and had very poor turf quality.

The elements in some de-icer compounds are also essential elements for plant growth. Turf color was evaluated to determine if any beneficial color enhancement occurred, especially from urea treatments containing nitrogen. Urea combinations with $CaCl_2$ enhanced turf color. Urea + $CaCl_2$ 50/50 provided the best color enhancement and was superior to the untreated control (Table 4).

In the fall of 1996, the entire study area was reseeded with perennial ryegrass to determine if winter de-icer products inhibit fall re-establishment. Turf re-established from the slicer seeding for most treatments. Treatments 7, 9, 10, 14, 15, 16, and 19 had significantly less turf cover after fall seeding than the other treatments. Treatments with poor re-establishment confirmed high rates of urea or rock salt.

Brine de-icing treatments were repeated in the winter of 1997 on the ISU campus. The preliminary results from 1996 indicate that there are significant turf quality and phytotoxicity differences among de-icer compounds and rates.

Data were analyzed using the Statistical Analysis System (SAS) version 6.08 and the Analysis of Variance (ANOVA) procedure. Fisher's least significant difference (LSD) tests were used to test for treatment effects on turfgrass factors.

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 Brine 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 10 to 1 scale: 10 = no injury and 1 = foliage completely brown.
[2] Percent living plant material was assessed as the percentage of area per plot covered by green material.
[3] Plugs were taken from rep 2 on 3/4/96 after 5 treatment applications. Percent recovery was assessed using a 10 to 1 scale: 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	10	6.0	10.0	8.0	37	100	68
3	30% Urea + 70% $CaCl_2$	6	60	1.3	1.0	1.2	2	1	1
4	30% Urea + 70% $CaCl_2$	12	120	1.3	1.0	1.2	1	1	1
5	KCl	1	10	6.3	9.0	7.7	27	95	61
6	KCl	6	60	1.3	1.3	1.3	2	2	2
7	KCl	12	120	1.0	1.0	1.0	0	1	1
8	Urea	1	10	3.3	3.0	3.1	10	42	26
9	Urea	6	60	1.0	1.0	1.0	0	1	1
10	Urea	12	120	1.0	1.0	1.0	0	1	1
11	Rock Salt	1	10	5.0	9.3	7.2	22	97	59
12	Rock Salt	6	60	1.0	1.0	1.0	0	1	1
13	Rock Salt	12	120	1.0	1.0	1.0	0	1	1
14	Safe Step	1	10	5.7	8.7	7.2	27	95	61
15	Safe Step	6	60	1.0	1.3	1.2	0	1	1
16	Safe Step	12	120	1.0	1.0	1.0	0	1	1
17	Mg Cl_2 (47% a.i.)[3]	1	10	3.7	6.0	4.8	10	85	48
18	Mg Cl_2 (47% a.i.)[3]	6	60	1.0	1.0	1.0	0	1	1
19	Mg Cl_2 (47% a.i.)[3]	12	120	1.0	1.0	1.0	0	1	1
20	$CaCl_2$ pellets	1	10	5.7	8.3	7.0	22	97	59
21	$CaCl_2$ pellets	6	60	1.0	1.3	1.2	0	1	1
22	$CaCl_2$ pellets	12	120	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 10 to 1 scale: 10 = no injury and 1 = foliage completely brown.
[2]Percent living plant material was assessed as the percentage of area per plot covered by green material.
[3]Magnesium chloride was applied at 1, 6, and 12 oz a.i. Mg Cl_2 was 47% a.i. so the applied amounts were 2.1, 2.8, & 5.6 oz for a total of 21, 28, & 56 oz.

Table 3. Percent turf cover, weed cover, and bare soil data for field plots of Kentucky bluegrass treated with de-icing products for the 1996 Brine De-icer Study.

	De-icer product	Rate oz/yd²	Total applied oz/yd²	Percent turf cover[1] July 1	Percent turf cover[1] August 28	Percent turf cover[1] Mean % turf cover	Percent weed cover[2] July 1	Percent weed cover[2] August 28	Percent weed cover[2] Mean % weed cover	Percent bare soil[3] on August 28
1	Untreated Control	NA	NA	93	88	91	5	12	8	0
2	30% Urea + 70% $CaCl_2$	2	18	77	80	78	23	20	22	0
3	30% Urea + 70% $CaCl_2$	4	36	53	38	46	40	62	51	0
4	30% Urea + 70% $CaCl_2$	8	72	0	0	0	60	92	76	8
5	50% Urea + 50% $CaCl_2$	2	18	90	88	89	8	12	10	0
6	50% Urea + 50% $CaCl_2$	4	36	2	12	7	18	68	43	20
7	50% Urea + 50% $CaCl_2$	8	72	0	0	0	0	8	4	92
8	67% Urea + 33% $CaCl_2$	2	18	48	53	51	43	47	45	0
9	67% Urea + 33% $CaCl_2$	4	36	0	0	0	0	50	25	50
10	67% Urea + 33% $CaCl_2$	8	72	0	0	0	0	5	3	95
11	KCl	2	18	83	48	66	13	52	33	0
12	KCl	4	36	42	28	35	30	68	49	3
13	KCl	8	72	0	0	0	40	100	70	0
14	Urea	2	18	5	10	8	25	67	46	23
15	Urea	4	36	0	1	0	0	35	18	64
16	Urea	8	72	0	0	0	0	3	2	97
17	Rock Salt	2	18	73	67	70	13	37	25	0
18	Rock Salt	4	36	10	5	8	48	95	72	0
19	Rock Salt	8	72	0	0	0	43	67	55	33
20	Safe Step	2	18	90	67	78	7	33	20	0
21	Safe Step	4	36	65	57	61	17	43	30	0
22	Safe Step	8	72	0	0	0	77	100	88	0
23	Mg Cl_2 (47% a.i.)	4	39	75	50	63	18	45	32	5
24	Mg Cl_2 (47% a.i.)	9	77	2	5	3	82	95	88	0
25	Mg Cl_2 (47% a.i.)	17	153	0	0	0	82	100	91	0
26	$CaCl_2$ pellets	2	18	88	72	80	7	28	18	0
27	$CaCl_2$ pellets	4	36	38	23	31	53	77	65	0
28	$CaCl_2$ pellets	8	72	0	0	0	96	100	98	0
	$LSD_{0.05}$			25	32	26	31	40	32	27

[1]Percent turf cover was assessed as the percentage of area per plot covered by turf species.
[2]Percent weed cover was assessed as the percentage of area per plot covered by weed species.
[3]Percent bare soil was assessed as the percentage of area per plot devoid of plant cover.

Table 4. Turf quality and turf color data for field plots of Kentucky bluegrass treated with de-icing products for the 1996 Brine De-icer Study.

	De-icer product	Rate oz/yd^2	Total applied oz/yd^2	Turf quality[1] July 1	Turf quality[1] August 28	Turf quality[1] Mean turf quality	Turf color[2] July 1	Turf color[2] August 28	Turf color[2] Mean turf color
1	Untreated Control	NA	NA	8	7	8	7	7	7
2	30% Urea + 70% $CaCl_2$	2	18	8	6	7	9	6	7
3	30% Urea + 70% $CaCl_2$	4	36	5	4	5	7	3	5
4	30% Urea + 70% $CaCl_2$	8	72	2	2	2	1	0	1
5	50% Urea + 50% $CaCl_2$	2	18	8	9	8	9	9	9
6	50% Urea + 50% $CaCl_2$	4	36	1	3	2	1	5	3
7	50% Urea + 50% $CaCl_2$	8	72	1	1	1	1	0	1
8	67% Urea + 33% $CaCl_2$	2	18	6	6	6	8	8	8
9	67% Urea + 33% $CaCl_2$	4	36	1	2	1	1	0	1
10	67% Urea + 33% $CaCl_2$	8	72	1	1	1	1	0	1
11	KCl	2	18	7	5	6	7	4	6
12	KCl	4	36	4	3	4	7	2	5
13	KCl	8	72	2	2	2	1	0	1
14	Urea	2	18	1	2	2	1	2	2
15	Urea	4	36	1	2	1	1	0	1
16	Urea	8	72	1	1	1	1	0	1
17	Rock Salt	2	18	6	6	6	7	4	6
18	Rock Salt	4	36	3	2	2	3	0	2
19	Rock Salt	8	72	1	2	2	1	0	1
20	Safe Step	2	18	7	6	7	7	7	7
21	Safe Step	4	36	6	5	5	7	2	5
22	Safe Step	8	72	2	2	2	1	0	1
23	Mg Cl_2 (47% a.i.)	4	39	6	4	5	7	2	5
24	Mg Cl_2 (47% a.i.)	9	77	2	2	2	3	0	2
25	Mg Cl_2 (47% a.i.)	17	153	2	2	2	1	0	1
26	$CaCl_2$ pellets	2	18	7	5	6	7	5	6
27	$CaCl_2$ pellets	4	36	4	3	3	5	2	4
28	$CaCl_2$ pellets	8	72	2	2	2	1	0	1
	$LSD_{0.05}$			2	2	2	2	4	2

[1]Turf quality was assessed using a 10 to 1 scale: 10 = best quality, 2 = weeds only, and 1 = no green plant material.
[2]Turf color was assessed using a 9 to 0 scale: 9 = best, 1 = worst color, and 0 = no turf present.

Table 5. Percentage turf cover, weed cover, and bare soil 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]	Percentage turf cover[1] July 1	Percentage turf cover[1] August 28	Percentage turf cover[1] Mean % turf cover	Percentage weed cover[2] July 1	Percentage weed cover[2] August 28	Percentage weed cover[2] Mean % weed cover	Percent bare soil[3] on Aug 28
1	Untreated Control	NA	NA	88	90	45	7	10	8	0
2	30% Urea + 70% $CaCl_2$	1	10	98	98	49	2	2	2	0
3	30% Urea + 70% $CaCl_2$	6	60	0	3	1	17	87	52	10
4	30% Urea + 70% $CaCl_2$	12	120	0	0	0	15	50	33	50
5	KCl	1	10	92	90	45	3	9	6	0
6	KCl	6	60	0	0	0	27	97	62	3
7	KCl	12	120	0	0	0	2	40	21	60
8	Urea	1	10	48	83	33	5	13	9	3
9	Urea	6	60	0	0	0	0	0	0	100
10	Urea	12	120	0	0	0	0	0	0	100
11	Rock Salt	1	10	88	89	44	3	8	6	3
12	Rock Salt	6	60	0	0	0	67	100	83	0
13	Rock Salt	12	120	0	0	0	10	67	38	33
14	Safe Step	1	10	93	87	45	3	10	7	3
15	Safe Step	6	60	1	3	1	63	97	80	0
16	Safe Step	12	120	0	0	0	30	93	62	7
17	$MgCl_2$ (47% a.i.)[4]	1	10	85	72	39	7	12	9	17
18	$MgCl_2$ (47% a.i.)[4]	6	60	0	0	0	76	93	85	7
19	$MgCl_2$ (47% a.i.)[4]	12	120	0	0	0	70	97	83	3
20	$CaCl_2$ pellets	1	10	83	90	43	10	10	10	0
21	$CaCl_2$ pellets	6	60	3	8	3	85	92	88	0
22	$CaCl_2$ pellets	12	120	0	0	0	90	100	95	0
	$LSD_{0.05}$			9	10	4	21	26	19	25

[1]Percent turf cover was assessed as the percentage of area per plot covered by turf species.
[2]Percent weed cover was assessed as the percentage of area per plot covered by weed species.
[3]Percent bare soil was assessed as the percentage of area per plot devoid of plant cover.
[4]Magnesium chloride was applied at 1, 6, and 12 oz a.i. $MgCl_2$ was 47% a.i. so the applied amounts were 2.1, 2.8, & 5.6 oz for a total of 21, 28, & 56 oz.

