

1999 *Iowa Turfgrass Research Report*



IOWA STATE UNIVERSITY
University Extension
Ames, Iowa



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

FG-466/July 1999

In Cooperation with the
Iowa Turfgrass Institute

Field Day Program - July 29, 1999

9:00 a.m. Introductory Remarks - Registration Tent

9:30 a.m. CHOICE OF FOUR TOURS

All tours start from registration area. See following two pages for specific topics, speakers, times, and locations.

Tour #1 Lawn Care & Grounds -- Kentucky bluegrass traffic studies, prairie plants, seed establishment, shade study, crabgrass and corn gluten meal weed control, disease control, mower maintenance.

Tour #2 Golf Course -- Bentgrass varieties, crabgrass and corn gluten meal weed control, sloped green study, disease control, plant growth regulators, seed establishment, mower maintenance.

Tour #3 Sports Turf -- SportGrass and Enkamat, tarp color demonstration, Kentucky bluegrass traffic studies, bermudagrass/ryegrass, crabgrass control, disease control, mower maintenance, seed establishment.

Tour #4 Landscape -- Selection and care of landscape plants for Iowa.

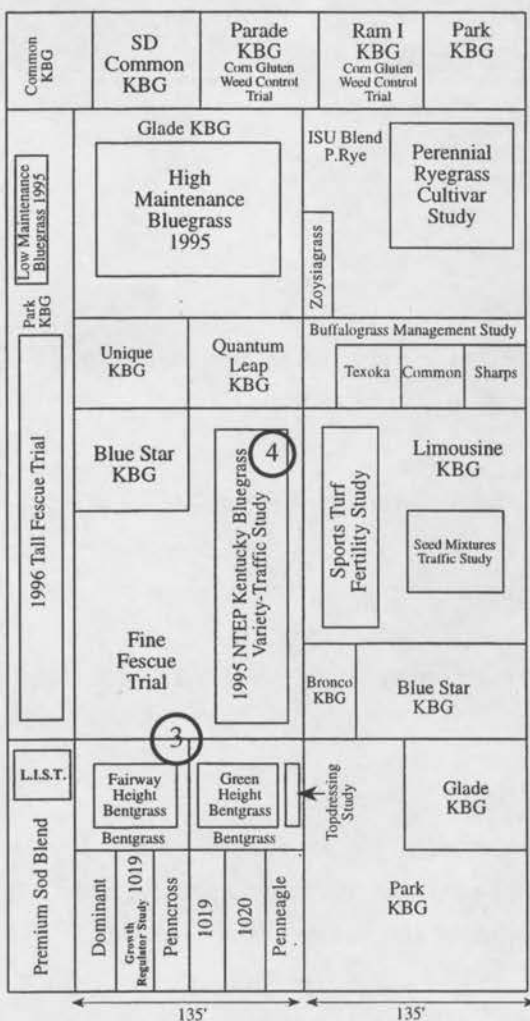
.....
11:30 a.m. Lunch (Served in Exhibit Area)
.....

1:00 p.m. Educational Sessions and Demonstrations

- ◆ **Pesticide Recertification Cont. Ed. Course (2 hours)** -- Main Building
- ◆ **Turf I.D. and Weed, Disease & Insect Control Tour** --
Dr. Dave Minner and Dr. Nick Christians
- ◆ **Vendors and Equipment** -- Exhibit Area

Wildflower
Native Grass
Establishment Study

Non-Irrigated
Buffalograss Test



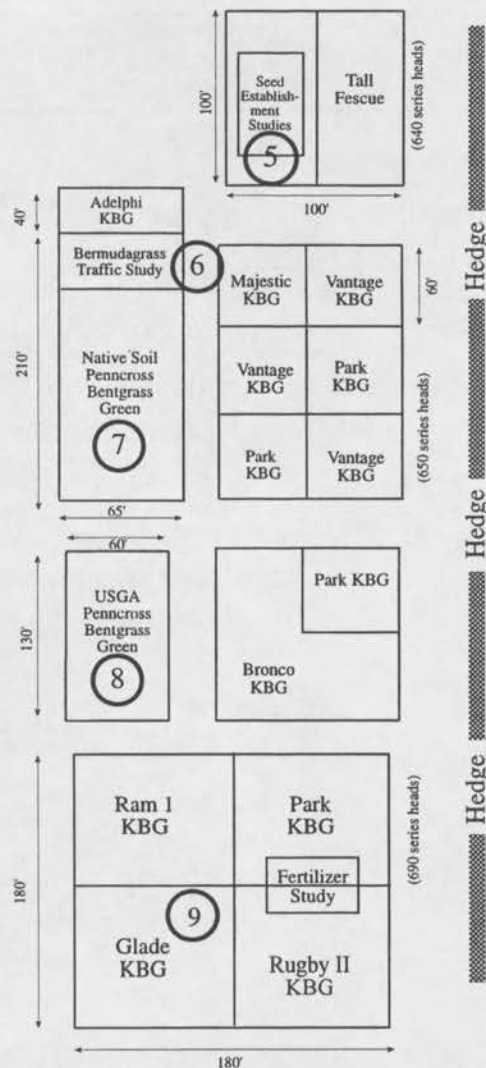
Prairie Plots
2

261,360 ft²
6.0 Acres

Weather
Station

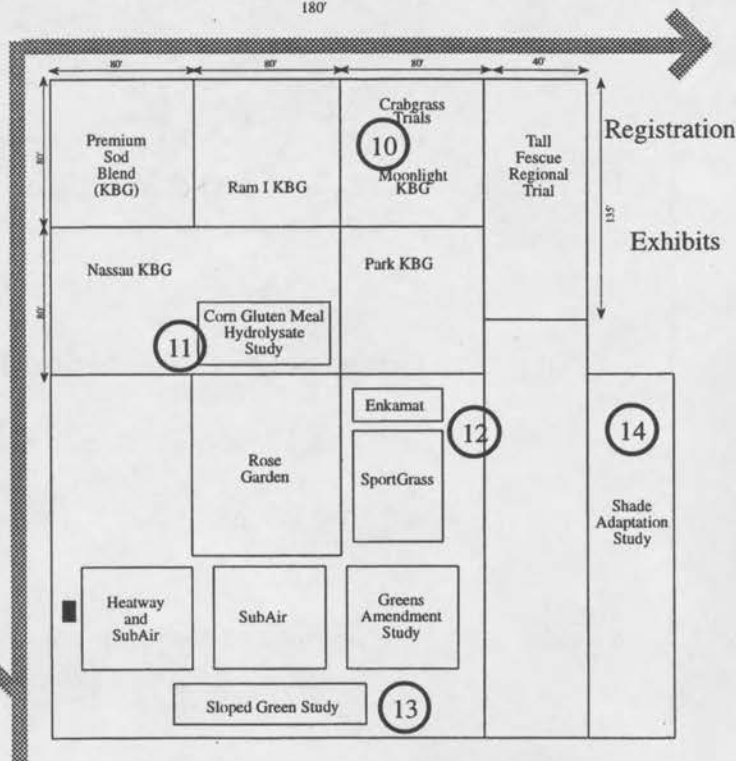
1
Turf
Building
Ornamental
Grasses

N



Hedge
Hedge
Hedge
Hedge

Parking



Registration

Exhibits

Time	Lawn Care/Grounds Tour	Golf Course Tour	Sports Turf Tour	Landscape Tour
9:30	#7 Disease control Mark Gleason	#13 Sloped green Deying Li	#10 Crabgrass control Barbara Bingham	Selection and care of landscape plants for Iowa.
9:45	#5 Seed establishment Young Joo	#11 CGM weed control Melissa McDade	#12 SportGrass and Enkamat Jay Hudson	
10:00	#4 Kentucky bluegrass-traffic Dave Minner	#10 Crabgrass control Barbara Bingham	#1 Mower maintenance Great American Outdoor	This is a riding wagon tour with Jeff Iles, Eldon Everhart, and Mike Bevins. Meet on the wagons by the registration tent at 9:30.
10:15	#2 Prairie plants Paul Stevens	#5 Seed establishment Nick Christians and Young Joo	#4 Kentucky bluegrass-traffic Dave Minner	
10:30	#1 Mower maintenance Great American Outdoor	#7 Disease control Mark Gleason	#5 Seed establishment Young Joo	
10:45	#10 Crabgrass control Barbara Bingham	#8 Plant growth regulators Mark Howieson	#6 Bermudagrass/ryegrass Dave Minner	
11:00	#11 CGM weed control Melissa McDade	#1 Mower maintenance Great American Outdoor	#7 Disease control Mark Gleason	
11:15	#14 Shade trial Gary Peterson	#3 Bentgrass varieties Nick Christians	#9 Response to tarp covers Paul Stevens	Jeff Iles, ISU Horticulture Eldon Everhart, ISU Extension Mike Bevins, State Horticulturist

Station	Speaker	Topic
1	Great American Outdoor	In-season mower maintenance.
2	Paul Stevens, ISU Horticulture	Prairie plant demonstration.
3	Nick Christians, ISU Horticulture	Fairway and putting green height bentgrass variety trials.
4	Dave Minner, ISU Horticulture	NTEP Kentucky bluegrass variety trial – traffic.
5	Young Joo, ISU Horticulture	Seed establishment study
6	Dave Minner, ISU Horticulture	Bermudagrass/ryegrass
7	Mark Gleason, ISU Plant Pathology	Disease control studies – pythium, dollar spot, and summer patch.
8	Mark Howieson, ISU Horticulture	Plant growth regulators
9	Paul Stevens, ISU Horticulture	Turf response to tarp covers
10	Barbara Bingham, ISU Horticulture	Pre- and postemergence control of crabgrass.
11	Melissa McDade, ISU Horticulture	Natural products for weed control
12	Jay Hudson, ISU Horticulture	Managing cool-season grasses as part of a SportGrass system. Stabilizing sand based athletic fields with Enkamat.
13	Deying Li, ISU Horticulture	Managing bentgrass stress on putting green slopes.
14	Gary Peterson, ISU Extension	Shade adaptation study.

Introduction

Nick E. Christians and David D. Minner

The following research report is the 20th 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 third year that the entire report is available on the Internet. It can be accessed at:

http://www.hort.iastate.edu/hort/pages/faculty/g_frame.html

Several new projects were started in the 1998 season. The fine fescue trial was replaced with a new trial that includes 79 species and cultivars. The fairway-height and green-height bentgrass studies were replaced with the newest cultivars from the National Turfgrass Evaluation Program (NTEP) in September. A new fairway height bluegrass study was also added for the first time. Other new research sites, including 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 were also completed in 1998.

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; Dr. Young Joo, visiting scientist; Jay Hudson, Deying Li, Mike Faust, Mark Howieson, Rod St. John, and Melissa McDade, graduate students; and all others employed at the field research area in the past year for their efforts in building the turf program. Jim Dickson left the manager position in 1998 and Rod St. John was hired into the position in 1999. We would like to thank Jim for his years of service to the 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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Weather data for the Iowa State University Horticulture Research Station January 1 to December 31, 1998.

January	Precipitation (inches)	High (F°)	Low (F°)
1		20	-1
2	0.09	45	19
3		54	33
4		51	20
5	0.31	33	23
6	0.06	35	32
7	0.01	35	30
8		33	28
9		36	27
10		32	8
11		20	6
12		18	7
13		19	0
14		14	-5
15		21	8
16	0.01	22	-1
17		24	15
18	0.01	26	-1
19		23	-2
20		23	12
21		27	11
22		30	23
23	0.16	34	26
24		31	8
25		31	19
26		38	16
27		36	12
28		37	23
29		40	24
30		38	18
31		32	15

February	Precipitation (inches)	High (F°)	Low (F°)
1	0.02	48	28
2	0.27	38	26
3	0.06	32	20
4		25	6
5		29	23
6		29	18
7		38	18
8		39	16
9		46	19
10		44	29
11	0.17	38	32
12		32	28
13		32	24
14	0.17	35	28
15	0.03	36	27
16		56	36
17	0.07	46	36
18	0.15	41	35
19	0.20	40	35
20	0.23	39	34
21	0.02	43	34
22		42	35
23		49	38
24	0.03	57	41
25		60	33
26	0.03	58	44
27		56	41
28		41	30

March	Precipitation (inches)	High (F°)	Low (F°)
1	0.03	32	27
2	0.07	33	27
3	0.04	41	24
4		32	24
5		36	21
6	0.01	35	30
7	0.01	40	21
8	0.01	36	29
9	0.02	34	27
10		27	6
11		16	-1
12		13	-1
13		16	-9
14	0.03	28	12
15		29	12
16		35	23
17		48	30
18	0.18	41	38
19	0.36	41	39
20		40	38
21		45	35
22		50	33
23		47	32
24		43	29
25	0.11	43	22
26	0.13	65	39
27		76	49
28	0.16	69	53
29	0.01	59	50
30		80	50
31	1.01	69	47

June	Precipitation (inches)	High (F°)	Low (F°)
1	0.05	74	58
2		75	58
3	0.37	55	45
4	0.16	64	52
5		68	52
6	0.15	70	58
7	0.08	70	46
8	1.55	65	58
9	0.03	67	58
10	0.65	76	55
11	0.84	76	66
12		80	61
13	0.41	83	60
14	2.43	68	64
15	0.23	76	64
16		81	62
17	0.46	81	62
18	2.55	78	66
19		88	62
20	1.08	89	70
21		84	65
22		84	62
23	0.71	84	64
24		90	66
25		94	78
26		95	76
27	0.31	96	72
28		89	69
29	0.83	88	64
30		82	66

May	Precipitation (inches)	High (F°)	Low (F°)
1	0.03	67	52
2		79	49
3	0.14	63	47
4		76	54
5		81	47
6		80	53
7	0.12	71	54
8	0.04	70	57
9		71	54
10		78	52
11		79	49
12		80	53
13	0.24	77	59
14		81	47
15		88	65
16	0.28	84	63
17		84	59
18		89	61
19	0.03	92	70
20	0.09	94	70
21	0.32	79	65
22	0.04	79	64
23	0.63	70	61
24	0.67	69	57
25		75	54
26		71	60
27		79	58
28		84	63
29		84	66
30	0.32	87	65
31	0.84	85	68

April	Precipitation (inches)	High (F°)	Low (F°)
1	0.12	52	42
2	0.02	42	37
3		48	39
4		47	36
5		59	33
6		60	36
7	0.25	68	48
8	0.17	59	52
9	0.39	52	44
10	0.01	58	41
11		64	34
12		74	45
13		72	54
14	0.02	66	53
15	0.02	67	45
16	0.37	56	45
17	0.01	54	38
18		62	35
19		66	42
20	0.10	66	45
21	0.66	55	45
22		65	41
23		71	38
24		75	40
25		79	45
26	0.03	73	57
27	0.06	62	50
28		63	40
29		66	39
30	0.12	58	49

September	Precipitation (inches)	High (F°)	Low (F°)
1		82	54
2		78	50
3		86	62
4		85	58
5		88	58
6		92	65
7		76	53
8		72	48
9		74	45
10		64	63
11		90	54
12		93	52
13		89	61
14	0.09	78	65
15		84	62
16		79	57
17		85	57
18		86	59
19		90	64
20	0.27	81	60
21		65	50
22		68	43
23	0.25	72	38
24		79	57
25		87	61
26	0.18	89	70
27		82	60
28		82	54
29		87	63
30		79	46

August	Precipitation (inches)	High (F°)	Low (F°)
1		81	53
2		80	57
3	0.05	73	62
4	0.03	84	65
5	0.03	82	67
6	0.24	77	66
7	0.04	70	65
8	0.01	80	65
9		85	62
10		91	67
11		84	65
12		88	62
13		82	64
14		82	66
15	0.57	87	63
16	0.01	86	64
17		88	67
18	0.10	87	72
19		87	69
20		89	69
21	0.23	93	71
22	0.11	82	71
23		90	71
24		92	75
25		88	70
26		84	63
27		83	59
28	1.04	77	68
29	0.03	86	66
30		90	62
31		87	59

July	Precipitation (inches)	High (F°)	Low (F°)
1		85	65
2		88	66
3	0.18	86	72
4		86	68
5	0.12	73	66
6	0.34	92	73
7		90	71
8		90	70
9		91	72
10		91	72
11		86	70
12		87	67
13		90	69
14	0.02	88	74
15	0.21	87	66
16		86	64
17	1.11	82	65
18		82	61
19		88	67
20		91	70
21	0.01	95	74
22	0.16	85	71
23		83	66
24		78	58
25		82	63
26		77	64
27		82	59
28		86	62
29		89	59
30		81	58
31		79	60

December	Precipitation (inches)	High (F°)	Low (F°)
1		65	33
2		59	47
3		32	42
4	0.02	69	44
5		64	38
6		39	26
7		43	18
8		50	22
9		50	26
10		46	20
11		50	29
12		53	24
13		52	24
14		56	23
15		50	29
16		43	30
17		41	19
18		44	28
19		28	13
20		20	8
21		11	2
22		15	-3
23		22	6
24		28	5
25		33	15
26		25	6
27		38	15
28		39	14
29		39	0
30		6	-9
31		10	-14

November	Precipitation (inches)	High (F°)	Low (F°)
1		53	43
2		48	38
3		43	29
4		44	29
5		38	30
6		41	25
7		35	23
8	0.14	37	32
9	0.15	45	36
10	0.38	57	33
11		49	30
12		44	28
13		54	26
14		57	33
15		47	32
16		49	35
17		51	35
18		56	33
19		42	26
20		40	21
21		55	21
22		62	42
23		58	30
24		57	27
25		59	37
26		67	30
27		68	31
28		58	37
29	0.05	70	55
30		57	35

October	Precipitation (inches)	High (F°)	Low (F°)
1		65	35
2	0.47	50	45
3	0.40	51	45
4	0.75	56	50
5	0.03	66	54
6		56	46
7		62	38
8		65	33
9		67	41
10		72	45
11	0.03	71	48
12		63	40
13		61	36
14	0.06	56	37
15		72	50
16	0.04	74	61
17	0.71	70	47
18		61	42
19		63	37
20	0.04	50	33
21		60	33
22		63	29
23		66	40
24	0.03	67	45
25	0.01	71	52
26	0.09	75	45
27	0.68	70	55
28	0.14	65	46
29		73	54
30		56	43
31		50	44

Results of Regional Kentucky Bluegrass Cultivar Trials

Nick E. Christians, David D. Minner, 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. Three trials were underway at Iowa State University during the 1998 season. The first, a high-maintenance study, was established in 1995, and received 4 lb N/1000 ft²/yr, and is irrigated as needed. The second trial was established in 1995 and received 4 lb N/1000 ft²/yr, is irrigated as needed and receives 'traffic'. They are mowed at two inches. The third trial was established in the fall of 1995 and was a low-maintenance study that received 1 lb of N/1000 ft²/yr in September and is non-irrigated. The objective of the high-maintenance, irrigated study was to investigate cultivar performance under a cultural regime similar to that used on irrigated home lawns in Iowa. The objective of the second study was to observe cultivar response under conditions similar to those found in irrigated lawns and sports fields that receive substantial traffic wear. The objective of the third study was to evaluate cultivars under conditions similar to those maintained in a park or school ground.

The values listed under each month in Tables 1 and 2 are the averages of visual quality ratings made on three replicated plots for the three studies. Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = worst 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 1998 season. The cultivars are listed in descending order of average quality.

Data for genetic color (Gcol), spring greenup (Grn), and leaf texture (Leaf) also are included for the high-maintenance, irrigated and for the low-maintenance trials. Genetic color was rated using a 9 to 1 scale with 9 = dark and 1 = light green. Spring greenup was estimated using a 9 to 1 scale with 9 = green and 1 = dormant turf. Leaf texture was assessed with a 9 to 1 scale with 9 = fine and 1 = coarse texture.

Data for the high-maintenance, irrigated traffic study are included in Table 3. The cultivars are listed in descending order according to wear tolerance ratings for the 1998 season. Tolerance was assessed using a 9 to 1 scale with 9 = best and 1 = worst tolerance. The first cultivar listed was the most wear tolerant cultivar. The percentage of fall ground cover (Fcov) data also are included in Table 3.

Table 1. 1998 visual quality¹ and other ratings² for the high-maintenance, irrigated Kentucky bluegrass trial.