Table 6. Turf quality and turf color 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]	Turf quality[1]			Turf color[2]		
				July 1	August 28	Mean turf quality	July 1	August 28	Mean turf color
1	Untreated Control	NA	NA	8	8	8	7	7	7
2	30% Urea + 70% $CaCl_2$	1	10	9	9	9	9	10	9
3	30% Urea + 70% $CaCl_2$	6	60	2	2	2	0	0	0
4	30% Urea + 70% $CaCl_2$	12	120	2	1	2	0	0	0
5	KCl	1	10	8	7	7	7	7	7
6	KCl	6	60	2	2	2	0	0	0
7	KCl	12	120	1	1	1	0	0	0
8	Urea	1	10	5	7	6	9	10	10
9	Urea	6	60	1	1	1	0	0	0
10	Urea	12	120	1	1	1	0	0	0
11	Rock Salt	1	10	7	7	7	7	7	7
12	Rock Salt	6	60	2	2	2	0	0	0
13	Rock Salt	12	120	2	2	2	0	0	0
14	Safe Step	1	10	8	7	8	7	7	7
15	Safe Step	6	60	2	2	2	0	0	0
16	Safe Step	12	120	2	2	2	0	0	0
17	Mg Cl_2 (47% a.i.)[3]	1	10	7	5	6	7	6	7
18	Mg Cl_2 (47% a.i.)[3]	6	60	2	2	2	0	0	0
19	Mg Cl_2 (47% a.i.)[3]	12	120	2	2	2	0	0	0
20	$CaCl_2$ pellets	1	10	7	6	7	7	7	7
21	$CaCl_2$ pellets	6	60	2	2	2	0	0	0
22	$CaCl_2$ pellets	12	120	2	2	2	0	0	0
	$LSD_{0.05}$			1	1	1	1	1	1

[1]Turf quality was assessed using a 10 to 1 scale: 10 = best quality, 2 = weeds only, and 1 = no green plant material.
[2]Turf color was assessed using a 9 to 0 scale: 9 = best, 1 = worst color, and 0 = no turf present.
[3]Magnesium chloride was applied at 1, 6, and 12 oz a.i. Mg Cl_2 was 47% a.i. so the applied amounts were 2.1, 2.8, & 5.6 oz for a total of 21, 28, & 56 oz.

Table 7. Perennial ryegrass seedling vigor and percentage ryegrass cover data on October 10 for field plots of Kentucky bluegrass treated with de-icing products for the 1996 Brine De-icer Study and seeded with perennial ryegrass in the fall of 1996.

	De-icer product	Rate oz/yd²	Total applied oz/yd²	Ryegrass seedling vigor[1]	Percent ryegrass cover[2]
1	Untreated Control	NA	NA	9	77
2	30% Urea + 70% $CaCl_2$	2	18	9	80
3	30% Urea + 70% $CaCl_2$	4	36	9	78
4	30% Urea + 70% $CaCl_2$	8	72	8	67
5	50% Urea + 50% $CaCl_2$	2	18	9	78
6	50% Urea + 50% $CaCl_2$	4	36	7	72
7	50% Urea + 50% $CaCl_2$	8	72	3	20
8	67% Urea + 33% $CaCl_2$	2	18	9	80
9	67% Urea + 33% $CaCl_2$	4	36	2	18
10	67% Urea + 33% $CaCl_2$	8	72	1	13
11	KCl	2	18	10	80
12	KCl	4	36	8	70
13	KCl	8	72	9	78
14	Urea	2	18	5	48
15	Urea	4	36	2	20
16	Urea	8	72	2	7
17	Rock Salt	2	18	9	75
18	Rock Salt	4	36	7	63
19	Rock Salt	8	72	4	33
20	Safe Step	2	18	9	80
21	Safe Step	4	36	9	77
22	Safe Step	8	72	8	73
23	Mg Cl_2 (47% a.i.)	4	39	8	77
24	Mg Cl_2 (47% a.i.)	9	77	9	78
25	Mg Cl_2 (47% a.i.)	17	153	7	67
26	$CaCl_2$ pellets	2	18	9	78
27	$CaCl_2$ pellets	4	36	8	75
28	$CaCl_2$ pellets	8	72	7	67
	$LSD_{0.05}$			2	16

[1]Perennial ryegrass seedling vigor was assessed using a 10 to 1 scale: 10 = best and 1 = worst vigor.
[2]Percent perennial ryegrass cover was assessed as the percentage of area per plot covered by ryegrass.

Table 8. Perennial ryegrass seedling vigor and percentage ryegrass cover data on October 10 for field plots of Kentucky bluegrass treated with de-icing products for the 1996 Granular De-icer Study and seeded with perennial ryegrass in the fall of 1996.

	De-icer product	Rate oz/yd^2	Total applied oz/yd^2	Ryegrass seedling vigor[1]	Percent ryegrass cover[2]
1	Untreated Control	NA	NA	8	77
2	30% Urea + 70% $CaCl_2$	1	10	9	75
3	30% Urea + 70% $CaCl_2$	6	60	7	63
4	30% Urea + 70% $CaCl_2$	12	120	7	60
5	KCl	1	10	8	80
6	KCl	6	60	6	63
7	KCl	12	120	2	15
8	Urea	1	10	7	67
9	Urea	6	60	1	1
10	Urea	12	120	1	1
11	Rock Salt	1	10	8	73
12	Rock Salt	6	60	5	53
13	Rock Salt	12	120	2	10
14	Safe Step	1	10	8	75
15	Safe Step	6	60	7	65
16	Safe Step	12	120	3	30
17	Mg Cl_2 (47% a.i.)[3]	1	10	7	70
18	Mg Cl_2 (47% a.i.)[3]	6	60	6	55
19	Mg Cl_2 (47% a.i.)[3]	12	120	5	57
20	$CaCl_2$ pellets	1	10	8	80
21	$CaCl_2$ pellets	6	60	7	63
22	$CaCl_2$ pellets	12	120	6	55
	$LSD_{0.05}$			2	18

[1] Perennial ryegrass seedling vigor was assessed using a 10 to 1 scale: 10 = best and 1 = worst vigor.
[2] Percent perennial ryegrass cover was assessed as the percentage of area per plot covered by ryegrass.
[3] Magnesium chloride was applied at 1, 6, and 12 oz a.i. Mg Cl_2 was 47% a.i. so the applied amounts were 2.1, 2.8, & 5.6 oz for a total of 21, 28, & 56 oz.

The Effects of De-icing Chemicals on Turfgrass - 1997 Trial

David D. Minner, Barbara R. Bingaman, Jeffrey J. Salmond, and John E. Jordan

This is the second year of an ongoing study examining the effects of several common de-icer products on turfgrass. The purpose of this study is to evaluate the effects of runoff from various de-icer products on turf areas. This is accomplished by simulating brine runoff with spray applications of salt solution directly on turf plots throughout the winter and evaluating injury during the growing season. The study area is then reseeded in the fall to evaluate turf establishment in salt-affected soils.

The second year of this study was conducted in the winter and early spring of 1997 on the Iowa State University campus in Ames, Iowa. The experimental plot was in an area of established common Kentucky bluegrass and perennial ryegrass.

Individual experimental plots were 2 x 4 ft with three replications. Because of possible de-icer runoff, the test area was arranged so each individual plot was completely surrounded by a 1 ft border. The experimental design was a randomized complete block. There were two rows per replication with 2 ft borders between rows.

There were a total of 43 treatments (Table 1). Urea [$CO(NH_2)_2$] was applied alone and in two different mixtures with calcium chloride ($CaCl_2$). Potassium chloride (KCl) and Safe Step [50% salt ($NaCl_2$) + 50% potassium chloride] were applied alone. Magnesium chloride ($MgCl_2$) was applied alone and with urea. Calcium chloride also was applied alone and in combination with two additional nitrogen sources: ammonium nitrate (NH_4NO_3) and ammonium sulfate [$(NH_4)_2SO_4$]. In addition, rock salt was used in three different combinations with calcium chloride in a flake formulation. An untreated control was included for comparisons. Treatment rates of 2, 4, and 8 oz/yd^2 were used to simulate typical amounts of product used in the ice melt industry (Table 1). Nine applications were made during the winter resulting in a total application rate of 18, 36, and 72 oz/yd^2.

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 40 psi. Windbreak 'cages' were employed to prevent drift of the materials. No runoff or drift was observed after treatment differences became apparent on the turf. Applications were made on January 14, 23, and 31 and February 15, 17, 19, 22, 24, and 26.

Soil samples were taken from each plot on March 14. Samples were taken 4" deep and 10 samples were taken per plot. The soil was air dried, ground, and analyzed for electroconductivity by the Plant Nutrition Lab in the Department of Horticulture.

Turf phytotoxicity data were taken on February 27 and March 27. Phytotoxicity was assessed using a 10 to 1 scale: 10 = no injury and 1 = most serious damage (plot completely brown). Percent living green turf data were taken March 27. These figures represent the percentage of area per plot covered by green, healthy turf.

Data were analyzed using the Statistical Analysis System (SAS) version 6.10 and the Analysis of Variance (ANOVA) procedure. Fisher's least significant difference (LSD) tests were used as means comparisons analyses.

Table 1. Phytotoxicity[1] and percentage turf cover[2] data for field plots treated with de-icer products for the 1997 Brine De-icer Study.

Trt	De-icer product	Rate oz/yd^2	Total applied oz/yd^2	Phytotoxicity data Feb 25	March 27	Mean	Percentage turf cover (%) March 27
1	Untreated Control	NA	NA	8.0	8.3	8.2	89.7
2	30% Urea [$CO(NH_2)_2$]	2	18	7.0	7.0	7.0	66.3
3	+ 70% Calcium chloride ($CaCl_2$)	4	36	6.0	4.0	5.0	26.7
4		8	72	4.0	2.7	3.3	5.3
5	50% Urea [$CO(NH_2)_2$]	2	18	5.7	6.3	6.0	55.0
6	+ 50% Calcium chloride ($CaCl_2$)	4	36	4.0	3.3	3.7	15.0
7		8	72	3.0	2.0	2.5	3.7
8	61% Magnesium chloride [$MgCl_2$]	2	18	4.0	5.7	4.8	46.7
9	(47% a.i.) + 39% Urea [$CO(NH_2)_2$]	4	36	2.7	2.0	2.3	4.0
10		8	72	2.0	1.0	1.5	1.0
11	Potassium chloride (KCl)	2	18	5.7	6.0	5.8	51.7
12		4	36	3.7	5.0	4.3	45.0
13		8	72	1.7	3.3	2.5	11.7
14	Urea [$CO(NH_2)_2$]	2	18	1.0	2.0	1.5	5.0
15		4	36	1.0	1.0	1.0	1.0
16		8	72	1.0	1.0	1.0	1.0
17	Rock salt ($NaCl_2$)	2	18	4.0	5.7	4.8	63.3
18		4	36	2.0	3.3	2.7	23.7
19		8	72	2.0	1.7	1.8	3.7
20	Safe Step [50% ($NaCl_2$)	2	18	5.0	5.3	5.2	41.7
21	+ 50% Potassium chloride (KCl)]	4	36	4.0	6.0	5.0	55.0
22		8	72	3.0	2.3	2.7	7.0
23	Magnesium chloride ($MgCl_2$) (47% a.i.)	4	39	6.3	4.0	5.2	18.3
24		9	77	3.7	1.3	2.5	1.0
25		17	153	2.7	1.0	1.8	1.0
26	Calcium chloride ($CaCl_2$) pellets	2	18	5.3	3.3	4.3	13.3
27		4	36	5.0	2.3	3.7	7.0
28		8	72	4.3	1.7	3.0	2.3
29	42% Ammonium nitrate (NH_4NO_3)	2	18	5.7	3.7	4.7	16.7
30	+ 58% Calcium chloride ($CaCl_2$)	4	36	4.0	2.7	3.3	5.0
31		8	72	2.3	1.0	1.7	1.0

Trt	De-icer product	Rate oz/yd[2]	Total applied oz/yd[2]	Phytotoxicity data Feb 25	March 27	Mean	Percentage turf cover (%) March 27
32	54% Ammonium sulfate [$(NH_4)_2SO_4$]	2	18	2.0	4.0	3.0	25.0
33	+ 46% Calcium chloride ($CaCl_2$)	4	36	1.0	2.7	1.8	6.7
34		8	72	1.0	1.0	1.0	1.0
35	75% Rock Salt ($NaCl_2$)	2	18	5.0	4.7	4.8	38.3
36	+ 25% Calcium chloride ($CaCl_2$) flakes	4	36	4.0	4.0	4.0	25.0
37		8	72	3.0	2.3	2.7	7.0
38	67% Rock Salt ($NaCl_2$)	2	18	5.3	5.0	5.2	31.7
39	+ 33% Calcium chloride ($CaCl_2$) flakes	4	36	4.3	4.0	4.2	33.3
40		8	72	3.7	3.0	3.3	8.7
41	50% Rock Salt ($NaCl_2$)	2	18	5.3	6.0	5.7	46.7
42	+ 50% Calcium chloride ($CaCl_2$) flakes	4	36	5.0	5.0	5.0	30.0
43		8	72	4.7	2.7	3.7	13.7
	$LSD_{0.05}$			0.9	1.8	1.1	21.0

[1]Phytotoxicity was assessed using a 10 to 1 scale: 10 = no injury and 1 = foliage completely brown.
[2]These figures represent the total area per plot covered by green, healthy turf.