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
1	Award	7.3	5.3	6.7	6.3	7.3	7.7	7.7	8.0	8.0	7.5
2	Liberator (ZPS-2572)	6.0	5.0	7.0	6.3	7.7	7.7	7.3	8.0	8.0	7.5
3	BAR VB 3115B	6.0	4.7	7.3	7.0	8.0	6.3	7.3	7.7	8.0	7.4
4	PST-BO-141	7.7	5.3	6.3	6.7	7.7	6.7	7.0	7.7	8.0	7.3
5	Blacksburg	6.3	5.3	7.7	6.7	7.3	7.3	7.7	6.7	7.3	7.2
6	Haga	6.7	6.0	6.3	7.0	8.0	6.0	6.7	7.7	7.7	7.2
7	LKB-95	5.0	6.0	7.3	7.0	7.7	7.0	7.3	7.0	7.3	7.2
8	PST-B2-42	7.3	6.0	7.0	6.7	7.7	7.0	6.7	7.3	8.0	7.2
9	Quantum Leap (J-1567)	7.0	5.0	6.7	6.3	7.3	7.0	7.0	8.0	7.3	7.2
10	Absolute (MED-1497)	7.0	5.0	6.0	6.3	7.7	7.0	7.0	7.0	7.7	7.1
11	BA 81-058	6.3	6.0	6.0	6.7	6.3	7.0	6.7	7.7	8.0	7.1
12	Coventry	7.3	5.7	5.3	6.3	6.7	7.0	7.3	7.3	7.7	7.1
13	H86-690	7.7	7.0	7.3	7.3	8.0	6.7	7.3	6.7	6.7	7.1
14	Impact (J-1576)	6.7	5.3	7.0	6.3	6.7	7.3	7.0	7.3	7.7	7.1
15	Midnight	6.7	5.0	6.7	5.7	7.3	7.3	7.0	7.7	7.7	7.1
16	NJ 1190	6.0	7.0	7.3	6.3	6.7	7.0	7.0	7.7	7.7	7.1
17	Total Eclipse (TCR-1738)	7.3	5.3	6.7	6.3	6.3	7.0	7.3	7.7	7.7	7.1
18	Unique	6.7	5.3	6.7	6.0	7.7	6.3	7.3	7.3	7.7	7.1
19	Abbey	7.0	6.0	6.7	7.0	6.7	7.3	7.0	6.7	7.3	7.0
20	BA 73-373	7.0	6.0	6.3	6.3	7.7	7.0	7.0	7.0	7.0	7.0
21	BA 81-270	6.7	5.0	6.0	6.7	6.7	6.7	7.0	7.7	7.3	7.0
22	Baron	6.7	6.3	6.3	6.7	7.3	7.0	7.0	6.7	7.3	7.0
23	NJ-GD	7.0	6.7	6.3	6.7	6.3	7.0	7.0	7.3	7.7	7.0
24	Serene (PST-A7-245A)	6.7	5.0	6.0	6.3	6.7	6.7	7.7	7.0	7.7	7.0

	Cultivar	Geol	Grn	Leaf	Turf quality						
					May	June	July	Aug	Sept	Oct	Mean
25	Shamrock	6.7	6.7	6.7	6.3	6.7	6.3	8.0	6.7	8.0	7.0
26	ZPS-2183	6.7	6.3	6.7	6.7	7.0	6.3	7.7	7.0	7.3	7.0
27	Bartitia	6.7	4.3	6.7	6.3	6.7	6.7	7.7	6.7	7.7	6.9
28	Caliber	6.3	6.3	6.3	7.0	7.0	6.7	6.7	6.7	7.3	6.9
29	Challenger	6.7	5.3	7.0	6.3	6.7	6.7	6.7	7.3	7.7	6.9
30	Classic	7.0	6.3	6.3	6.3	7.7	6.0	6.3	7.3	7.7	6.9
33	Odyssey (J-1561)	7.3	5.7	6.7	6.3	7.0	7.0	6.7	7.0	7.3	6.9
32	America	7.7	5.3	7.3	6.7	6.7	6.3	6.3	7.3	7.3	6.8
33	Arcadia (J-1936)	7.3	5.0	6.0	6.3	6.7	6.7	6.7	7.3	7.3	6.8
34	Baronie	6.3	6.3	6.3	6.3	7.7	6.3	5.7	7.3	7.7	6.8
35	Nuglade	7.3	4.7	6.7	6.3	6.0	6.7	7.3	6.7	7.7	6.8
36	Pick 8	7.0	6.0	6.3	6.3	7.0	6.0	6.7	7.3	7.7	6.8
37	PST-BO-165	6.7	5.7	5.7	6.3	7.0	6.3	6.7	6.7	7.7	6.8
38	Seabring (BA 79-260)	7.0	5.7	6.7	6.3	6.7	6.7	6.7	7.0	7.7	6.8
39	Wildwood	7.0	5.3	7.0	6.7	7.0	6.7	6.3	6.7	7.3	6.8
40	Allure	6.7	5.7	5.3	6.3	6.7	6.7	7.7	6.3	6.7	6.7
41	Ascot	6.7	6.0	6.0	6.7	7.0	6.3	6.7	6.7	7.0	6.7
42	Bluechip (MED-1991)	7.3	6.0	6.3	7.0	6.3	6.7	7.3	6.0	6.7	6.7
43	Chateau	6.3	5.3	5.7	6.7	6.3	6.3	6.7	7.0	7.0	6.7
44	Explorer (Pick 3561)	6.0	5.7	6.7	6.0	6.3	6.7	6.3	7.0	7.7	6.7
45	Goldrush (BA 87-102)	6.7	5.3	6.3	6.3	7.0	6.7	6.3	6.7	7.0	6.7
46	Jefferson	7.3	6.3	7.0	6.7	7.0	6.3	6.7	6.7	7.0	6.7
47	Marquis	7.0	5.7	6.0	6.7	6.3	6.7	6.7	6.3	7.3	6.7
48	North Star (PST-A7-60)	6.3	5.0	6.7	6.7	6.7	6.7	6.3	6.7	7.3	6.7
49	Nustar	6.3	5.7	7.0	7.0	7.0	7.0	6.3	6.3	6.7	6.7
50	Rambo (J-2579)	6.7	5.7	7.7	7.0	6.0	7.0	6.7	6.3	7.3	6.7
51	Rugby II (MED-18)	6.7	5.0	6.3	6.3	6.3	7.0	6.3	7.3	7.0	6.7
52	Sodnet	7.0	6.0	6.3	6.0	6.7	7.0	6.3	7.0	7.3	6.7
53	A88-744	7.7	7.3	6.0	7.0	6.3	6.0	6.7	6.7	6.7	6.6
54	BA 75-490	6.7	7.3	6.0	6.3	6.0	6.7	6.7	6.7	7.0	6.6
55	BA 81-227	6.7	5.3	5.7	6.7	6.0	6.7	7.3	6.0	7.0	6.6
56	Blackstone (PST-638)	8.0	7.0	6.0	6.3	6.3	6.7	7.3	6.0	6.7	6.6
57	Cardiff	6.7	6.0	6.3	6.0	6.7	6.7	6.3	6.7	7.0	6.6
58	J-1555	6.7	5.7	6.7	6.3	6.0	6.7	6.3	7.0	7.0	6.6
59	Livingston	6.3	6.3	6.7	6.3	6.3	6.3	6.7	6.3	7.3	6.6
60	MED-1580	7.0	5.7	6.3	6.7	7.0	6.3	6.3	6.3	6.7	6.6
61	Nimbus	5.7	5.3	7.3	6.7	7.0	6.7	6.3	6.0	6.7	6.6
62	NJ-54	6.3	5.0	6.3	6.3	6.3	7.0	6.7	6.0	7.0	6.6
63	Raven	7.3	6.0	6.7	6.7	7.0	6.0	7.0	6.3	6.7	6.6
64	SR 2000	7.3	6.3	6.0	6.3	5.3	6.7	7.0	6.7	7.7	6.6
65	SR 2109	6.7	5.7	6.3	6.3	5.3	6.7	6.7	7.0	7.3	6.6
66	SRX 2205	6.7	5.3	8.0	6.7	6.7	6.7	6.3	6.3	6.7	6.6
67	BA 76-197	6.3	6.0	7.0	6.3	6.7	6.3	6.7	6.0	7.0	6.5
68	BA 81-113	7.0	6.3	6.7	6.3	7.0	6.7	6.7	6.0	6.3	6.5
69	Conni	6.0	4.3	7.3	6.3	6.0	6.3	6.7	6.3	7.3	6.5
70	Dragon (ZPS-429)	6.7	7.0	6.3	6.7	6.7	6.3	7.0	6.0	6.3	6.5
71	Limousine	6.7	5.7	7.0	6.3	7.7	6.0	6.0	6.3	6.7	6.5
72	SR 2100	7.7	6.0	5.3	6.7	6.3	5.3	7.0	6.3	7.3	6.5
73	ASP200 (HV 130)	6.7	5.3	6.0	6.7	6.7	6.3	5.7	6.7	6.7	6.4
74	BA 70-060	6.7	5.7	6.0	6.0	6.7	6.0	6.7	6.7	6.7	6.4
75	Chicago (J-2582)	6.3	5.7	6.3	7.0	6.3	6.0	5.7	6.7	6.7	6.4
76	Glade	7.0	5.3	6.7	6.3	6.3	6.7	6.0	6.3	6.7	6.4
77	Lipoa	7.3	4.7	8.0	6.7	6.3	6.0	6.0	6.3	7.0	6.4
78	Princeton 105	6.7	5.0	6.7	6.3	6.3	6.0	6.7	6.3	7.0	6.4
79	PST-P46	7.3	5.3	7.0	6.7	6.0	6.7	6.3	6.0	7.0	6.4
80	Apollo (PST-B3-180)	6.7	5.0	7.0	6.0	5.7	6.0	6.3	7.0	6.7	6.3
81	BA 81-220	6.3	6.0	6.3	7.0	7.0	6.3	6.0	6.0	5.7	6.3
82	Champagne (LTP-621)	6.7	6.7	6.0	6.0	6.0	6.0	6.0	6.7	7.0	6.3
83	Eclipse	6.3	6.0	6.3	6.0	6.0	6.0	6.3	6.7	6.7	6.3
84	Kenblue	6.3	7.3	7.7	6.7	7.3	5.7	5.7	5.7	6.7	6.3
85	Pick-855	7.0	6.0	6.3	6.3	6.3	6.3	6.0	6.3	6.7	6.3
86	Sidekick	7.0	6.3	6.0	6.3	5.7	6.0	6.3	6.7	6.7	6.3