The data taken thus far is inconclusive and only represents de-icer injury that appears in late-winter. Turf recovery data during spring, summer, and fall replanting will be determined in 1997.

Preliminary results indicate:

1. At the 2 oz/yd^2 rate, urea + calcium chloride (trt 2) had significantly more living turf cover than Safe Step (trt 20), urea (trt 14), magnesium chloride (trt 23), calcium chloride (trt 26), ammonium nitrate + calcium chloride (trt 29), ammonium sulfate + calcium chloride (trt 32) and rock salt + calcium chloride (trts 35, 38, and 41).

2. At the 4 oz/yd^2 rate, potassium chloride had significantly more living turf cover than urea + calcium chloride (trt 6), magnesium chloride + urea (trt 9), urea (trt 15), rock salt (trt 18), magnesium chloride (trt 24), calcium chloride (trt 27), ammonium nitrate + calcium chloride (trt 30) and ammonium sulfate + calcium chloride (trt 33).

3. All treatments gave similar injury at the highest treatment rate of 8 oz/yd^2.

4. All de-icer treatments resulted in significantly more injury than the untreated grass in the control plots.

Establishing and Maintaining Turfgrass Over a Steam Line, 1996-97 Data

David D. Minner, Jeffrey J. Salmond, John E. Jordan, and Barbara R. Bingaman

This two-year study was started in the summer of 1996 to evaluate the performance of various grass species planted in an area with elevated soil temperatures above a steam line. The 16-inch diameter steam line has 3.5 inches of insulation and is buried 3.5 ft below the surface. The 400° F steam temperature has produced summer-time soil temperatures of 120° F at the 12-inch depth. The performance of both warm- and cool-season grasses will be monitored over a two-year period. Kentucky bluegrass, perennial ryegrass, tall fescue, and combinations of these species represent the cool-season species. Three warm-season species: zoysiagrass, bermudagrass, and buffalograss, were used alone and in combination with cool-season species. A total of 18 different grass combinations were planted in the summer of 1996 from sod or seed.

The experiment was situated in a 320 ft x 10 ft area above a buried steam tunnel on the intramural recreational facility on the Iowa State University campus. Individual plot size was 5 ft x 10 ft and three replications were included. This trial was designed as a randomized complete block.

Visual turf quality, turf color, and percentage turf cover data were taken October 10, 1996 (Table 1) and April 3, 1997 (Table 4). Visual quality was assessed using a 10 to 1 scale: 10 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Brown or dormant turf was considered a negative aspect of overall turf quality, therefore winter dormant warm-season grasses received lower turf quality scores based primarily on poor turf color. Turf color was evaluated with a 9 to 1 scale: 9 = best color and 1 = poorest color. Percentage turf cover represents the percent of area per plot covered by turf.

Soil temperatures were taken in 1996 and 1997. On October 10, 1996 three readings were taken from each 5 ft x 10 ft plot (east, middle, and west) at three different depths: 1, 6, and 12 inches (Tables 3 and 4). This same methodology was followed for the temperature data taken March 8 for the 6- and 12-inch depths. The 5 ft by 10 ft plots were placed perpendicular to the length of the steam line so that the middle of each plot was directly over the steam line and received higher temperatures than either the east or west section of each plot The 1-inch data, however, were replaced by 'middle' readings at the 2-inch depth. On April 3, only one temperature was taken from the 'middle' of each plot at 2, 6, and 12 inches deep (Tables 5 and 6).

Data were analyzed with the Statistical Analysis System version 6.10 (SAS Institute, 1989) using the Analysis of Variance (ANOVA) and General Linear Methods (GLM) procedures. Fisher's Least Significant Difference test (LSD) was used to compare means where appropriate.

Table 1. Turf quality, turf color, and percent turf cover data taken October 10, 1996 in plots established for the 1996 Steam Line Study.

	Grass Type	Started from sod	Started from seed	Turf quality[1]	Turf color[2]	Percent living green turf cover[3]
1	Perennial ryegrass		X	8	9	87
2	Kentucky bluegrass	X		9	9	92
3	Tall fescue	X		–	-	—
4	Kentucky bluegrass + p. ryegrass		X	4	9	40
5	Tall fescue + K. bluegrass		X	3	9	28
6	Zoysiagrass	X		10	9	100
7	Zoysiagrass + tall fescue/K. bluegrass	X	X	10	9	100
8	Buffalograss	X		10	9	100
9	Buffalograss + K. bluegrass/p. ryegrass	X	X	10	9	100
10	Bermudagrass	X		9	9	100
11	Bermudagrass + K. bluegrass/p. ryegrass	X	X	9	9	100
12	Zoysiagrass		X	2	8	5
13	Bermudagrass		X	5	9	60
14	Buffalograss		X	5	8	57
15	Zoysiagrass + tall fescue/K. bluegrass		X	2	8	5
16	Bermudagrass + K. bluegrass/p. ryegrass		X	5	9	63
17	Buffalograss + K. bluegrass/p. ryegrass		X	5	8	57
18	Tollifaro Bermudagrass		X	4	9	33
19	Jackpot[4]			6	9	0
20	Jackpot[4]			5	9	0
21	J-554[4]			5	9	0
22	J-36[4]			2	8	0
23	J-36[4]			1	8	0
24	J-37[4]			1	8	0
	$LSD_{0.05}$			1	1	13

[1]Turf quality was assessed using a 10 to 1 scale: 10 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2]Turf color was assessed using a 9 to 1 scale: 9 = best color, 6 = lowest acceptable color, and 1 = poorest color.
[3]Percent living green turf cover represents the percentage of area per plot covered by living green turf species.
[4]These grasses were not replicated. They were planted in Rep 2 only and are not included in the analyses.

Table 2. Turf quality, turf color, and percent turf cover data taken April 3, 1997 in plots established for the 1996 Steam Line Study.

	Grass Type	Started from sod	Started from seed	Turf quality[1]	Turf color[2]	Percent living green turf cover[3]
1	Perennial ryegrass		X	6	7	67
2	Kentucky bluegrass	X		6	8	87
3	Tall fescue	X		0	0	0
4	Kentucky bluegrass + p. ryegrass		X	6	7	80
5	Tall fescue + K. bluegrass		X	4	8	53
6	Zoysiagrass	X		5	1	3
7	Zoysiagrass + tall fescue/K. bluegrass	X	X	5	1	3
8	Buffalograss	X		5	1	5
9	Buffalograss + K. bluegrass/p. ryegrass	X	X	5	1	5
10	Bermudagrass	X		5	1	10
11	Bermudagrass + K. bluegrass/p. ryegrass	X	X	5	1	10
12	Zoysiagrass		X	1	1	2
13	Bermudagrass		X	1	1	2
14	Buffalograss		X	1	2	2
15	Zoysiagrass + tall fescue/K. bluegrass		X	1	1	2
16	Bermudagrass + K. bluegrass/p. ryegrass		X	1	2	5
17	Buffalograss + K. bluegrass/p. ryegrass		X	1	2	7
18	Tollifaro Bermudagrass		X	1	1	2
19	Jackpot[4]			1	1	3
20	Jackpot[4]			1	1	3
21	J-554[4]			1	1	3
22	J-36[4]			1	1	1
23	J-36[4]			1	1	1
24	J-37[4]			1	1	1
	$LSD_{0.05}$			1	1	14

[1]Turf quality was assessed using a 10 to 1 scale: 10 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
[2]Turf color was assessed using a 9 to 1 scale: 9 = best color, 6 = lowest acceptable color, and 1 = poorest color.
[3]Percent living green turf cover represents the percentage of area per plot covered by living green turf species.
[4]These grasses were not replicated. They were planted in Rep 2 only and are not included in the analyses.

Table 3. Soil temperatures on October 10, 1996 in turf plots included in the 1996 Steam Line Study.

	Grass Type	12-inch				6-inch			
		East	Middle	West	Mean	East	Middle	West	Mean
		F°							
1	Perennial ryegrass	79	85	72	78	71	79	68	73
2	Kentucky bluegrass	82	93	76	84	72	82	68	74
3	Tall fescue	-	-	-	-	71	78	67	72
4	Kentucky bluegrass + p. ryegrass	79	85	73	79	70	78	67	72
5	Tall fescue + K. bluegrass	77	85	74	79	71	78	66	71
6	Zoysiagrass	83	93	76	84	75	88	71	78
7	Zoysiagrass + tall fescue/K. bluegrass	75	84	74	77	75	88	71	78
8	Buffalograss	-	-	-	-	74	86	71	77
9	Buffalograss + K. bluegrass/P. ryegrass	-	-	-	-	74	84	71	76
10	Bermudagrass	74	95	80	83	73	84	69	75
11	Bermudagrass + K. bluegrass/P. ryegrass	-	-	-	-	73	84	69	75
12	Zoysiagrass	75	84	70	76	73	80	67	73
13	Bermudagrass					71	80	68	73
14	Buffalograss	74	76	71	74	70	75	67	71
15	Zoysiagrass + tall fescue/K. bluegrass	-	-	-	-	71	80	68	73
16	Bermudagrass + K. bluegrass/P. ryegrass	79	91	81	83	71	77	68	72
17	Buffalograss + K. bluegrass/P. ryegrass	76	89	76	80	71	81	68	73
18	Tollifaro Bermudagrass	-	-	-	-	69	77	80	75
19	Jackpot[1]	-	-	-	-	-	-	-	-
20	Jackpot[1]	-	-	-	-	-	-	-	-
21	J-554[1]	-	-	-	-	-	-	-	-
22	J-36[1]	-	-	-	-	-	-	-	-
23	J-36[1]	94	101	80	92	73	90	85	83
24	J-37[1]	-	-	-	-	-	-	-	-

[1]These grasses were not replicated. They were planted in Rep 2 only.

Table 4. Soil temperatures (F°) on October 10, 1996 in turf plots established for the 1996 Steam Line Study.

	Grass Type	Temperature depth 1-inch East	Middle	West	Mean
		F°			
1	Perennial ryegrass	68	72	66	69
2	Kentucky bluegrass	69	74	67	70
3	Tall fescue	70	73	66	70
4	Kentucky bluegrass + p. ryegrass	69	72	67	69
5	Tall fescue + K. bluegrass	70	73	67	70
6	Zoysiagrass	72	80	68	73
7	Zoysiagrass + tall fescue/K. bluegrass	71	81	68	73
8	Buffalograss	70	78	68	72
9	Buffalograss + K. bluegrass/p. ryegrass	70	79	68	72
10	Bermudagrass	68	75	66	70
11	Bermudagrass + K. bluegrass/p. ryegrass	68	75	66	70
12	Zoysiagrass	67	72	64	67
13	Bermudagrass	64	70	67	67
14	Buffalograss	64	68	63	65
15	Zoysiagrass + tall fescue/K. bluegrass	66	72	64	67
16	Bermudagrass + K. bluegrass/p. ryegrass	65	67	63	65
17	Buffalograss + K. bluegrass/p. ryegrass	66	72	65	68
18	Tollifaro Bermudagrass	61	70	62	64
19	Jackpot[1]	-	-	-	-
20	Jackpot[1]	-	-	-	-
21	J-554[1]	-	-	-	-
22	J-36[1]	-	-	-	-
23	J-36[1]	68	80	77	75
24	J-37[1]	-	-	-	-

[1]These grasses were not replicated. They were planted in Rep 2 only.

Table 5. Soil temperatures on March 8, 1997 for selected grass species included in the 1996-97 Steam Line Study.

		Temperature depth								
		12-inch				6-inch				2-inch
Trt	Grass Type	East	Middle	West	Mean	East	Middle	West	Mean	Middle
		F°								
2	Kentucky bluegrass	59	67	53	60	55	63	51	56	56
4	Kentucky bluegrass + Perennial ryegrass	56	62	49	56	52	58	48	53	53
5	Tall fescue + Kentucky bluegrass	57	62	49	56	51	57	46	52	53
6	Zoysiagrass	61	70	53	62	56	67	51	58	61
8	Buffalograss	62	69	54	62	54	64	53	57	58
10	Bermudagrass	61	68	53	60	55	63	50	56	56
	$LSD_{0.05}$	3	5	3	2	NS	4	2	2	3

Table 6. Soil temperatures on April 3, 1997 and mean temperatures for 1997 for selected grass species included in the 1996-97 Steam Line Study.

		April 3, 1997			Mean 1997 temperatures		
Trt	Grass Type	12-inch	6-inch	2-inch	12-inch	6-inch	2-inch
		F°					
2	Kentucky bluegrass	77	74	72	72	68	61
4	Kentucky bluegrass + Perennial ryegrass	77	73	72	69	66	63
5	Tall fescue + Kentucky bluegrass	74	72	72	68	65	62
6	Zoysiagrass	78	75	73	74	71	67
8	Buffalograss	79	75	73	74	69	65
10	Bermudagrass	79	74	73	73	68	64
	$LSD_{0.05}$	NS	NS	NS	5	4	3

Managing Cool-season Grasses as Part of a SportGrass® System

David D. Minner, Jeffrey J. Salmond, and John E. Jordan

New and innovative systems are being developed for natural grass fields. Coaches, athletes, and trainers prefer natural grass to reduce physical stress on players. Artificial surfaces are more durable because of low maintenance and longer life (Morehouse, 1992). SportGrass® is the first product that combines the playability of natural grass with the durability of synthetic turf.

SportGrass® system consists of a natural grass playing surface grown into a layer of amended sand. The system consists of natural grass growing in a synthetic matrix with fibrillated fibers (polypropylene blades) with a backing. Within the layer of sand are polypropylene grass blades tufted into a woven black backing (SportGrass® literature, 1996). The SportGrass® system is combined with rapidly draining sand-based systems. Roots can grow through the woven backing and into the sand below. Since grass roots grow down through the synthetic fibers and backing, the crown and roots of the plant are "protected." SportGrass® is stabilized horizontally by the backing and vertically by the polypropylene blades. Grass can be established by seeding or sprigging. Processes are being commercially developed to produce SportGrass® sod.

The SportGrass® system was designed to reduce divots, ruts, and bare spots due to heavy traffic. The product claims to reduce the need for renovation and frequent repairs. Cool-season and warm-season turfgrasses can be grown in the SportGrass® system. If the natural grass is briefly worn away, the synthetic and sand portions of the SportGrass® system maintain a stable playing surface. SportGrass® also aids in a quicker recovery of the turfgrass (http://www.sportgrass.com).

The SportGrass® material is produced in 15 ft by 100 ft rolls. The synthetic turf mat is laid on top of the sand-based root zone. During installation, the seams of the synthetic material are temporarily held to the root zone with metal sod staples. Sand that matches the root zone is then topdressed and brushed into the polypropylene blade matrix. As an alternative, a gunit gun has been used to blow dry sand into the polypropylene fibers. Once the matrix has been filled, seeding or sprigging can take place. The seed is typically sliced into the surface so that the plant crown develops within the sand/fiber matrix. SportGrass® can also be installed as sod. The topdessed synthetic material is placed over a plastic sheet to impede root penetration. The sod can then be harvested mechanically using large roll sod equipment. SportGrass® has the potential for use on football, baseball, and soccer fields and golf courses.

Two separate studies, each with a specific objective, were initiated in the fall of 1996. The first objective was to evaluate conventional methods of turfgrass management as they apply to SportGrass®. Of particular interest is how grass management practices influence the accumulation of organic matter within the synthetically-reinforced zone. Clipping removal, cultivation, and plant growth regulators will be evaluated (Table 1).

The second objective was to evaluate how grass species, seeding rates, and traffic intensity influence the performance of the natural grass and synthetic turf combination. (Table 2).

Table 1. Treatments used to evaluate management of the grass mat within the SportGrass® system.

Trt	Clippings	Cultivation	PGR	Other	with SportGrass®
1.	Catch	none	none	none	yes
2.	Return	none	none	none	yes
3.	Return	Verticut	none	none	yes
4.	Return	Solid core	none	none	yes
5.	Return	none	Primo	none	yes
6.	Return	none	none	after thatch accumulates, begin thatch reduction treatment	yes
7.	Return	none	none	Seeded control	no
8.	Return	none	none	Sodded control	no

Table 2. Species layout.

Trt	Grass species (whole plot trt)	Seeding rate lb/1000 ft^2	Traffic Intensity (Split plot)	
			Low	High
1.	Kentucky bluegrass	2	yes	
2.	Kentucky bluegrass	2		yes
3.	Kentucky bluegrass	4	yes	
4.	Kentucky bluegrass	4		yes
5.	Perennial ryegrass	7	yes	
6.	Perennial ryegrass	7		yes
7.	Perennial ryegrass	14	yes	
8.	Perennial ryegrass	14		yes
9.	KB & PR	2 & 7	yes	
10.	KB & PR	2 & 7		yes
11.	KB & PR	4 & 14	yes	
12.	KB & PR	4 & 14		yes

Evaluating a Forced-air System for Sand Based Creeping Bentgrass Putting Greens

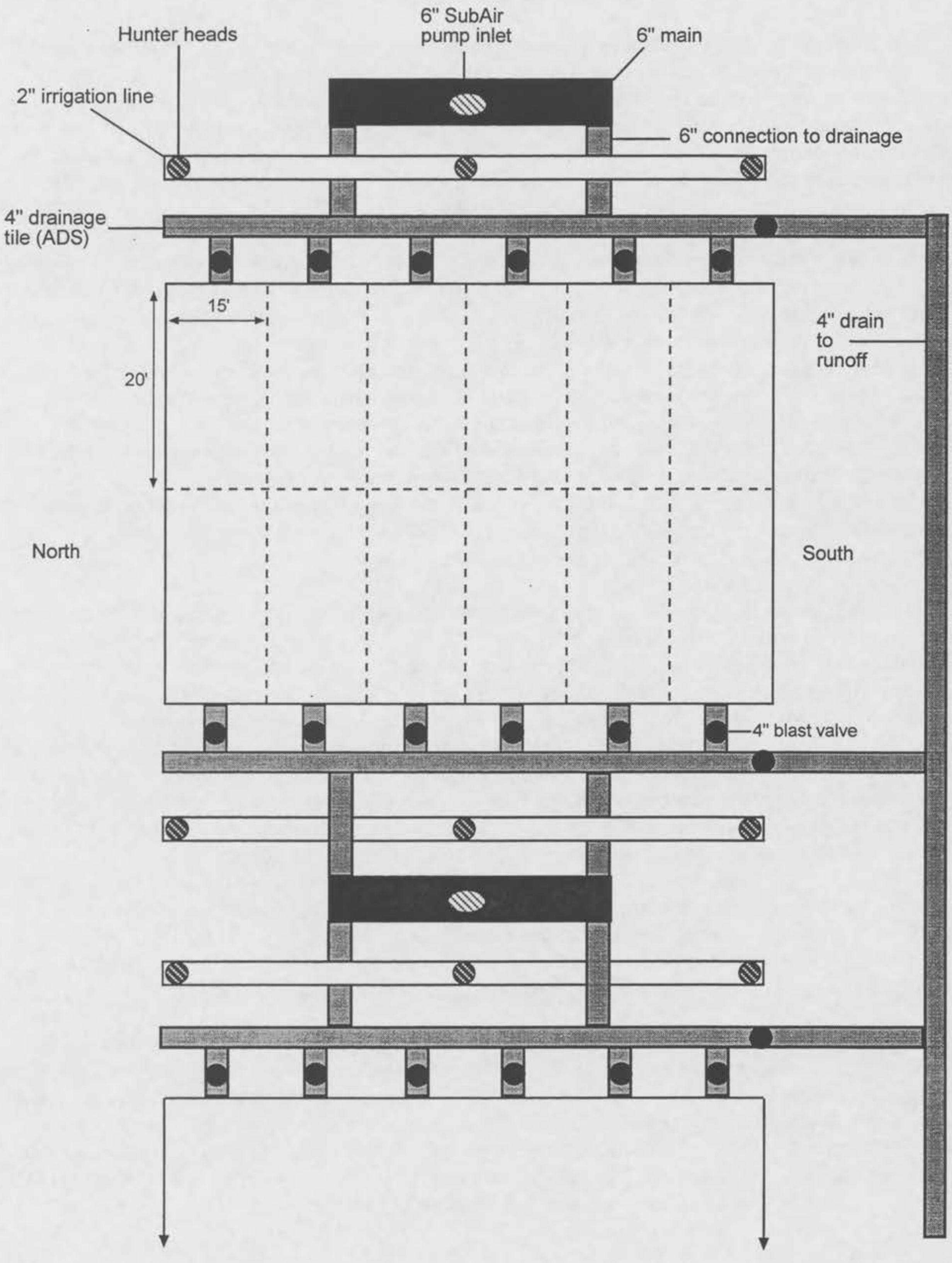
David D. Minner, John E. Jordan, and Jeffrey J. Salmond

Properly constructed sand based greens provide rapid internal drainage and resistance to compaction. Topdressing, coring, slicing, and hydrojetting are routinely used to maintain porosity and allow passive air movement into the root zone. Even with the best management, summer stress can lead to shallow roots that require frequent irrigation and green syringing. Eventually greens become too wet, diseases invade, and high canopy, mat, and root zone temperatures cause severe turf loss. Forced-air-subsurface-systems are a new concept that can directly effect root zone temperatures and aeration. It may also effect microbial activity. Root zone fungi and bacteria produce CO_2 and other gaseous by-products. We will investigate the by-products of microbial activity to determine if they have any effect on plant growth. Dr. Clint Hodges, our resident turfgrass pathologist, has measured ethylene and other light hydrocarbons in levels that cause a plant response. Forced-air systems actively pump air into the drainage system and through the sand root zone. It is proposed that cooler air, supported by ground temperature, can be used to reduce damaging high temperatures in the turf canopy and near the root zone surface. Preliminary research and observations indicate that certain components of the USGA Sand Green Specification are required for forced-air-subsurface-systems to function properly. Specifications that are especially important are a network of perforated drain lines, a 4-inch gravel layer, and a specialized sand root zone.

Our objective is to determine what effect subsurface-forced-air has on microbial activity, root zone temperature and moisture, root growth, turf appearance, dew formation, and dry spot.

Construction on the sand based putting green began in the fall of 1995 with completion in August, 1996. Final grading and seeding took place in September. Trenches were dug and completed in November to house the electricity for the forced-air machines. Plastic barriers between the plots will be installed in summer, 1997. Two SubAir™ commercial blowers are used to force air into the drain line and through the green profile. When the direction of air flow is reversed the same blowers are used to remove air and water from the green profile.

SubAir/Heatway plot plan layout



Rubber Tire Particles as a Topdressing Amendment for Intensely Trafficked Grass - 1996 Data

Jeffrey J. Salmond and David D. Minner

The U.S. discards about 250 million tires a year. 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 come 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 7:1. 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, growing on a Nicolett (fine-loamy, mixed, mesic Aquic Hapludoll) soil, 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. A 3/4-inch or larger hollow-tine would provide better incorporation of the crumb and buffings rubber. All topdressing materials were 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.

The study was arranged in a randomized complete block design with three replications. Individual plots were 4 ft by 6 ft. The plots were topdressed with nine treatments and a control (Table 2). Each of the rubber treatments were topdressed to a particular depth of 0.38 and 0.75 inches. A proposed higher rate, 1.0 inch, could not be reached at the initiation of the study.

Traffic simulation was performed with a Brouwer machine having two rollers. Each roller consisted of having 1/2" football cleats surrounding it. Traffic was done on one-foot centers across the plots. Compaction treatments were performed for a short time in June with a Brouwer smooth roller filled with water to a weight of 900 pounds. Traffic and compaction treatments were performed on Monday, Wednesday, and Friday during the traffic period. Traffic started in April and ended in June, to simulate spring athletic activity. The turfgrass was allowed to recover during a no-traffic period in the summer. Traffic continued in September and October to simulate fall sports.