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
87	VB 16015	8.0	7.3	6.7	5.7	6.0	6.3	6.3	6.3	7.0	6.3
88	ZPS-309	6.3	6.3	6.7	6.7	6.7	5.7	6.7	5.7	6.3	6.3
89	BA 75-163	7.7	6.3	5.3	6.0	5.7	6.3	6.3	6.3	6.7	6.2
90	BA 75-173	7.0	6.0	6.3	6.3	6.3	6.0	6.0	6.0	6.3	6.2
91	BAR VB 5649	6.3	6.3	6.7	5.7	6.7	6.7	5.7	7.0	5.7	6.2
92	Baruzo	6.7	6.3	7.7	6.7	7.0	5.3	6.0	6.0	6.3	6.2
93	Misty (BA 76-372)	7.3	5.0	5.3	6.3	6.0	5.3	5.7	6.7	7.0	6.2
94	Pepaya (DP 37-192)	6.3	5.0	6.3	6.3	6.0	6.7	5.7	6.3	6.3	6.2
95	Moonlight (PST-A418)	8.0	5.0	5.7	6.0	5.0	6.0	6.0	6.3	7.0	6.1
96	BA 77-702	7.0	5.7	5.7	6.0	6.0	5.7	6.0	6.0	6.3	6.0
97	Fortuna	6.7	6.0	7.0	6.7	6.0	5.7	6.3	5.7	5.7	6.0
98	LTP-620	7.0	6.3	5.7	6.3	5.7	5.7	5.7	6.3	6.3	6.0
99	Compact	6.0	5.3	5.7	6.7	6.0	5.7	5.7	5.3	6.3	5.9
100	Platini	6.7	6.0	6.7	6.7	6.7	5.7	6.0	5.3	5.3	5.9
101	BAR VB 6820	7.0	5.7	7.3	6.7	6.7	5.3	4.7	5.3	5.7	5.7
102	BAR VB 233	6.0	6.0	7.0	7.0	7.7	4.7	4.7	5.0	4.7	5.6
103	HV 242	6.7	7.0	7.0	5.7	5.7	5.7	4.7	5.3	5.7	5.4
	LSD _{0.05}	1.7	1.0	1.4	NS	2.0	1.2	1.6	1.5	1.5	1.0

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

²Genetic color (Gcol) was rated using a 9 to 1 scale: 9 = dark and 1 = light green. Spring greenup (Grn) was determined using a 9 to 1 scale: 9 = green and 1 = dormant. Leaf texture (Leaf) was assessed with a 9 to 1 scale: 9 = fine and 1 = coarse texture.

NS = means are not significantly different at the 0.05 level

Table 2. 1998 visual quality¹ and other ratings² for the 1995 low-maintenance, non-irrigated Kentucky bluegrass trial.

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
1	BAR VB 3115B	7.0	6.0	6.3	7.0	7.0	6.3	6.0	4.7	6.3	6.2
2	Caliber	6.0	5.7	6.0	6.3	6.0	5.7	6.0	5.7	6.3	6.0
3	Bartitia	6.0	4.7	6.0	6.0	6.0	6.3	5.7	5.3	5.7	5.8
4	Eagleton	7.3	5.3	5.7	5.0	6.3	6.7	6.0	4.3	6.7	5.8
5	Canterbury	6.0	6.0	6.3	6.7	6.3	5.7	5.7	4.7	5.3	5.7
6	South Dakota	5.7	7.7	6.0	5.0	6.0	5.7	5.7	6.0	6.0	5.7
7	Kenblue	6.0	6.3	6.3	4.7	5.7	6.0	5.7	5.0	6.7	5.6
8	BAR VB 233	5.0	4.7	5.7	6.7	6.0	4.7	5.0	4.3	5.3	5.3
9	BAR VB 5649	5.3	4.3	6.0	5.7	6.0	5.3	5.7	4.0	5.3	5.3
10	Baron	6.0	4.0	6.0	5.0	5.3	6.0	5.0	3.3	6.3	5.2
11	Baronie	4.7	5.3	6.7	6.3	6.3	5.3	5.0	3.7	4.7	5.2
12	BH 95-199	5.3	6.0	6.0	5.7	4.7	5.7	4.7	4.7	5.7	5.2
13	Blue Star	5.0	5.3	6.0	5.0	5.7	5.0	5.0	4.3	5.3	5.1
14	North Star (PST-A7-60)	5.7	3.7	6.0	5.0	5.0	5.3	5.7	4.0	5.3	5.1
15	MTT 683	5.3	3.7	6.3	5.3	5.3	5.3	5.3	4.0	4.7	5.0
16	Baruzo	5.0	5.3	6.0	5.3	5.3	5.3	4.7	3.7	4.7	4.8
17	Dragon (ZPS-429)	5.3	5.3	6.0	5.0	5.3	4.7	4.7	3.3	6.0	4.8
18	VB 16015	6.0	7.0	5.7	5.3	5.0	4.3	4.7	4.0	5.3	4.8
19	PST-B9-196	5.0	6.0	4.7	5.3	5.3	4.7	4.0	3.7	4.7	4.6
20	Lipoa	4.3	5.3	5.7	4.7	5.0	4.7	3.7	4.0	5.0	4.5
21	BAR VB 6820	5.7	4.0	6.3	3.7	4.3	4.3	4.0	3.3	4.0	3.9
	LSD _{0.05}	2.1	1.1	1.2	1.0	0.9	1.4	1.9	2.8	2.7	1.0

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

²Genetic color (Gcol) was rated using a 9 to 1 scale: 9 = dark and 1 = light green.

Spring greenup (Grn) was determined using a 9 to 1 scale: 9 = green and 1 = dormant. Leaf texture (Leaf) was assessed with a 9 to 1 scale: 9 = fine and 1 = coarse texture.

NS = means are not significantly different at the 0.05 level

Table 3. 1998 fall ground cover¹ and wear tolerance ratings² for the 1995 high-maintenance, irrigated traffic regional Kentucky bluegrass test.

	Cultivar	Fall ground cover (%)	Wear tolerance
1	ZPS-309	18.3	8.3
2	Pepaya (DP 37-192)	20.0	7.7
3	BAR VB 5649	43.3	6.3
4	HV 242	38.3	6.3
5	Platini	40.0	6.3
6	Absolute (MED-1497)	40.0	6.0
7	BAR VB 233	38.3	6.0
8	Dragon (ZPS-429)	38.3	6.0
9	SR 2100	50.0	6.0
10	ZPS-2183	43.3	6.0
11	BA 75-163	45.0	5.7
12	Baruzo	56.7	5.7
13	H86-690	50.0	5.7
14	Liberator (ZPS-2572)	61.7	5.7
15	Lipoa	41.7	5.7
16	SR 2000	48.3	5.7
17	SRX 2205	45.0	5.7
18	BA 81-113	45.0	5.3
19	BAR VB 6820	53.3	5.3
20	Bartitia	56.7	5.3
21	Blacksburg	43.3	5.3
22	Haga	51.7	5.3
23	Impact (J-1576)	50.0	5.3
24	J-1555	60.0	5.3
25	Livingston	45.0	5.3
26	MED-1580	56.7	5.3
27	A88-744	55.0	5.0
28	Abbey	56.7	5.0
29	BA 73-373	55.0	5.0
30	BA 76-197	56.7	5.0
31	BA 81-058	50.0	5.0
32	Challenger	56.7	5.0
33	Compact	56.7	5.0
34	Eclipse	56.7	5.0
35	Explorer (Pick-3561)	58.3	5.0
36	Jefferson	50.0	5.0
37	Moonlight (PST-A418)	61.7	5.0
38	NJ-54	55.0	5.0
39	NJ-GD	50.0	5.0
40	Nuglade	60.0	5.0
41	Nustar	55.0	5.0
42	Pick-855	55.0	5.0
43	PST-BO-165	51.7	5.0
44	PST-P46	51.7	5.0
45	Quantum Leap (J-1567)	55.0	5.0
46	Sodnet	60.0	5.0
47	VB 16015	66.7	5.0
48	Apollo (PST-B3-180)	65.0	4.7
49	Arcadia (J-1936)	60.0	4.7
50	Ascot	53.3	4.7
51	ASP200 (HV 130)	56.7	4.7
52	BA 81-220	58.3	4.7
53	Baronie	53.3	4.7
54	Blackstone (PST-638)	56.7	4.7
55	Caliber	56.7	4.7
56	Conni	60.0	4.7
57	Fortuna	63.3	4.7
58	Goldrush (BA 87-102)	56.7	4.7
59	Marquis	53.3	4.7
60	Pick 8	60.0	4.7

	Cultivar	Fall ground cover (%)	Wear tolerance
61	Seabring (BA 79-260)	60.0	4.7
62	Baron	55.0	4.3
63	Midnight	56.7	4.3
64	Misty (BA 76-372)	58.3	4.3
65	North Star (PST-A7-60)	61.7	4.3
66	Odyssey (J-1561)	58.3	4.3
67	PST-B2-42	70.0	4.3
68	PST-BO-141	58.3	4.3
69	Shamrock	61.7	4.3
70	SR 2109	58.3	4.3
71	Total Eclipse (TCR-1738)	68.3	4.3
72	Wildwood	58.3	4.3
73	Allure	58.3	4.0
74	America	68.3	4.0
75	BA 77-702	66.7	4.0
76	BA 81-227	63.3	4.0
77	Cardiff	56.7	4.0
78	Champagne (LTP-621)	66.7	4.0
79	Classic	66.7	4.0
80	Glade	66.7	4.0
81	Kenblue	66.7	4.0
82	LTP-620	68.3	4.0
83	Rambo (J-2579)	70.0	4.0
84	Raven	61.7	4.0
85	Award	58.3	3.7
86	BA 70-060	68.3	3.7
87	BA 75-173	71.7	3.7
88	BA 75-490	68.3	3.7
89	Nimbus	70.0	3.7
90	NJ 1190	73.3	3.7
91	Rugby II (MED-18)	68.3	3.7
92	Unique	65.0	3.7
93	Bluechip (MED-1991)	66.7	3.3
94	Chicago (J-2582)	60.0	3.3
95	Limousine	66.7	3.3
96	LKB-95	73.3	3.3
97	Princeton 105	70.0	3.3
98	Sidekick	68.3	3.3
99	BA 81-270	68.3	3.0
100	BAR VB 3115B	76.7	3.0
101	Chateau	78.3	2.7
102	Coventry	75.0	2.7
103	Serene (PST-A7-245A)	76.7	2.3
	LSD _{0.05}	23.1	2.1

¹These values represent the percentage of area per plot covered by turf in the fall of 1998.

²Wear tolerance was assessed using a 9 to 1 scale: 9 = best and 1 = worst wear tolerance.

Regional Tall Fescue Cultivar Evaluation - Established 1996

Nick. E. Christians and James R. Dickson

This was the second year of data collection 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 ft²) plots were established for each cultivar in the spring of 1996. The trial is maintained at a 2-inch mowing height, 3.5 lbs N/1000 ft² were applied during the growing season, and the area was irrigated when needed to prevent drought. Preemergence herbicide was applied once in the spring.

Cultivars were evaluated for turf quality each month of the growing season. Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst 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 for genetic color (Gcol), spring greenup (Grn), and leaf texture (Leaf) also are included. Genetic color was rated using a 9 to 1 scale with 9 = dark and 1 = light green. Spring greenup was estimated using a 9 to 1 scale with 9 = green and 1 = dormant turf. Leaf texture was assessed with a 9 to 1 scale with 9 = fine and 1 = coarse texture.

Table 1. 1998 visual quality¹ and other ratings² for the tall fescue regional cultivar trial established in 1996.

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
1	Renegade	7.0	4.0	6.0	6.7	5.0	6.7	6.3	6.0	7.3	6.3
2	Titan 2	6.3	4.7	5.3	5.3	6.3	6.3	6.0	6.3	6.7	6.2
3	Arid	5.7	6.0	4.3	5.7	5.7	6.3	5.7	6.7	6.3	6.1
4	Plantation (Pennington 1901)	7.0	4.0	5.3	5.7	5.3	5.3	5.7	7.3	6.7	6.0
5	Kentucky-31 w/endo	6.0	6.0	4.0	5.7	6.0	6.3	6.3	5.7	5.3	5.9
6	MB 28	7.0	4.3	6.7	5.7	5.3	6.0	6.3	6.0	6.3	5.9
7	Pixie E+	7.0	5.3	6.0	6.0	6.0	5.7	6.3	5.7	5.7	5.9
8	ISI-TF11	6.3	4.3	5.3	5.3	5.3	5.7	6.3	6.3	6.0	5.8
9	MB 216	7.7	4.3	5.7	5.7	5.3	5.3	6.0	6.3	6.0	5.8
10	Millennium (TMI-RBR)	6.7	4.0	6.7	5.3	4.7	6.0	6.7	6.0	6.3	5.8
11	Regiment	7.0	5.7	6.3	5.7	5.0	5.7	6.3	6.0	6.0	5.8
12	Crossfire II	7.0	4.7	5.3	5.3	5.0	5.3	6.3	6.3	5.7	5.7
13	CU9501T	7.0	4.3	5.7	6.0	4.3	5.0	6.3	6.0	6.0	5.6
14	Duster	7.0	4.3	5.3	5.3	5.3	5.3	5.7	6.3	5.7	5.6
15	Finelawn Petite	7.0	4.0	5.7	5.0	4.7	5.0	6.3	6.3	6.0	5.6
16	Marksman	6.0	4.3	5.0	5.3	6.0	5.7	5.7	6.0	5.0	5.6
17	Shenandoah	6.3	4.3	6.3	5.7	5.3	6.0	5.3	6.0	5.3	5.6
18	Tulsa	5.7	4.0	6.0	5.3	5.0	5.7	5.0	6.7	6.0	5.6
19	WRS2	7.0	4.0	6.0	5.0	4.7	5.3	6.3	6.3	6.0	5.6
20	Aztec II (TMI-AZ)	7.0	4.0	6.3	5.0	4.7	5.7	6.0	6.0	5.7	5.5
21	Bonsai 2000 (Bullet)	7.3	4.3	5.7	5.7	4.7	4.7	6.0	6.0	6.0	5.5
22	Pick FA B-93	7.0	4.3	5.7	4.7	4.7	5.7	5.3	6.3	6.3	5.5
23	Rebel Sentry (AA-A91)	6.0	4.3	6.3	5.0	5.0	5.7	5.3	5.7	6.3	5.5
24	Bandana (PST-R5AE)	6.7	5.0	6.7	5.3	5.0	5.3	5.7	6.0	5.0	5.4
25	J-101	7.0	4.0	7.0	5.0	4.0	5.0	5.7	6.3	6.3	5.4
26	Leprechaun	6.3	4.0	6.3	5.3	5.0	5.0	6.3	5.3	5.7	5.4
27	PST-523	6.3	4.7	6.3	5.3	5.0	5.0	6.0	6.0	5.0	5.4
28	Safari	6.0	5.3	5.7	5.7	4.7	5.3	5.3	5.7	5.7	5.4
29	WX3-275	5.7	4.7	6.7	5.3	5.0	5.0	6.3	5.7	5.3	5.4
30	ZPS-5LZ	7.0	4.0	6.3	5.3	5.0	5.3	5.7	5.7	5.3	5.4
31	Anthem II (TMI-FMN)	6.7	4.7	6.7	5.0	4.3	4.7	6.0	6.0	5.7	5.3
32	BAR FA6 US6F	7.0	4.0	5.7	5.0	4.3	5.3	5.3	5.7	6.0	5.3
33	Coronado	6.7	4.0	7.0	5.3	4.7	5.3	5.3	6.0	5.3	5.3

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
34	Coyote	6.7	4.7	6.3	4.7	4.7	5.3	5.0	6.7	5.7	5.3
35	DP 7952	6.0	5.7	5.0	5.0	4.7	5.3	5.7	5.3	5.7	5.3
36	Empress	6.3	4.0	5.7	4.7	4.3	5.0	6.0	6.0	5.7	5.3
37	Genesis	7.0	4.0	6.0	5.0	4.3	5.0	6.3	5.7	5.7	5.3
38	OFI-96-32	6.7	4.0	6.3	5.3	5.0	5.0	5.3	5.3	5.7	5.3
39	PRO 8430	6.3	4.7	6.0	5.3	4.7	5.0	5.3	5.7	6.0	5.3
40	PSII-TF-10	6.7	6.3	6.0	5.3	4.3	5.3	5.7	5.3	5.7	5.3
41	PSII-TF-9	6.3	4.7	5.0	5.0	4.7	5.0	5.7	5.0	6.3	5.3
42	PST-5M5	7.0	4.3	5.3	5.0	4.7	4.3	5.3	6.0	6.3	5.3
43	Rebel 2000 (AA-989)	7.0	4.0	5.3	5.3	4.3	5.0	6.0	5.7	5.3	5.3
44	Rembrandt (LTP-4026 E+)	7.0	3.7	5.7	5.0	4.3	5.3	5.0	6.3	5.7	5.3
45	Wolfpack (PST-R5TK)	6.7	5.0	5.7	5.0	4.7	5.0	5.7	5.7	5.7	5.3
46	WVPB-1D	6.7	5.0	6.0	4.7	4.7	5.3	5.7	5.7	5.7	5.3
47	ZPS-2PTF	7.0	4.0	6.0	5.3	4.3	5.0	6.0	5.7	5.7	5.3
48	Alamo E	6.7	4.0	6.0	5.3	4.7	5.0	5.0	6.0	5.3	5.2
49	ATF-038	6.0	4.0	5.3	4.7	4.0	5.3	5.3	5.7	6.0	5.2
50	Gazelle	6.0	4.7	6.7	4.7	5.0	5.0	5.3	6.0	5.3	5.2
51	JSC-1	6.7	4.3	6.3	5.0	4.3	5.0	6.0	5.3	5.7	5.2
52	MB 213	6.7	4.0	5.0	5.0	5.0	5.0	5.7	5.0	5.7	5.2
53	MB 29	6.7	4.0	5.0	5.3	5.0	5.3	5.0	5.0	5.3	5.2
54	R5AU	7.0	4.0	6.3	5.0	4.3	5.0	6.3	5.0	5.7	5.2
55	Southern Choice	6.7	4.0	7.0	5.3	4.7	5.0	5.7	5.0	5.7	5.2
56	SR 8210	6.0	4.0	6.0	5.0	4.7	4.7	5.3	5.7	5.7	5.2
57	SRX 8084	6.3	4.3	6.0	4.7	4.7	5.0	5.7	5.7	5.3	5.2
58	Tar Heel	7.0	4.3	6.3	4.3	4.0	5.3	6.3	5.7	5.7	5.2
59	Twilight II (TMI-TW)	7.0	4.0	6.0	4.7	4.3	5.7	5.7	5.7	5.0	5.2
60	ATF-253	7.0	4.3	6.7	4.7	4.3	5.3	5.0	5.7	5.7	5.1
61	Bravo (RG-93)	6.7	4.7	5.7	5.0	4.7	5.0	5.0	5.3	5.3	5.1
62	Falcon II	6.7	4.7	5.0	4.7	4.0	5.0	5.7	5.3	6.0	5.1
63	JTTFA-96	5.7	6.3	5.7	5.3	3.7	4.7	5.7	5.0	6.0	5.1
64	JTTFC-96	5.7	5.3	6.3	5.3	5.0	5.0	5.0	4.7	5.3	5.1
65	Kickoff (PST-5E5)	6.3	4.0	6.7	5.3	4.7	4.3	5.7	4.7	5.7	5.1
66	Masterpiece (LTP-SD-TF)	7.0	4.3	7.7	4.3	4.3	4.7	5.3	5.7	6.0	5.1
67	MB 212	7.0	4.7	6.3	5.0	4.7	5.0	5.0	5.3	5.7	5.1
68	MB 215	7.0	4.0	6.3	4.3	4.0	4.7	5.7	6.3	5.3	5.1
69	Mustang II	6.0	4.3	6.3	4.7	4.7	4.7	5.7	5.7	5.0	5.1
70	OFI-931	6.7	4.0	6.3	5.3	4.0	4.7	5.3	5.3	6.0	5.1
71	Shortstop II	6.0	4.0	7.0	5.0	4.3	5.0	5.3	5.3	5.3	5.1
72	WPEZE (WVPB-1C)	6.7	4.3	6.7	5.3	4.7	3.7	6.0	5.7	5.3	5.1
73	Apache II	6.3	4.0	5.7	4.7	4.7	5.0	5.3	4.7	5.7	5.0
74	ATF-022	6.3	4.7	5.3	5.0	4.3	4.3	5.3	5.3	5.7	5.0
75	BAR FA 6D	6.3	4.3	6.7	5.0	4.3	5.0	5.3	5.0	5.3	5.0
76	CU9502T	5.7	4.3	7.0	4.3	4.3	4.3	5.7	5.3	6.0	5.0
77	Jaguar 3	6.7	4.7	6.7	5.0	4.0	4.7	5.3	6.0	5.0	5.0
78	Lion	6.7	4.7	6.0	4.7	4.3	5.3	5.7	5.0	5.0	5.0
79	MB 214	7.3	4.0	6.7	5.0	4.3	5.3	5.0	5.0	5.3	5.0
80	WVPB-1B	6.3	4.3	6.3	5.0	5.0	5.0	5.0	5.0	5.0	5.0
81	ATF-188	6.3	4.0	6.0	4.7	3.7	4.3	5.7	5.3	5.7	4.9
82	ATF-192	6.0	4.0	5.0	4.3	4.3	4.3	4.7	6.0	6.0	4.9
83	ATF-196	6.3	4.3	7.3	4.3	4.7	4.3	5.0	5.3	5.7	4.9
84	AV-1	6.3	4.7	5.7	4.0	4.0	4.7	5.7	5.7	5.3	4.9
85	BAR FA 6LV	5.7	4.3	7.3	5.0	4.3	4.7	5.0	5.0	5.7	4.9
86	BAR FA6 US2U	6.7	4.3	7.0	4.7	3.7	4.7	6.0	5.3	5.3	4.9
87	BAR FA6D USA	6.7	4.3	6.7	4.7	4.3	5.0	5.3	5.3	5.0	4.9
88	Cochise II	6.7	4.0	6.0	4.7	4.0	4.7	5.3	5.7	5.0	4.9
89	DLF-1	6.0	5.0	6.0	5.0	4.7	4.7	5.3	5.3	4.7	4.9