Ratings were taken on the basis of five parameters. Turf quality, density and color were visually rated on a 10 to 1 scale: 6 = lowest acceptable value for a specific parameter, 10 = the best appearance and 1 = the least desirable appearance (Table 2). Traffic tolerance was assessed by visually estimating percent turf cover and quality. Turf quality is often the simultaneous perception of turf color, texture, and density. Turf color ranged from 10 = dark green to 1 = yellow or brown. Turf texture was not considered as a component of turf quality in this study. Turf density and retention of a vegetative mat or thatch were given more consideration when rating turf quality on treatments receiving traffic in this study. Turf density was a visual estimate of plants per unit area.

Percent living turfgrass cover and percent of soil, sand, or rubber topdressing showing were evaluated for the area of plot (Table 3). Percent living turfgrass cover is probably the most important parameter in terms of evaluating the detrimental effects of traffic on athletic turf. Following traffic treatments, turf begins to decline and the underlying materials, bare soil, sand, or rubber, become visible. The percent cover values estimate how much grass, bare soil, sand, or rubber is visible on the surface. Treatments with a high percentage of turf cover and low percentage of sand or rubber topdressing showing are more desirable.

Surface hardness was evaluated during the traffic and recovery periods (Table 4). The g-max was recorded using 0.5 kg and 2.25 kg drop hammers. The values were stored with the BrÅel and Kjër 2515 Vibration Analyzer and later relayed to a compatible computer. Higher g-max values indicate a harder, less resilient surface.

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 between treatment effects on visual quality, density, color, percent turf cover, and percent topdressing showing (Tables 2 and 3). LSD means comparisons were also made to test between treatments effects on surface hardness (g-max) (Table 4).

One of the interesting effects from rubber occurred on frozen ground (Table 4). During the winter period, sand treatments show a higher g-max with 0.5 and 2.25 kg hammers. Frozen conditions on 22 January 1997 caused a harder surface for the control compared to rubber topdressed turf (high rates of coarse crumb, medium buffing, and coarse buffing and low rates of medium crumb or buffing using the 0.5 kg hammer). With the 2.25 kg hammer, the sand and soil control was significantly harder compared to the high rates of coarse crumb and coarse buffing. Preliminary results display that the higher rate of rubber, 0.75 inches, provides the best overall effects as compared to the lower rates of rubber, sand and the soil control.

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. Turf quality[1], density[2], and color[3] evaluated on 'Midnight' Kentucky bluegrass after periods of traffic and recovery.

	Treatment	Rate	After spring traffic			After summer recovery			After fall traffic		
			June 21, 1996			August 14, 1996			November 8, 1996		
		(in)	quality	density	color	quality	density	color	quality	density	color
1.	Coarse crumb	0.38	6.0	5.3	6.3	4.7	5.0	5.7	3.7	3.0	6.0
2.	Coarse crumb	0.75	6.7	6.3	7.3	6.7	6.0	6.3	5.0	5.0	7.3
3.	Medium crumb	0.38	5.7	5.7	6.7	5.7	5.0	5.7	4.3	3.3	6.7
4.	Medium crumb	0.75	7.7	6.7	7.0	6.7	6.3	6.3	6.3	6.3	6.7
5.	Medium buffing	0.38	7.0	7.0	6.3	6.7	6.3	6.7	6.0	6.0	7.0
6.	Medium buffing	0.75	8.0	7.0	7.7	8.3	7.7	7.7	8.0	7.7	7.7
7.	Coarse buffing	0.38	6.0	6.0	6.7	5.7	5.7	7.0	4.7	4.7	7.3
8.	Coarse buffing	0.75	7.7	6.7	7.3	8.0	7.3	7.7	6.3	6.7	7.3
9.	Sand	0.75	7.0	7.0	7.0	7.3	7.0	6.7	6.0	6.0	7.7
10.	Control	–	5.7	5.3	6.3	4.0	3.3	6.3	3.7	3.0	6.3
	$LSD_{(0.05)}$		1.0	NS	NS	2.3	1.8	1.7	2.5	2.6	NS

[1]Grass quality was rated on a 10 to 1 scale: 6 = lowest acceptable quality, 10 = best quality.
[2]Grass density was rated on a 10 to 1 scale: 6 = lowest acceptable density, 10 = highest density.
[3]Grass color was rated on a 10 to 1 scale: 10 = dark green, 6 = lowest acceptable color, 1 = yellow or brown.
NS = not significantly different at the 0.05 level.

Table 3. Percent turf cover[1] and percent soil, sand, or rubber topdressing showing[2] evaluated on 'Midnight' Kentucky bluegrass after periods of traffic and recovery.

	Treatment	Rate	After spring traffic		After summer recovery		After fall traffic	
			June 21, 1996		August 14, 1996		November 8, 1996	
		(in)	turf cover	topdress	turf cover	topdress	turf cover	topdress
1.	Coarse crumb	0.38	70.0	15.0	60.0	7.3	51.7	43.3
2.	Coarse crumb	0.75	81.7	36.7	80.0	10.0	66.7	35.0
3.	Medium crumb	0.38	70.0	5.0	70.0	4.0	65.0	20.7
4.	Medium crumb	0.75	81.7	11.7	88.3	6.7	86.7	8.3
5.	Medium buffing	0.38	78.3	4.0	88.0	1.7	86.7	5.7
6.	Medium buffing	0.75	88.3	6.0	97.7	2.3	91.7	5.7
7.	Coarse buffing	0.38	71.7	11.7	75.0	5.0	75.0	20.0
8.	Coarse buffing	0.75	83.3	25.3	93.0	6.7	86.7	15.0
9.	Sand	0.75	80.0	5.0	93.0	1.7	80.0	15.0
10.	Control	–	56.7	0	48.3	0	51.7	0
	$LSD_{(0.05)}$		12.3	15.6	21.5	NS	27.0	21.0

[1]Percent turfgrass cover of plot area.
[2]Percent of plot area showing soil, sand, or rubber topdressing.
NS = not significantly different at the 0.05 level.

Table 4. Surface hardness as suggested by g-max for 'Midnight' Kentucky bluegrass topdressed with various granular rubber treatments and evaluated after periods of traffic and recovery. Higher g-max values indicate a harder, less resilient surface. G-max was determined using 0.5 kg and 2.25 kg drop hammers.

	Treatment	Rate (in)	Spring Traffic Period				Summer Recovery		Fall Traffic Period		Winter Period			
			5-28-96		6-13-96		7-1-96		10-1-96		1-22-97†		2-23-97††	
			0.5 kg	2.25 kg	0.5 kg	2.25 kg	0.5 kg	2.25 kg	0.5 kg	2.25 kg	0.5 kg	2.25 kg	0.5 kg	2.25 kg
			g-max											
1.	Coarse crumb	0.38	68	44	135	84	169	109	92	107	305	291	193	212
2.	Coarse crumb	0.75	62	42	114	66	117	89	89	87	159	201	222	174
3.	Medium crumb	0.38	68	44	140	85	189	114	94	104	239	325	205	191
4.	Medium crumb	0.75	62	43	117	75	135	100	89	92	280	278	246	220
5.	Medium buffing	0.38	66	45	117	82	161	119	95	104	218	296	313	280
6.	Medium buffing	0.75	62	44	118	74	127	97	85	91	200	259	242	235
7.	Coarse buffing	0.38	70	46	128	86	215	127	99	108	282	275	239	233
8.	Coarse buffing	0.75	66	45	122	77	136	106	90	96	180	187	210	178
9.	Sand	0.75	74	49	135	81	166	104	88	104	271	327	313	283
10.	Control	–	69	45	174	89	301	134	110	120	346	301	163	187
	$LSD_{(0.05)}$		4	2	19	11	34	14	NS	13	105	69	NS	73

†Frozen conditions throughout profile.
††Top cm of profile thawed, remaining profile frozen.
NS = not significantly different at the 0.05 level.

The Effect of Topdressing with Rubber Buffings on Intensely Trafficked Football Turf

Jeffrey J. Salmond and David D. Minner

A study was initiated during the summer of 1996 at Ames High School football field in Ames, Iowa to evaluate the effects of buffings rubber on a intensely trafficked football turf. The experimental plots were arranged behind the east goal post on a mature stand of Kentucky bluegrass overseeded with perennial ryegrass. The experimental plot was measured to the size of a football exercise apparatus called strings. The object of the exercise is to develop balance of the athlete and to teach foot and eye coordination. The athlete runs through the strings by placing his foot into the desired square sector. The coach can instruct the athlete to do various exercises such as a criss-cross, bunny-hop, side step, diagonal, and others. The apparatus was placed over the experimental plot such that each square of the apparatus was over the top of the 2 x 3 ft treatments and controls. The number of feet to hit each plot was calculated with a hand-held counter and later recorded to find the total number of feet placed into each square (Table 1). Human athletes, wearing 3/8-inch high-density plastic cleats, were used to uniformly apply traffic to the research plots during a football practice exercise. Other research has used various cleated roller devices to simulate traffic (i.e. Brinkman traffic simulator, Differential slip-2 simulator, and modified Brouwer roller). Overall plot size was 6 x 20 ft with individual plots being 2 x 3 ft for a total of 18 plots, 2 rows of 9 plots each. Plots were positioned opposite one another in pairs. Each pair of plots had a rubber treatment and a non-rubber control. There were three replications of each pair of plots. The three treatments were 0.25-, 0.50- and 0.75-inch depths of medium buffings rubber (Table 2). The particle size of medium buffings is 1 mm diameter (18 mesh) to 0.5 mm diameter (35 mesh). The average ratio of length to width for the longest treads of rubber is approximately 7:1. A 6 x 20 ft area was scalp-mowed to 0.75 inches and core aerified with 0.50-inch diameter hollow tines, cores removed, and rubber topdressing treatments applied on 3 June 1996 (Table 2). It was found that topdressing the scalp plot with the 0.75-inch treatment was excessive, therefore a remaining amount of rubber was added later, after settling had occurred, to achieve the desired amount.

The main objective was to evaluate the effects of buffings rubber on turf cover under intense football-type traffic. A secondary objective was to evaluate turf re-establishment by reseeding into worn turf containing rubber buffings.

Measurements were taken for traffic [percentage of turfgrass cover with the remaining percentage equal to the amount of topdressed rubber or soil showing] (Table 3) and temperatures within the grass canopy and at a 1.0-inch depth (Table 4). The surface/canopy temperature was measured using a hand-held infrared probe (Cole-Parmer, Type J, model # H-39652-00) plugged into a thermocouple thermometer held at a height of 24 inches above the plot. The effective diameter cone measured was 6-inches with an area of 28.3 square inches. The 1.0-inch depth temperature was measured with a 12-inch, 0.25-inch diameter heavy-duty penetration probe (Cole-Parmer, Type T, model # H-93601-26). A g-max was also initially measured (Table 3).

Results of surface/canopy temperature showed that the rubber treatments were 6 to 9° F higher than the no-rubber controls. However, temperatures at the 1.0-inch depth showed the rubber treatments having the same and in some cases a lower temperature than the no-rubber control (Table 4). Black rubber exposed to direct sunlight may accelerate turf canopy temperature but has little impact on shallow soil temperatures. It may be possible that the rubber layer is acting like a mulch and reducing underlying soil temperature.

The plots were overseeded on 24 September 1996. Grass plants were at a height of 1.0-inch on 16 October 1996. No phytotoxicity was observed at this time on the new seedlings.

Table 1. Average number of feet hit into each plot for the 5-day training camp.

Date	Aug 5	Aug 6	Aug 7	Aug 8	Aug 9	Total
Average number of feet per plot	130	330	550	445	346	1670
Total number of feet for entire exp plot (all 20 plots)	2600	6608	11,000	8910	6920	33,440

Table 2. Treatments and the arrangement of treatments in the experimental plots.

1	C	2	C	3	C	1	C	2	C
C	3	C	1	C	2	C	3	C	1
Rep I			Rep II			Rep III			leftover

Depths
1. 0.25-inch medium rubber buffings
2. 0.50-inch medium rubber buffings
3. 0.75-inch medium rubber buffings

C = control, no rubber

Table 3. Initial g-max before traffic and the percentage turf cover during traffic treatments.

Treatments	G-max June 5, 1996	percent turf cover Aug 6	Aug 7	Aug 8	Aug 9
1. 0.25-inch depth of MB	62.1	96.7	80.0	53.3	18.3
control for trt 1	67.0	93.3	65.0	43.3	7.3
2. 0.50-inch depth of MB	61.0	95.0	90.0	60.0	35.0
control for trt 2	66.7	90.0	31.7	28.3	6.7
3. 0.75-inch depth of MB	60.0	95.0	73.3	30.7	36.7
control for trt 3	68.1	95.0	65.0	36.7	10.0

MB=Medium rubber buffings

Table 4. Surface and subsurface temperatures taken on 24 September 1996, 45 days after traffic treatments were applied. Air temperature was 67° F during data collection.

Treatments	Average temperature on the surface (°F)	Average temperature at the 1.0-inch depth (°F)
1. 0.25-inch depth of MB	73.4	67.6
control for trt 1	67.2	68.2
2. 0.50-inch depth of MB	74.2	67.2
control for trt 2	68.3	67.6
3. 0.75-inch depth of MB	78.0	66.6
control for trt 3	69.0	67.7

MB=Medium rubber buffings

Tree Planting Basics

Jeffery K. Iles

Anyone can plant a tree. Prepare a hole just wide enough to accommodate the roots, dig it extra deep and then throw in peat moss or gravel to enhance root growth and drainage, don't worry about removing root enclosures like containers, or burlap and twine (they'll decompose eventually), amend the backfill soil with rich organic materials and fertilizer, remove one-third of the branches to compensate for root loss, and stake the tree to prevent any movement. Right? Of course not! But unfortunately, many of these outdated, ill-founded practices persist. Yes, anyone can plant a tree, but to ensure success, sound installation practices must be followed.

Initial Considerations

Before you pick up the shovel, review your game plan one more time. Have you chosen trees that conform to any and all spatial constraints presented by the site (consider power lines, sidewalks, streets, etc.)? Have you chosen trees with the genetic wherewithal to cope with any unique environmental conditions (consider south-facing walls that turn into blast furnaces in summer, wind tunnels, wet areas, etc.)? Were your trees purchased from reputable nursery operators (not dug from the woods) and are they of the highest quality? Finally, have you made plans to protect trees from mechanical injury, heat and cold, and from drying-out during transportation to the planting site and as they await installation? If you can answer yes to all of these questions, then you're ready to plant.

General Site Preparation

Ideally, the planting hole should be two to three times the width of the rootball, container, or rootmass (the poorer the soil, the wider the hole), with sides that slope towards the base of the rootball (Fig. 1). Wide planting holes provide a beneficial zone of well-aerated and well-drained soil that tree roots will readily exploit during the establishment period. In addition, sloped walls help direct growing root tips upward to the surface rather than in a circling pattern. Hole depth should allow the tree to be positioned so that the root collar or trunk flare is level with, or slightly higher than the surrounding grade. Never dig the hole deeper than the height of the rootball or rootmass because the tree may settle deeper into the hole than intended. Planting too deep, either intentionally or unintentionally, can cause trees to die within months of installation, or lead to other chronic problems (girdling roots, stem or trunk rots, etc.) that significantly shorten their lives.

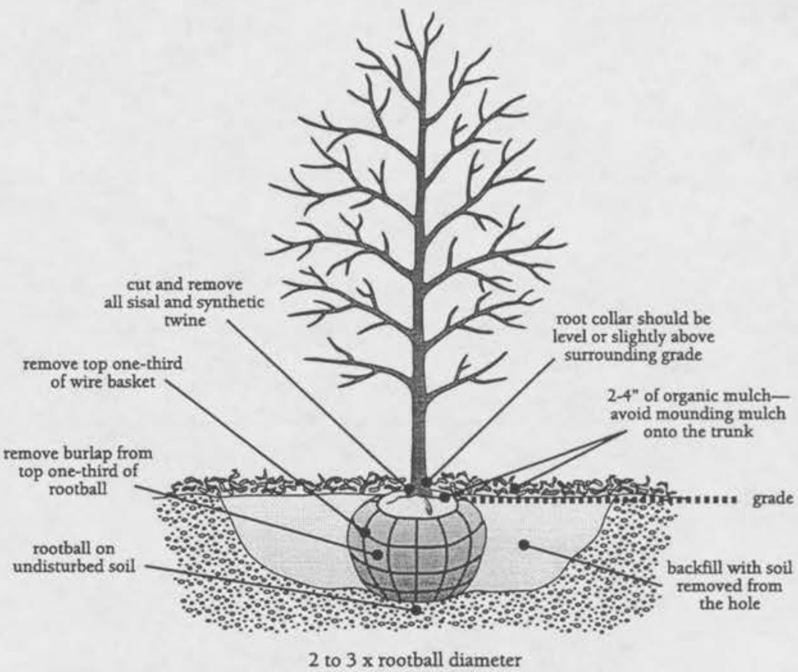


Figure 1. Tree planting method for well-drained soil. The planting hole should be 2 to 3 times the width and no deeper than the height of the rootball.

But what about planting trees in new housing developments where the "growing medium" is compacted clay subsoil? When confronted with situations where drainage is poor and soil oxygen is in short supply, only species tolerant of these challenging conditions should be used. Alternatively, you might install expensive and elaborate subsurface drainage systems, or plant trees in raised berms (natural-appearing land forms composed of good topsoil). If trees must be planted directly into poorly-drained or compacted soils, a wide, shallow hole should be prepared so as much as one-third of the rootball or rootmass protrudes above the surrounding grade (Fig. 2). This technique raises the zone of active root growth above potentially saturated, oxygen deficient conditions.

Contrary to popular belief, soil removed from the planting hole is the most appropriate backfill material. Soil amendments like peat moss, ground bark, and composted manures mixed with the native soil and used as backfill have not proven beneficial to tree establishment. In fact, studies have shown tree root systems in amended soils remain confined to the amended soil in the planting hole, while trees planted without the "benefit" of soil amendments developed roots far beyond the original planting hole. And on poorly-drained sites, soil amendments can collect too much water. Because amended soil has greater pore space than surrounding clay soil, water will move into it preferentially. During periods of heavy rainfall, the amended planting hole can fill up with water like a bathtub, causing root suffocation and tree death.

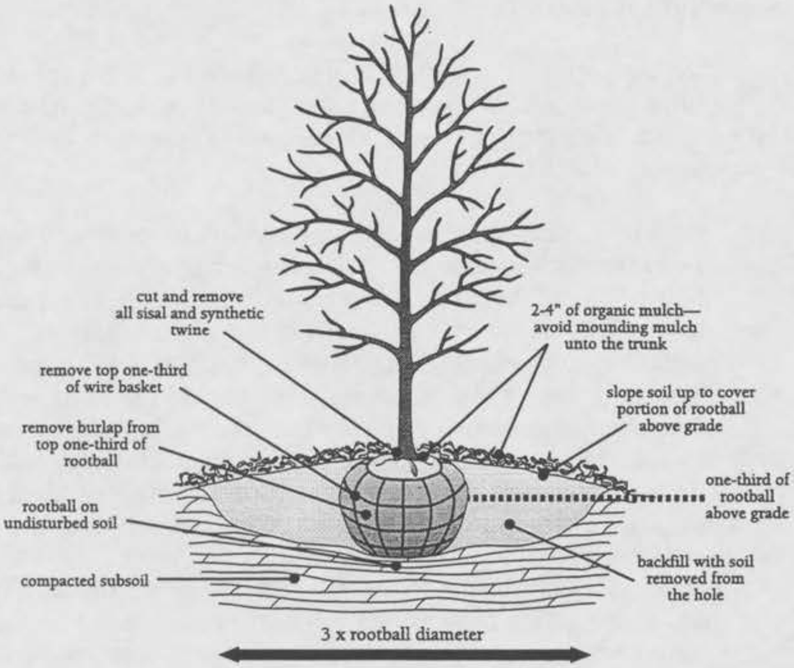


Figure 2. Tree planting method for poorly-drained soil. The planting hole should be 3 times the width of the rootball and shallow to allow one-third of the rootball to protrude above grade.

Planting Bare-root Trees

Damaged, broken, or excessively long roots should be pruned from bare-root trees prior to planting. When positioned in the hole, root systems should not be twisted, bent, or kinked. Planting bare-root trees is made easier by building a firm, cone-shaped mound of soil at the bottom of the hole. When roots are spread evenly over the mound or pedestal, the ground line on the trunk (indicating previous planting depth at the nursery) should be at, or just above the surrounding grade. After proper depth has been determined, backfill soil can be added, taking care to work the soil around the roots. Watering the backfill when three-fourths completed, and again when the backfill matches the surrounding grade, will eliminate undesirable air pockets. **Caution:** *Do not place excess soil, especially clay-type soil, over the planting site. When heaped over the plant roots, clay soil forms a layer that oxygen and water cannot readily penetrate. Adding clumps of turfgrass in the "overfill" also is to be avoided.*

Planting Balled & Burlapped Trees

Balled & burlapped (B&B) trees must be handled carefully to prevent damage to the trunk and to the roots inside the rootball. Trees should always be handled by the rootball and not by the stem or trunk.

To determine proper hole depth, examine the rootball to locate the original "ground level" at which the tree was growing in the nursery. Repeated cultivation in the nursery sometimes causes extra soil to accumulate around the trunk, disguising the original grade. Trees can be planted too deep when the planter assumes the top of the rootball is the original ground level. Peel back the burlap from the top of the rootball and look for the flared trunk base that increases in diameter as it meets the ground. Also look for roots. If these features aren't immediately apparent, scrape the soil away until fibrous roots are discovered. Now the true depth of the root system can be determined and an appropriate hole can be prepared.

Balled & burlapped trees should be gently lowered, not dropped, into the prepared hole. If plastic or poly-burlap has been used to encase the rootball, it should be removed before backfilling begins. These materials interrupt water movement from the surrounding soil into the rootball, and also may restrict root growth.

Deciding which other support-lending materials to remove from the rootball before backfilling begins is handled on a case-by-case basis. If the rootball is exceptionally sturdy, all burlap, sisal and synthetic twine, and the wire basket can be removed before backfilling begins, however, removing these materials at this stage may result in the loss of rootball integrity and cause root damage. A safer method involves backfilling layers of soil around the rootball until one-half to two-thirds of the planting hole is full. Then, all twine from around the trunk, and the top one-third of the wire basket can be removed from the rootball to eliminate the possibility of root or stem girdling. Next, burlap covering the top one-third of the rootball can be cut away to allow free movement of water into the rootball. Removing the burlap is preferred over simply folding it back into the planting hole because a burlap "wad" two or more layers thick may form which could hamper root egress in the first few months after transplanting. Now backfilling can be completed, gently firming the backfill soil with your hands. Because dry rootballs will result in poor growth, a thorough watering is absolutely essential for the newly planted tree. A "deep-root" feeder or watering needle can be used to force water throughout the rootball to "recharge" it and promote root development. Also, make sure the backfill soil is thoroughly watered to eliminate air pockets.

Planting Container-grown Trees

Container-grown trees are planted using many of the same techniques described for balled & burlapped trees. But before backfilling begins, all containers must be removed from the rootball or rootmass. Even the so-called "plantable" or paper mache containers should be removed to keep them from interfering with root growth and drainage.

When planting a large tree, or if a tree is poorly established in the container (a common problem when container-grown trees are purchased in early spring), the planting operation is made easier by first, cutting away the bottom of the container, and then lowering the rootball into the hole before removing the rest of the container.

Occasionally, container-grown trees may become pot-bound or root-bound (roots dense and circling). If not corrected, this condition can restrict root growth development into the surrounding soil and make it difficult to wet the original root mass. Several vertical cuts made the length of the rootmass will disrupt circling roots and lessen the chance for girdling roots later in the life of the tree.