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
90	EA 41	6.7	4.0	7.0	4.7	4.3	4.7	5.3	5.0	5.7	4.9
91	OFI-96-31	5.3	4.0	6.0	4.7	4.3	5.0	5.3	5.3	5.0	4.9
92	OFI-FWY	6.3	4.0	5.7	4.7	4.3	4.7	4.7	5.7	5.7	4.9
93	PC-AO	7.0	4.7	6.0	4.7	4.7	4.7	5.0	5.0	5.3	4.9
94	ATF-257	6.7	4.0	4.7	5.0	4.0	4.3	5.0	4.7	6.0	4.8
95	BAR FA6 US3	5.7	4.0	6.0	4.3	4.3	4.7	5.0	5.0	5.3	4.8
96	Coronado Gold (PST-5RT)	6.3	3.7	6.0	5.0	4.3	4.3	5.0	5.0	5.3	4.8
97	ISI-TF9	6.0	5.0	6.7	4.0	4.3	4.3	5.7	5.0	5.3	4.8
98	Kitty Hawk S.S.T. (SS45DW)	5.3	4.0	6.0	4.3	4.3	4.7	5.0	5.3	5.0	4.8
99	MB 26	6.0	3.7	6.7	4.3	4.0	5.0	4.7	5.3	5.3	4.8
100	Pick FA XK-95	7.0	4.3	5.3	4.3	3.7	4.3	5.7	5.7	5.3	4.8
101	SRX 8500	7.0	4.0	5.7	5.3	4.3	4.7	4.7	5.0	5.0	4.8
102	TA-7	6.7	4.7	5.3	5.0	4.3	4.3	5.0	5.7	4.7	4.8
103	Arid 3 (J-98)	6.0	4.0	5.7	4.7	4.0	4.7	5.0	4.7	5.0	4.7
104	Bonsai	6.0	4.7	5.3	5.3	4.3	4.0	5.3	4.3	5.0	4.7
105	Good-en (KOOS 96-14)	6.0	4.3	5.7	4.7	4.3	4.3	5.0	4.7	5.0	4.7
106	MB 210	6.3	4.3	6.3	5.0	4.0	4.7	4.7	4.7	5.0	4.7
107	OFI-951	6.3	4.3	6.3	4.3	3.7	4.7	5.0	5.0	5.3	4.7
108	Pick FA 15-92	6.7	4.3	6.3	4.3	3.7	4.3	5.0	5.0	5.7	4.7
109	Pick RT-95	6.0	4.0	6.7	5.0	3.3	3.7	5.7	5.3	5.3	4.7
110	Arabia (J-5)	7.0	4.3	5.7	5.0	3.7	4.3	4.7	4.7	5.0	4.6
111	ATF-020	5.7	4.0	5.3	4.0	4.0	4.7	4.7	5.0	5.3	4.6
112	Comstock (SSDE31)	6.3	4.7	6.0	3.7	4.3	4.3	5.0	5.0	5.0	4.6
113	PICK FA 20-92	6.7	4.0	6.0	4.0	3.7	4.0	5.7	5.3	5.0	4.6
114	Sunpro	6.3	4.3	6.0	4.0	4.0	4.0	5.0	5.3	5.0	4.6
115	Tomahawk-E	6.3	4.3	6.0	4.7	4.3	4.0	4.3	5.0	5.0	4.6
116	EC-101	5.7	4.0	5.3	4.7	4.0	4.7	4.3	4.7	4.7	4.5
117	ISI-TF10	7.0	4.7	5.7	4.7	3.3	4.3	4.7	5.0	5.0	4.5
118	Reserve (ATF-182)	6.0	4.7	6.7	4.3	4.3	4.0	5.0	4.7	4.7	4.5
119	BAR FA6 US1	6.3	4.0	6.3	4.7	3.7	4.0	5.0	5.0	4.3	4.4
120	Pick FA 6-91	5.0	4.0	5.3	4.3	4.7	4.3	4.3	4.3	4.7	4.4
121	Arid 2 (J-3)	6.7	4.3	5.7	4.3	3.7	4.3	4.3	4.7	4.7	4.3
122	DP 50-9011	5.0	4.7	6.0	4.0	4.0	3.7	4.3	5.0	5.0	4.3
123	Equinox (TMI-N91)	5.7	4.3	6.0	4.0	4.0	4.3	4.3	4.3	5.0	4.3
124	MB 211	6.3	4.3	6.0	4.3	3.3	4.0	4.7	4.7	4.7	4.3
125	Pick GA-96	6.7	4.3	6.0	4.0	4.0	4.3	4.0	5.0	4.7	4.3
126	Pick FA N-93	6.0	4.3	5.0	4.0	3.3	4.0	4.7	4.3	5.0	4.2
127	Pick FA UT-93	5.7	4.3	7.3	4.0	4.0	4.3	4.3	4.0	4.3	4.2
128	PST-5TO	6.7	4.0	6.0	3.7	3.3	4.3	4.3	4.7	5.0	4.2
129	AA-983	6.7	4.7	6.3	4.0	3.3	3.7	4.3	3.7	4.7	3.9
	LSD _{0.05}	1.7	1.1	2.6	2.0	1.9	2.2	2.3	2.4	NS	1.5

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

²Genetic color (Gcol) was rated using a 9 to 1 scale: 9 = dark and 1 = light green. Spring greenup (Grn) was determined using a 9 to 1 scale: 9 = green and 1 = dormant. Leaf texture (Leaf) was assessed with a 9 to 1 scale: 9 = fine and 1 = coarse texture.

NS = means are not significantly different at the 0.05 level

Regional Fine Fescue Cultivar Evaluation - 1993

Nick. E. Christians and James R. Dickson

This was the final year of data from the '93 fine fescue trial. This was a National Turfgrass Evaluation Program (NTEP) trial. It was conducted at many locations around the U.S. The purpose of the trial was to study the regional adaptation of 59 fineleaf fescue cultivars. Cultivars were evaluated for quality each month of the growing season through August. The study was conducted in full sun. Three replications of the 3 x 5 ft (15 ft²) plots were established for each cultivar in September of 1993. The trial was maintained at a 2-inch mowing height, fertilized with 3.5 lbs N/1000 ft² during the growing season, and irrigated when needed to prevent drought. Preemergence herbicide was applied once in the spring.

Visual quality was evaluated monthly in 1998 from May through August. Quality was assessed using a 9 to 1 with 9 = best, 6 = lowest acceptable, and 1 = worst quality. Genetic color was rated in August using a 9 to 1 scale with 9 = darkest and 1 = lightest green.

A new fine fescue trial was initiated in September 1998. Seventy-nine fineleaf fescue cultivars were established for evaluation. The study was arranged in full sun with three replications and individual plot size of 5 x 5 ft. Percentage fall living ground cover data were taken in October.

Table 1. The 1998 genetic color and visual quality ratings¹ for cultivars in the 1993 Fineleaf Fescue Cultivar Trial.

Cultivar	Species	Color	May	June	July	August	Mean
1 Rondo	STC	6.7	7.0	7.7	7.0	5.3	6.8
2 Jasper (E)	STC	4.3	6.3	6.7	7.0	5.3	6.3
3 PST-4VB Endo	STC	4.3	7.0	6.7	6.7	4.7	6.3
4 Shadow II (PST-44D)	CF	5.7	6.3	7.0	6.3	5.7	6.3
5 Jamestown II	CF	5.3	6.0	6.7	6.7	6.0	6.3
6 Tiffany	CF	5.0	6.3	6.7	6.7	5.0	6.2
7 Shademaster II	STC	4.7	7.0	6.3	6.0	5.0	6.1
8 Banner II	CF	4.7	6.3	6.3	5.7	6.0	6.1
9 Banner III (MB 61-93)	CF	4.7	6.3	6.3	6.0	5.7	6.1
10 Culumbra (MB 64-93)	CF	4.0	6.3	6.7	6.0	5.3	6.1
11 PST-4ST	STC	4.7	7.0	6.7	6.0	4.3	6.0
12 Victory (E)	CF	3.3	6.3	7.3	5.7	4.3	5.9
13 Treazure (ZPS-MG)	CF	4.0	6.7	6.7	5.7	4.7	5.9
14 BAR UR 204	STC	3.0	6.7	7.0	6.0	3.3	5.8
15 Victory II (Pick 4-91W)	CF	4.3	6.3	5.3	6.3	5.0	5.8
16 K-2 (MB 65-93)	CF	4.7	6.0	6.0	6.0	5.3	5.8
17 SR 5100	CF	4.7	6.3	5.7	6.0	5.0	5.8
18 Sandpiper (PRO 92/20)	CF	4.7	6.0	6.0	6.0	5.3	5.8
19 Flyer II (ZPS-4BN)	STC	4.3	6.0	6.3	6.3	4.3	5.8
20 NJ F-93	CF	4.3	5.7	6.3	5.3	5.3	5.7
21 Medina	CF	3.3	6.3	6.7	5.7	4.0	5.7
22 Bridgeport	CF	3.0	6.7	6.3	5.3	4.0	5.6
23 PST-4DT	STC	4.3	5.7	6.3	6.3	4.0	5.6
24 Shadow (E)	CF	5.0	6.0	6.0	5.7	4.7	5.6
25 CAS-FR13	STC	4.7	5.3	6.7	6.0	4.3	5.6
26 Aruba	STC	2.7	5.7	5.7	6.7	4.0	5.5
27 Eco (MB 63-93)	CF	3.3	6.0	6.3	5.7	4.0	5.5
28 Dawson	SLC	3.7	6.3	6.0	5.7	3.7	5.4
29 Darwin	CF	4.0	5.7	6.0	5.0	5.0	5.4
30 WX3-FFG6	STC	4.3	5.7	6.0	5.7	4.3	5.4
31 WX3-FF54	CF	3.3	6.0	6.0	5.7	4.0	5.4
32 Brittany	CF	3.7	6.3	5.3	6.0	4.0	5.4