Planting Trees in Fabric Containers

Several in-ground fabric containers, using various designs and fabrics, have been produced by R. Reiger and C. Whitcomb. All of these fabric in-ground containers are removed from the field at harvest, with the containers not being removed until trees are transplanted. A new in-ground fabric container is made from Biobarrier™, a product composed of Typar geotextile and Treflan herbicide. While this new in-ground fabric container (the Geocell™) still allows for the lateral exchange of water between the native soil in and surrounding the container, it differs from the previous in-ground fabric containers in that the herbicide keeps the roots from growing through the fabric into the surrounding soil. No root loss should occur at harvest with the Geocell™, whereas up to 20% of roots may be lost using other types of in-ground fabric containers. In addition, the Geocell™ is not used, as are other in-ground fabric containers, for root ball protection and tree shipping/marketing, and often remains behind in the production hole. But if trees are received with grow bags still attached to the root balls, they must be removed at planting to prevent possible root deformation and prolonged restriction of nutrient and carbohydrate movement.

Planting with a Tree Spade

Trees transplanted with a tree spade generally respond like B&B trees, however, if the planting hole is dug with a tree spade in clay soil and the sides of the hole become glazed, some roots could have trouble growing into the surrounding soil. To alleviate this problem, enlarge the hole before planting so roots can penetrate the loosened backfill soil. Lower the spade with the root ball into the hole and partially fill in around the spade with loosened backfill soil. Firm the soil and add water to settle.

Trees moved with a tree spade into loamy or sandy soils can usually be planted into the "spaded hole" with little, if any alterations to the hole. The tree often ends up a little higher than the surrounding grade, which is certainly much better than planting too deeply.

The Establishment Period - Post-plant Care

In USDA hardiness zones 4 and 5, the establishment period lasts about 12 months per inch of trunk diameter. For a two-inch caliper tree, this translates into a 24-month establishment period.

Proper **water** management is crucial for newly-planted trees. Recent evidence suggests frequent irrigation provides more benefit than applying large volumes of water infrequently. This is in direct contrast to the recommendation for established trees where occasional irrigation with large water volumes is considered better than light, frequent applications. Be sure to gradually increase the area irrigated around the tree to accommodate root growth.

Bare-root trees and those planted in windy, exposed sites may require **staking** for support. Staking materials should not girdle or injure the stem and should allow some trunk movement or sway. When possible, stakes should be removed after one year of service.

Severe **pruning** at planting time is unnecessary and may reduce the growth rate of developing roots. Remove only dead, broken, or rubbing branches.

Mulching the area around newly-planted trees with pine needles, wood chips, shredded bark, or slightly decomposed leaves (2 to 4 inches deep) is highly recommended. Mulching increases tree growth by reducing turfgrass competition, conserving soil moisture, and reducing the chance of mechanical injury from lawn mowers and string trimmers. The only precaution is to keep mulch several inches away from the trunk so it will not rot the trunk.

Finally, ensuring good aeration for developing roots through proper planting techniques and providing adequate moisture to the root-zone and surrounding backfill are far more important than applying **fertilizer** at planting time. Fertilizer is more appropriately applied at the beginning of the second growing season.

Crabapples: Sales Trends and Consumer Preferences in Iowa

Jeffery K. Iles and Joanna S. Stookey

Abstract
A survey questionnaire was sent to 180 active members of the Iowa Nursery and Landscape Association to assess the importance of crabapples to the nursery and landscape industry in Iowa, identify the number of crabapple taxa offered, and characterize consumer preferences which influence crabapple inventories as perceived by questionnaire respondents. Most of the respondents (83%) identified crabapples as their customers' preferred flowering tree, with cultivars `Prairifire', `Spring Snow', and `Snowdrift' as the most popular taxa. Slightly less than two-thirds of all respondents indicated they had eliminated certain crabapple selections from their product line since 1990. The cultivars `Radiant' and `Royalty' were cited most frequently as discontinued taxa, primarily because of disease problems. Businesses must continually evaluate the appropriateness of the crabapples they carry to ensure they are offering only those selections with excellent ornamental utility and superior disease resistance.

Introduction

Crabapples are the most widely cultivated small landscape tree in the northern United States and southern Canada (Egolf, 1987). Defined as those taxa in the genus *Malus* that bear fruits 5 cm (2 inches) in diameter or smaller, crabapples offer spectacular spring flowers, attractive summer foliage, an autumnal display of vividly colored fruit, and an array of growth habits and sizes to complement any landscape situation (Brewer et al., 1979; Fiala, 1994; Flint, 1991).

An examination of nursery catalogs underscores the popularity of crabapples. Approximately 200 taxa are currently available from nursery sources, and dozens more become available each year (Green, 1996; Palven, 1988). But with this abundance comes confusion and skepticism over the quality and uniqueness of each selection. In addition, many homeowners and nursery professionals have developed negative attitudes toward all crabapples because of inferior performances by a few widely planted selections. For instance, the cultivars `Almey', `Eleyi', `Hopa', and `Radiant' were selected by breeders and became commonplace in residential and commercial landscapes because of their showy, 7 to 10-day floral display each spring. Unfortunately, little consideration was given to their aesthetic impact at other times of the year. Thus, many established landscapes are blighted with these and other disease-prone crabapples that defoliate prematurely, flower only in alternate years, and/or produce undesirable fruit litter.

Over the last several decades, both early and more recent crabapple introductions have been held to a higher standard where disease resistance, aesthetic qualities, and maintenance considerations are given equal weight (Green, 1991; Guthery and Hasselkus, 1992). As a result, the majority of taxa available today are excellent landscape plants. Still, a surprising number of undesirable selections can be found in nurseries and garden centers. Failure to purge these substandard selections from wholesale and retail inventories could further undermine the reputation of this useful plant group and erode consumer confidence in the nursery industry.

The objectives of this study were to: 1) assess the importance of crabapples to the nursery and landscape industry in Iowa and identify the number of crabapple taxa offered, and 2) characterize consumer preferences that influence crabapple inventories as perceived by nursery operators participating in this study.

Materials and Methods

Survey questionnaires were sent by first-class mail to 180 active members of the Iowa Nursery and Landscape Association. Mailed questionnaires included a cover letter explaining the objectives of the research and instructions for returning the completed questionnaire. Association members surveyed were assured of the confidentiality of their responses. The initial mailing was sent on June 7, 1996, with follow-up mailings to nonrespondents on July 1.

Completed questionnaires were received from 105 firms (58.3% response rate), however, five businesses were eliminated from the study because they neither grew nor sold crabapples. Firms were grouped according to their primary business type: retail nursery/garden center, landscape design/installation, rewholesale nursery, and production nursery. Because of the low number of responses, data from rewholesale nurseries, production nurseries, and one lawn care business, were grouped and analyzed together. Incomplete data for questions unanswered were not adjusted, and percentage results presented in tables are based upon actual reported totals. The frequency distribution of respondents was tabulated for each question with PROC FREQ of SAS (SAS Institute, Cary, N.C.).

The questionnaire contained 16 numbered questions in both closed-end and open-end form, and addressed the following areas: a) the relative popularity of crabapples compared to other flowering trees, b) the number of crabapple taxa offered for sale and identification of best-selling selections, c) the number of crabapple taxa eliminated from inventories since 1990, and why, d) crabapple traits that most influence customers' decisions to purchase, e) identification of fruitless selections sold in Iowa, and f) the outlook for future crabapple sales.

Results and Discussion

Most of the questionnaires were completed by owners and/or managers (96%). Respondents grouped themselves into five business categories, with retail nurseries and landscape design/installation firms comprising 90% of all respondents. Specifically, the participant profile was distributed in the following manner: Landscape design/installation (51%), retail nursery/garden center (39%), production nursery (5%), rewholesale nursery (4%), and lawn care (1%).

To gauge the relative importance of crabapples, respondents were asked to rate six species of flowering trees (rated on a scale of 1 to 6 where 1 = most and 6 = least) in order of their popularity with customers. Most believed crabapples were the preferred flowering tree as 83% gave them a rating of 1 (Table 1). Serviceberry was the most frequent choice as second most popular tree (28%).

Decisions concerning which crabapples to offer for sale are complicated by changing consumer demand and the overwhelming number of taxa available. Most nursery businesses are obliged to carry selections that provide a range of flower and fruit colors, and growth habits (weeping, spreading, upright, columnar, etc.). In Iowa, retail nurseries offer the widest assortment of crabapples, averaging 13.9 selections per business (SEM = 2.05). Landscape design/installation firms averaged 10.3 selections (SEM = 1.15), while the combination of all other respondents averaged 11.3 selections per business (SEM = 5.99).

When respondents were asked how they offer crabapples for sale, most retail nurseries (85%) and a majority of landscaping firms (55%) said they sell crabapples as container-grown trees. Over one-third (39%) of landscaping firms reported selling balled-and-burlapped crabapples, but only two landscape respondents stated their businesses offer large specimens transplanted with a tree spade.

The cultivars 'Prairifire', 'Spring Snow', and 'Snowdrift' were cited most frequently as the best-selling crabapple selections (Table 2). In 1996, the Iowa Nursery and Landscape Association designated 'Prairifire' as the "Tree of the Year." Because of its disease-resistant history and bright red-purple flowers (Dayton, 1982), the popularity of 'Prairifire' is not surprising, however, this promotion undoubtedly contributed to its prominent standing in Iowa. Almost one-third of retail (30%) and landscape design (29%) respondents also chose 'Prairifire' as their personal favorite.

Because any amount of fruit litter is intolerable in certain landscape situations, the demand for fruitless flowering trees is great. The selection 'Spring Snow', which is essentially sterile, satisfies this need and explains its popularity with customers of Iowa nurseries and landscaping firms. Finally, white-flowering `Snowdrift', despite its susceptibility to the diseases apple scab (*Venturia inaequalis*) and fire blight (*Erwinia amylovora*), remains a favorite long after its introduction in 1965. Unfortunately, several respondents listed the cultivars `Pink Perfection', `Radiant', `Royalty', and `Sparkler' among their best-selling selections. These cultivars have serious disease problems and should not be offered as viable choices (Fiala, 1994).

A majority of all respondents (61%) indicated they had eliminated certain crabapple selections from their product line since 1990. Of the 34 discontinued taxa identified by respondents, the cultivars `Radiant' (19%) and `Royalty' (15%) were most frequently mentioned (Table 3). Disease problems were cited by 75% of respondents as the predominant reason for eliminating these and other crabapples from inventories.

A large number of retailers (77%) and landscaping firms (61%) indicated they place equal emphasis on flowering, fruiting, growth habit, and disease resistance characteristics when describing a particular crabapple to a customer. Yet, approximately three-fourths of retailers (72%) and landscapers (76%) declared their customers are still most interested in flower color. The necessity of offering a variety of crabapples with all flower colors represented was reemphasized as 36% of all respondents stated their customers were equally interested in white, red, and pink forms.

Fruiting characteristics of crabapples are a contentious issue in the selection process. In fact, 29% of all respondents reported that 26% to 50% of their customers find crabapple fruit objectionable. Another 18% remarked that 51% to 75% of their customers found fruit objectionable. Intolerance of fruit-bearing crabapples has prompted a large number of respondents (82%) to carry a fruitless selection, and for most (93%), `Spring Snow' was the lone offering. Although a beautiful tree in bloom, `Spring Snow' is subject to slight apple scab and mild fire blight (Fiala, 1994). Enthusiasm for this disease-prone crabapple should be tempered and alternative fruitless selections, or trees that bear small, persistent fruit should be identified and promoted.

The majority of respondents (90%) felt crabapple sales had either increased or remained the same during the period from 1990 to 1996, and a slightly larger group (93%) predicted sales would increase or remain the same during the next five years.

Positive feelings about past sales and optimistic perceptions for the future revealed in this study, bode well for crabapple use in Iowa, and presumably in other regions of the United States and Canada. Still, nursery and landscape businesses must continually evaluate the appropriateness of crabapple selections they offer. Fellow green industry professionals and an increasing number of sophisiticated gardening clients demand crabapples with excellent ornamental utility and superior disease resistance.

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Table 1. Rating of flowering trees in order of popularity with respondents' customers.