	Cultivar	Species	Color	May	June	July	August	Mean
33	ISI-FC-62	CF	3.7	5.7	6.0	5.3	4.7	5.4
34	Flyer	STC	3.0	5.3	6.3	5.3	3.7	5.2
35	Jamestown	CF	3.3	6.0	5.7	5.3	3.7	5.2
36	Common creeping	STC	3.0	6.0	6.0	5.3	3.3	5.2
37	Discovery	HF	3.0	7.7	6.3	3.7	2.7	5.1
38	Molinda	CF	3.0	5.3	6.0	5.0	3.3	4.9
39	Seabreeze	SLC	4.0	5.7	5.3	5.3	3.3	4.9
40	MB 66-93	CF	3.3	5.3	5.0	4.7	4.3	4.8
41	MB 82-93	HF	3.0	6.3	6.0	3.7	3.0	4.8
42	Osprey (PRO 92/24)	HF	3.0	6.7	6.7	2.7	3.0	4.8
43	Cascade	CF	4.0	5.7	5.0	5.0	3.7	4.8
44	BAR Frr 4ZBD	STC	4.7	5.0	5.3	4.7	3.7	4.7
45	TMI-3CE	CF	4.3	4.7	5.3	4.3	4.0	4.6
46	Quatro (FO 143)	SF	3.3	5.3	5.3	3.7	3.0	4.3
47	Aurora w/endo.	HF	3.3	5.0	5.0	4.0	3.0	4.3
48	Ecostar	HF	2.0	6.0	5.3	2.7	2.3	4.1
49	Nordic	HF	2.7	4.7	4.7	3.7	3.0	4.0
50	Spartan	HF	3.0	5.0	5.0	3.3	2.7	4.0
51	Reliant II	HF	3.0	4.7	5.3	3.0	2.7	3.9
52	Scaldis	HF	2.7	5.0	4.7	3.0	2.7	3.8
53	Pamela	HF	3.3	4.7	5.0	3.3	2.3	3.8
54	Silverlawn (WVPB-STCR-101)	STC	4.7	4.3	5.3	3.3	2.0	3.8
55	Defiant (MB 81-93)	HF	2.3	5.0	5.3	3.0	2.0	3.8
56	Vernon (MB 83-93)	HF	2.0	4.7	4.3	3.7	2.0	3.7
57	Brigade	HF	2.7	4.7	4.3	3.0	2.0	3.5
58	67135	SF	3.3	4.3	3.7	3.7	2.3	3.5
59	SR 3100	HF	3.0	4.0	4.0	2.7	2.7	3.3
	LSD _(0.05)		2.1	1.4	1.6	1.5	2.1	1.2

¹Genetic Color (Color): 9 = dark green and 1 = light green and visual quality is assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

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

Table 2. Percentage fall living ground cover¹ for cultivars established in the 1998 Fineleaf Fescue Cultivar Trial.

#	Name	Species	Percentage fall cover (%)
1	Sandpiper	CF	90.0
2	Salsa	STF	89.7
3	Pathfinder		86.7
4	Jamestown II	CF	86.7
5	Boreal	STF	83.3
6	SRX 52LAV	STF	80.0
7	Seabreeze	SLF	78.3
8	DGSC 94	STF	76.7
9	Brittany	CF	76.7
10	Jasper II	STF	76.7
11	Culombra	CF	76.7
12	SRX 52961	STF	76.7
13	PST-EFL	STF	73.3
14	Common creeping red	STF	73.3
15	ACF 092	CF	71.7
16	Shademark	STF	71.7
17	ISI Frr 5	STF	71.7
18	ABT-CHW-3	CF	71.7
19	ASR 049	SLF	70.0
20	Dawson E+	SLF	70.0

Species and Cultivar Trials

#	Name	Species	Percentage fall cover (%)
21	Defiant	HF	70.0
22	Pick FF A-97	HF	70.0
23	Bridgeport	CF	70.0
24	Longfellow II	CF	70.0
25	ABT-CR-3	STF	70.0
26	ABT-HF1	HF	68.3
27	SR 5100	CF	68.3
28	ABT-HF-3	HF	68.3
29	Intrigue	CF	66.7
30	Oxford		66.7
31	Magic	CF	66.7
32	Pick Frc 4-92	CF	66.7
33	Treasure (E)	CF	66.7
34	Shadow II	CF	66.7
35	ISI Frr 7	STF	66.7
36	ABT-CHW-2	CF	66.7
37	SR 6000	TH	66.7
38	ABT-CR-2	STF	66.7
39	4001	HF	65.0
40	Florentine	STF	65.0
41	Tiffany	CF	65.0
42	SRX 3961	HF	65.0
43	Heron	HF	65.0
44	ASC 082	STF	63.3
45	BAR CHF 8 FUS2	CF	63.3
46	Pick Frc A-93	CF	63.3
47	Shademaster II	STF	63.3
48	MB-63	CF	63.3
49	ISI F1 12	HF	63.3
50	ABT-HF-4	HF	63.3
51	ABT-CHW-1	CF	63.3
52	ABT-HF-2	HF	63.3
53	Banner III	CF	63.3
54	BAR HF 8 FUS	HF	61.7
55	Rescue 911	HF	60.0
56	PST-4FR	STF	60.0
57	Discovery	HF	60.0
58	Quatro	SF	60.0
59	AHF 008	HF	58.3
60	ASC 087	STF	56.7
61	AHF 009	HF	56.7
62	Ambassador		56.7
63	BAR CF 8 FUS1	STF	56.7
64	Reliant II	HF	56.7
65	Minotaur	HF x BF	55.0
66	PST-47TCR	STF	55.0
67	BAR SCF 8 FUS3	SLF	53.3
68	SR 3200	BF	53.3
69	Nordic (E)	HF	53.3
70	Scaldis	HF	51.7
71	Bighorn	HF	51.7
72	ISI F1 11	HF	51.7
73	Attila E	HF	50.0
74	PST-4HM	CF	50.0
75	Osprey	HF	50.0
76	PST-4MB	BHF	48.3
77	ASC 172	STF	40.0
78	MB-82	HF	36.7
79	LSD _{0.05}		15.9

¹These figures represent the percentage area covered by fine fescue.

BF = blue fescue, BHF = blue hard fescue, CF = creeping fescue, HF = hard fescue, SF = sheep fescue, SLF = slender creeping fescue, STF = strong fescue, TH = tufted hairgrass.

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 ft²/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 assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst 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 for genetic color (Gcol), spring greenup (Grn), and leaf texture (Leaf) are also included. Genetic color was rated using a 9 to 1 scale with 9 = dark and 1 = light green. Spring greenup was estimated using a 9 to 1 scale with 9 = green and 1 = dormant turf. Leaf texture was assessed with a 9 to 1 scale with 9 = fine and 1 = coarse texture.

Table 1. 1998 visual quality¹ and other ratings² for the national perennial ryegrass study.

	Cultivar	Gcol	Grn	Leaf	Turf quality						Mean
					May	June	July	Aug	Sept	Oct	
1	Divine	7.0	5.7	6.0	5.0	7.7	5.7	6.0	7.3	7.7	6.6
2	Secretariat (RPBD)	6.7	6.3	5.7	5.3	7.0	6.3	6.7	7.3	7.0	6.6
3	SR 4010 (SRX 4010)	6.0	6.3	5.3	6.0	7.0	6.7	6.7	6.7	6.7	6.6
4	Line Drive (MB 47)	7.7	6.3	5.3	5.3	6.3	6.0	6.7	7.3	7.3	6.5
5	Monterey (J-1706)	7.0	5.7	5.7	6.0	7.7	5.7	6.3	6.7	6.7	6.5
6	SR 4400 (SRX 4400)	7.0	5.3	6.0	5.7	7.0	6.7	6.0	7.0	6.7	6.5
7	Achiever	6.3	6.0	5.7	5.3	7.0	6.0	5.7	7.0	7.3	6.4
8	Blackhawk (TMI-EXFLP94)	7.0	6.0	5.0	5.3	7.3	6.3	6.0	7.0	6.7	6.4
9	Edge	6.3	6.3	5.3	5.7	6.7	6.3	6.3	6.7	6.7	6.4
10	Excel (MB 1-5)	7.3	6.0	5.3	6.0	7.7	6.0	5.3	7.0	6.3	6.4
11	Express	6.7	6.0	6.0	5.7	6.7	6.0	6.0	7.3	7.0	6.4
12	Manhattan 3	6.3	5.3	5.7	5.0	7.0	5.7	6.3	7.3	7.0	6.4
13	Premier II (BAR USA 94-II)	7.3	6.3	5.3	5.3	7.3	6.0	6.0	6.7	7.0	6.4
14	Spell Bound (WVPB-93-KFK)	6.3	5.3	5.7	5.7	6.7	6.0	6.0	7.0	7.0	6.4
15	Wizard (MB 41)	7.0	6.3	6.0	5.7	6.3	5.7	6.0	7.3	7.3	6.4
16	WX3-93	7.0	5.7	5.3	4.7	7.0	6.3	6.3	7.3	7.0	6.4
17	Accent	6.7	5.3	5.0	4.7	7.0	6.0	6.3	7.0	6.7	6.3
18	Assure	6.7	6.3	5.3	5.0	6.7	6.0	6.0	7.0	7.0	6.3
19	Brightstar	7.3	5.7	5.3	5.0	7.0	6.0	5.7	7.0	7.0	6.3
20	Buccaneer II (WVPB 92-4)	6.7	5.7	5.3	5.7	7.3	6.0	5.3	7.0	6.7	6.3
21	Caddieshack (MED 5071)	6.3	5.7	5.7	5.3	6.7	6.0	6.0	7.0	7.0	6.3
22	CAS-LP23	7.0	6.0	6.0	5.3	6.7	6.0	6.0	7.0	6.7	6.3
23	ISI-MHB	7.0	5.7	6.0	5.0	6.3	6.0	6.3	7.0	7.0	6.3
24	Mardigras (ZPS-2NV)	6.3	6.0	5.7	5.7	6.3	6.3	6.3	6.7	6.3	6.3
25	Mb 45	7.7	5.0	5.7	4.7	7.7	6.0	6.0	7.0	6.7	6.3
26	Nobility	7.3	5.0	5.0	5.3	7.7	6.0	5.3	6.7	6.7	6.3
27	Omega3 (ZPS-2DR-94)	7.0	5.7	6.0	5.7	7.3	6.0	6.0	6.7	6.3	6.3
28	PST-2CB	7.3	6.0	5.7	5.0	6.7	6.0	6.0	7.0	7.0	6.3
29	Saturn II (ZPS-2ST)	7.3	5.3	5.7	5.7	6.3	5.7	6.0	7.0	7.3	6.3
30	Sonata (PST-2R3)	7.0	5.7	5.0	5.3	7.3	5.7	6.3	7.0	6.3	6.3
31	Stallion Select	7.0	6.0	5.7	5.0	6.7	6.7	5.7	7.0	6.7	6.3
32	Vivid	7.0	5.3	5.7	5.0	8.0	6.0	5.7	7.0	6.3	6.3
33	Wind Star (PST-28M)	6.7	6.0	5.3	5.3	7.7	6.0	6.0	6.7	6.3	6.3
34	ASP400 (APR 106)	6.3	5.0	5.0	5.3	6.3	6.0	6.0	6.7	7.0	6.2
35	Blazer III (Pick 928)	6.7	6.0	6.0	5.0	7.0	6.0	5.7	7.0	6.7	6.2
36	Catalina (PST-GH-94)	7.7	5.3	6.3	4.7	7.3	5.7	5.7	7.0	7.0	6.2
37	Chaparral (PST-2DLM)	7.3	6.0	6.3	4.7	6.3	6.0	5.3	7.3	7.7	6.2
38	Cutter	6.3	5.3	6.0	5.7	6.3	5.7	6.0	7.0	6.3	6.2
39	Dancer	7.3	5.7	5.3	5.3	7.0	6.0	5.7	7.0	6.3	6.2
40	Imagine	7.3	5.3	6.3	4.3	6.3	6.3	6.0	7.0	7.0	6.2