	Response (%) by Rating[z]					
Tree species	1	2	3	4	5	6
Callery pear	6.1 (n=6)	19.6 (n=19)	13.5 (n=13)	19.5 (n=17)	16.2 (n=13)	19.5 (n=16)
crabapple	82.7 (n=81)	11.4 (n=11)	3.1 (n=3)	2.3 (n=2)	0.0 (n=0)	1.2 (n=1)
dogwood	7.1 (n=7)	20.6 (n=20)	13.5 (n=13)	11.5 (n=10)	15.0 (n=12)	29.3 (n=24)
Japanese tree lilac	3.1 (n=3)	12.4 (n=12)	26.1 (n=25)	25.3 (n=22)	27.5 (n=22)	8.5 (n=7)
magnolia	0.0 (n=0)	8.2 (n=8)	16.7 (n=16)	24.1 (n=21)	26.3 (n=21)	28.1 (n=23)
serviceberry	1.0 (n=1)	27.8 (n=27)	27.1 (n=26)	17.2 (n=15)	15.0 (n=12)	13.4 (n=11)
	n=98	**n=97**	**n=96**	**n=87**	**n=80**	**n=82**

[z]Rating where 1 = most popular and 6 = least popular.

Table 2. Respondents' answer to the request, "List your three best-selling crabapples."

	Response (%) by Business Focus			
Taxa[z]	Total	Retail[y]	Landscape[x]	Other[w]
`Prairifire´	23.4 (n=67)	23.9 (n=27)	22.8 (n=34)	25.0 (n=6)
`Spring Snow´	22.4 (n=64)	20.4 (n=23)	22.1 (n=33)	33.3 (n=8)
`Snowdrift´	14.3 (n=41)	14.2 (n=16)	14.8 (n=22)	12.4 (n=3)
`Indian Magic´	5.2 (n=15)	8.8 (n=10)	2.7 (n=4)	4.2 (n=1)
`Profusion´	4.2 (n=12)	2.7 (n=3)	4.7 (n=7)	8.3 (n=2)
`Pink Spires´	3.8 (n=11)	2.7 (n=3)	5.4 (n=8)	0.0 (n=0)
`Red Splendor´	3.5 (n=10)	4.4 (n=5)	3.4 (n=5)	0.0 (n=0)
`Adams´	2.1 (n=6)	0.0 (n=0)	4.0 (n=6)	0.0 (n=0)
Centurion®	1.7 (n=5)	2.7 (n=3)	0.7 (n=1)	4.2 (n=1)
`Donald Wyman´	1.7 (n=5)	0.9 (n=1)	2.7 (n=4)	0.0 (n=0)
sargentii	1.7 (n=5)	1.8 (n=2)	2.0 (n=3)	0.0 (n=0)
`Robinson´	1.4 (n=4)	1.8 (n=2)	0.7 (n=1)	4.2 (n=1)
`Royalty´	1.4 (n=4)	2.7 (n=3)	0.7 (n=1)	0.0 (n-0)
Harvest Gold®	1.0 (n=3)	0.0 (n=0)	2.0 (n=3)	0.0 (n=0)
`Liset´	1.0 (n=3)	0.9 (n=1)	1.3 (n=2)	0.0 (n=0)
`Red Barron´	1.0 (n=3)	1.8 (n=2)	0.7 (n=1)	0.0 (n=0)
`Sparkler´	1.0 (n=3)	0.9 (n=1)	1.3 (n=2)	0.0 (n=0)
`Thunderchild´	1.0 (n=3)	0.9 (n=1)	0.7 (n=1)	4.2 (n=1)
`Amer. Masterpiece´	0.7 (n=2)	1.8 (n=2)	0.0 (n=0)	0.0 (n=0)
`Coralburst´	0.7 (n=2)	0.0 (n=0)	1.3 (n=2)	0.0 (n=0)
Golden Raindrops®	0.7 (n=2)	0.9 (n=1)	0.0 (n=0)	4.2 (n=1)
`Pink Perfection´	0.7 (n=2)	0.9 (n=1)	0.7 (n=1)	0.0 (n=0)
`Radiant´	0.7 (n=2)	0.0 (n=0)	1.3 (n=2)	0.0 (n=0)
Red Jewel™	0.7 (n=2)	0.0 (n=0)	1.3 (n=2)	0.0 (n=0)
Sugar Tyme®	0.7 (n=2)	0.9 (n=1)	0.7 (n=1)	0.0 (n=0)
	n=286	**n=113**	**n=149**	**n=24**

[z]Of the 34 taxa listed by respondents, only those mentioned two or more times are included.
[y]Retail nurseries/garden centers.
[x]Landscape design/installation firms.
[w]Other = rewholesale nurseries, production nurseries, and one lawn care firm.

Table 3. Crabapples eliminated from respondents' product line since 1990.

Taxa[z]	Response (%) by Business Focus			
	Total	Retail[y]	Landscape[x]	Other[w]
'Radiant'	18.6 (n=22)	19.0 (n=11)	18.5 (n=10)	16.7 (n=1)
'Royalty'	15.3 (n=18)	17.2 (n=10)	14.8 (n=8)	0.0 (n=0)
'Thunderchild'	7.6 (n=9)	10.3 (n=6)	5.6 (n=3)	0.0 (n=0)
'Hopa'	6.8 (n=8)	8.6 (n=5)	3.7 (n=2)	16.7 (n=1)
'Red Splendor'	5.1 (n=6)	0.0 (n=0)	7.4 (n=4)	33.3 (n=2)
'Indian Magic'	4.2 (n=5)	0.0 (n=0)	9.3 (n=5)	0.0 (n=0)
'Brandywine'	3.4 (n=4)	1.7 (n=1)	5.6 (n=3)	0.0 (n=0)
'Adams'	2.5 (n=3)	1.7 (n=1)	1.9 (n=1)	16.7 (n=1)
'Profusion'	2.5 (n=3)	3.4 (n=2)	1.9 (n=1)	0.0 (n=0)
'Red Jade'	2.5 (n=3)	3.4 (n=2)	1.9 (n=1)	0.0 (n-0)
× *zumi*	2.5 (n=3)	1.7 (n=1)	3.7 (n=2)	0.0 (n=0)
'Bechtel'	1.7 (n=2)	1.7 (n=1)	1.9 (n=2)	0.0 (n=0)
Candied Apple®	1.7 (n=2)	1.7 (n=1)	1.9 (n=1)	0.0 (n=0)
'Dolgo'	1.7 (n=2)	1.7 (n=1)	1.9 (n=1)	0.0 (n=0)
'Eleyi'	1.7 (n=2)	1.7 (n=1)	0.0 (n=0)	16.7 (n=1)
floribunda	1.7 (n=2)	0.0 (n=0)	3.7 (n=2)	0.0 (n=0)
'Liset'	1.7 (n=2)	1.7 (n=1)	1.9 (n=1)	0.0 (n=0)
sargentii	1.7 (n=2)	1.7 (n=1)	1.9 (n=1)	0.0 (n=0)
	n=118	**n=58**	**n=54**	**n=6**

[z]Of the 34 taxa listed by respondents, only those mentioned two or more times are included.
[y]Retail nurseries/garden centers.
[x]Landscape design/installation firms.
[w]Other = rewholesale nurseries, production nurseries, and one lawn care firm.

Crabapple Bloom Sequence and Length of Bloom Period in 1996

Jeffery K. Iles and Joanna S. Stookey

Introduction

Crabapples (*Malus spp.*), like many woody landscape plants, have relatively short flowering periods. If weather conditions are favorable during the spring bloom period (mild temperatures, moderate breezes, and little or no rainfall), the floral display on individual trees may be ornamentally effective for up to 10 days (Fiala, 1994). Unfortunately for Midwesterners, high winds, frequent rainfall, and temperatures ranging from below freezing to 90° F often coincide with the first crabapple blossom. But by carefully selecting early-, mid-, and late-season flowering crabapples for the landscape, the threat of capricious spring weather ruining the entire floral display is reduced, and the long-awaited flowering period can be significantly extended.

Materials and Methods

Blossom times and/or bloom sequences have been reported for many crabapples (den Boer, 1995; Warren, 1987). But, similar information is not available for a number of other crabapple taxa commonly used in today's landscapes. During the spring of 1996, crabapples planted at the Iowa State University Horticulture Research Station (lat. 42°3'N) as part of the National Crabapple Evaluation Program, were evaluated for bloom sequence and length of ornamentally effective bloom period. Using the concept of a Blossom Time Index (BTI) developed by John H. den Boer, crabapples were assigned to four bloom period categories (very early season, early season, mid-season, and late season). The BTI's reported in Table 1 represent the average number of days to first flower after a reference crabapple taxon has flowered.

Results and Discussion

In this study, `Pink Spires´ was the first crabapple to flower (5/9/96) and thus became the reference point for categorizing all other taxa. Days of Effective Bloom, also reported in Table 1, represents the average number of days from first open flower to 50% petal drop. In 1996, favorable weather conditions during the very early season in Iowa promoted extended flowering periods. This helps to explain the unusually high number of days of effective bloom for `Dolgo´, `Pink Spires´, and `Selkirk´.

Data from a single season cannot provide the same detail that would result from a multi-year study. Still, information from our investigations during the spring of 1996 lays the foundation for future observation, and classifies, in some cases for the first time, relative blossom times for several new crabapple taxa. Information about blossom times will be of particular interest to growers and retailers of crabapples as they plan future inventories, and to those who include crabapples in their landscape designs.

Literature Cited

den Boer, J.H. 1995. Blossom times. *Malus* 9(1):10-16.
Fiala, J.L. 1994. Flowering crabapples: The genus *Malus*. Timber Press, Portland, Oregon.
Warren, K. 1987. Crabapple bloom sequence. *Malus* 2(3):7.

Table 1. Relative bloom sequence as indicated by a blossom time index (BTI) and days of ornamentally effective bloom for selected crabapple taxa during spring 1996.

Taxa	BTI[z]	Days of Effective Bloom[y]
<u>VERY EARLY SEASON</u>		
`Dolgo′	1.3[x]	9.4
`Pink Spires′	0.0	9.3
`Selkirk′	3.0	8.0
<u>EARLY SEASON</u>		
`Adams′	6.0	5.0
baccata `Jackii′	4.7	5.3
Centurion®	5.0	6.0
floribunda	6.0	6.0
`Hopa′	4.0	6.0
`Indian Summer′	4.0	6.0
`Louisa′	5.3	5.7
`Morning Sun′	5.0	6.0
`Ormiston Roy′	6.0	5.3
`Professor Sprenger′	6.0	5.0
`Ralph Shay′	5.0	6.0
`Red Barron′	5.0	7.0
`Red Jade′	6.0	5.3
`Red Splendor′	5.7	5.3
`Sentinel′	4.0	7.0
`Silver Drift′	5.3	5.7
`Thunderchild′	5.0	6.0
Weeping Candied Apple®	5.7	5.3
`White Angel′	6.0	6.3
<u>MID-SEASON</u>		
`Canary′	7.0	4.0
`Candymint Sargent′	8.0	4.3
Christmas Holly™	7.0	6.0
`David′	8.3	6.7
`Donald Wyman′	7.0	6.0
`Henning′ (`Henningii′)	7.0	6.0
`Indian Magic′	7.0	4.7
`Jewelberry′	7.0	5.7
Lancelot®	8.0	6.7
`Liset′	8.0	7.0
`Mary Potter′	8.0	6.0
Molten Lava®	7.0	5.0
Pink Princess™	8.0	4.0
`Pink Satin′	7.0	6.3
`Prairifire′	8.0	5.0
`Profusion′	7.0	5.0
Red Jewel™	8.0	4.0
`Robinson′	7.7	4.0
Royal Fountain®	8.0	4.3
`Ruby Luster′	8.0	6.3
`Sinai Fire′	6.3	5.0
`Snowdrift′	8.3	5.7

Taxa	BTI[z]	Days of Effective Bloom[y]
'Strawberry Parfait'	8.0	4.0
Sugar Tyme®	7.0	4.0
Velvet Pillar™	8.3	6.0
White Cascade™	7.7	5.6
× *zumi* 'Bob White'	6.7	4.3
× *zumi* var. *calocarpa*	8.0	5.0
× *zumi* 'Winter Gem' ('Glen Mills')	7.0	4.0
LATE SEASON		
'Adirondack'	9.0	5.3
Camelot®	8.7	5.0
'Doubloons'	9.0	6.0
Golden Raindrops®	10.0	5.0
Harvest Gold®	9.0	6.0
'Prairie Maid'	9.0	5.0
'Silver Moon'	10.0	6.0

[z]Blossom Time Index - number of days to first flower after the first crabapple blooms ('Pink Spires' = 0.0).
[y]Days from first open flower to 50% petal drop.
[x]All values are means of three different trees randomized.

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