	Cultivar	Gcol	Grn	Leaf	Turf quality						
					May	June	July	Aug	Sept	Oct	Mean
41	KOOS 93-6	6.7	5.0	5.7	5.3	7.0	6.0	6.0	6.3	6.3	6.2
42	Laredo	6.3	6.3	5.3	5.3	7.0	5.7	6.0	6.7	6.7	6.2
43	LRF-94-CB	7.7	6.0	6.3	4.7	6.3	5.7	6.7	7.0	7.0	6.2
44	Night Hawk	7.3	6.0	5.7	5.3	6.3	6.0	5.7	7.0	7.0	6.2
45	Omni	6.3	5.3	6.0	4.7	7.0	6.3	5.7	7.0	6.3	6.2
46	Panther (ZPS-PR1)	6.7	5.7	5.3	5.0	7.0	6.0	6.0	6.7	6.3	6.2
47	Pennant II (MB 42)	8.0	5.7	5.7	5.0	7.3	5.7	5.7	7.0	6.7	6.2
48	Protocol (KOOS 93-3)	6.7	5.3	5.3	5.7	6.0	6.0	6.3	7.0	6.3	6.2
49	PS-D-9	6.7	5.7	5.7	5.0	6.7	5.7	6.0	7.0	6.7	6.2
50	Quickstart	6.7	5.7	5.3	4.3	7.0	6.3	5.7	7.0	7.0	6.2
51	R2 (ISI-R2)	6.7	5.7	5.7	5.7	6.3	6.0	5.7	7.0	6.3	6.2
52	Roadrunner (PST-2ET)	6.7	6.3	5.7	5.0	7.0	5.7	6.0	7.0	6.3	6.2
53	Stardance (PST-2FE)	7.0	6.0	6.0	4.7	7.0	6.3	5.3	7.0	6.7	6.2
54	Sunshine(Pick LP 102-92)	7.7	6.0	6.0	4.7	7.3	5.7	6.0	7.0	6.7	6.2
55	Academy (PC-93-1)	6.3	5.7	5.0	5.3	7.0	5.7	6.0	6.3	6.3	6.1
56	APR 124	6.3	5.3	5.3	5.3	6.3	5.7	5.7	7.0	6.3	6.1
57	Elf	6.0	6.0	5.7	5.3	7.3	6.0	5.7	6.3	5.7	6.1
58	Esquire	7.3	5.7	5.3	5.0	7.0	6.0	5.3	6.7	6.7	6.1
59	Majesty (MB 43)	7.0	6.0	5.7	5.0	6.7	6.3	6.0	6.3	6.0	6.1
60	MB 44	6.7	5.7	6.7	5.3	7.7	5.7	6.0	6.0	5.7	6.1
61	Palmer III (LRF-94-MPRH)	7.0	5.3	6.0	5.3	6.7	6.0	6.3	6.3	5.7	6.1
62	Riviera II	7.0	5.7	5.3	4.7	6.7	6.0	6.0	7.0	6.3	6.1
63	APR 066	6.3	6.0	5.7	5.0	6.0	5.7	6.0	6.7	6.7	6.0
64	APR 131	7.0	6.0	5.7	5.0	6.0	5.7	6.0	6.7	6.7	6.0
65	BAR ER 5813	6.7	5.3	6.0	5.7	7.0	5.7	6.0	6.0	5.7	6.0
66	Passport (PST-2FF)	7.0	5.7	5.7	4.7	6.3	5.7	5.7	7.0	6.7	6.0
67	Pegasus	6.7	6.3	5.7	5.0	6.3	5.7	5.0	7.3	6.7	6.0
68	Precision	6.3	6.0	5.7	5.3	6.3	5.7	5.7	6.7	6.3	6.0
69	Prizm	6.3	6.3	5.3	4.7	6.3	6.0	5.7	7.0	6.3	6.0
70	SR 4200	7.0	6.3	5.7	5.3	6.3	6.0	5.7	6.3	6.3	6.0
71	Stallion Supreme (PSI-E-1)	6.3	5.3	5.7	5.3	6.3	6.0	6.0	6.3	6.0	6.0
72	Top Hat	7.3	6.0	6.3	4.0	6.7	6.3	5.7	6.7	6.7	6.0
73	WVPB-PR-C-2	7.0	5.7	5.3	5.3	6.3	6.3	5.7	6.3	6.0	6.0
74	Advantage	7.3	5.0	5.7	5.0	6.3	5.7	5.7	6.7	6.0	5.9
75	Citation III (PST-2DGR)	6.7	5.3	6.3	4.3	6.3	6.0	5.7	6.7	6.7	5.9
76	DLP 1305	6.3	6.0	5.7	5.3	6.3	5.3	5.7	6.7	6.0	5.9
77	DSV NA 9401	6.0	5.3	5.3	4.7	5.0	5.7	6.3	7.3	6.7	5.9
78	Legacy II (LESCO-TWF)	7.3	5.7	5.0	5.7	6.7	5.3	5.7	6.3	6.0	5.9
79	Morning Star	7.0	5.0	5.3	5.3	5.3	6.0	5.7	7.0	6.3	5.9
80	MVF-4-1	7.0	5.3	5.7	5.3	7.0	5.7	5.0	6.7	6.0	5.9
81	Navajo	7.0	6.3	5.3	4.7	6.0	5.7	6.0	7.0	6.3	5.9
82	Top Gun (J-17030)	6.3	6.7	6.0	4.3	6.3	6.0	5.7	7.0	6.0	5.9
83	WX3-91	6.0	5.3	5.7	4.3	6.3	6.0	6.0	6.7	6.0	5.9
84	Brightstar II (PST-2M3)	7.7	5.7	7.0	3.3	6.3	6.3	6.0	6.7	6.3	5.8
85	Calypso II	6.7	6.0	5.7	4.7	6.3	6.0	6.0	6.0	6.0	5.8
86	Head Start (Pick PR 84-91)	7.3	5.7	6.0	5.0	6.3	5.7	5.7	6.3	6.0	5.8
87	NINE-O-ONE	7.3	5.0	5.3	4.3	6.3	5.3	5.3	7.0	6.3	5.8
88	Repell III (LRF-94-C7)	7.7	6.0	6.3	4.0	6.0	5.7	6.0	6.7	6.7	5.8
89	Saturn	6.7	6.0	5.3	4.7	6.0	5.7	5.0	7.0	6.3	5.8
90	Williamsburg	6.0	5.7	5.3	5.3	6.7	6.0	5.3	6.0	5.7	5.8
91	Wind Dance (MB 46)	7.7	5.3	6.0	4.0	5.3	5.3	5.0	7.3	7.7	5.8
92	Figaro	6.7	5.7	6.0	5.0	5.7	5.7	5.3	6.7	6.0	5.7
93	DSV NA 9402	6.3	5.3	5.3	5.3	5.7	5.0	5.7	6.3	5.7	5.6
94	Prelude III (LRF-94-B6)	7.7	5.3	6.7	4.0	6.0	5.7	5.3	6.7	6.0	5.6
95	Pennfine	7.0	5.3	7.3	4.7	5.3	5.7	4.3	6.7	6.3	5.5
96	Linn	5.7	5.0	7.7	3.0	4.0	3.3	4.0	6.0	5.7	4.3
	LSD _{0.05}	1.3	NS	1.7	1.9	1.4	1.2	1.4	NS	1.9	0.7

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

²Genetic color (Gcol) was rated using a 9 to 1 scale: 9 = dark and 1 = light green. Spring greenup (Grn) was determined using a 9 to 1 scale: 9 = green and 1 = dormant. Leaf texture (Leaf) was assessed with a 9 to 1 scale: 9 = fine and 1 = coarse texture.

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

Shade Adaptation Study - 1998

Nick E. Christians, Barbara R. Bingaman, Lois A. Benning, 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*).

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*. Both areas are located under a canopy of a mature 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 ft²/year. No weed control has been required on the area. The grass is irrigated during extended drought periods but is otherwise not irrigated.

Monthly quality data are collected from May through October (Table 1 and 2). Visual quality was based on a scale of 9 to 1: 9 = best quality, 6 = lowest acceptable quality, and 1 = worst quality.

Table 3 contains a cumulative list of yearly averages from the original trial for years 1991 through 1998. Note that the final averages include data from 1988 to 1998, although only data from 1991 on are listed in the table to save space. The species and varieties are ranked from best to worst over the 11-year period.

Table 1. 1998 Visual quality¹ data for turfgrass cultivars in the Shade Trial established in 1987.

Cultivar	May	June	July	August	September	October	Mean
1 Victor (C.F.)	7.3	7.7	7.0	6.0	7.0	7.0	7.0
2 Waldina (H.F.)	6.7	6.3	6.0	6.3	6.7	6.7	6.4
3 Shadow (C.F.)	7.0	7.0	6.3	5.3	6.0	6.3	6.3
4 Jamestown (C.F.)	6.0	7.0	6.0	5.3	6.0	6.3	6.1
5 Waldorf (C.F.)	7.3	6.7	6.0	5.0	5.7	5.7	6.1
6 Agram (C.F.)	6.7	6.3	5.7	5.0	6.0	6.3	6.0
7 Atlanta (C.F.)	6.0	6.3	5.7	5.3	5.7	6.3	5.9
8 Pennlawn (C.R.F.)	7.0	7.3	5.3	4.3	5.7	5.3	5.8
9 Mary (C.F.)	5.7	6.7	6.0	4.7	6.0	6.0	5.8
10 Bar Fo 81-225 (H.F.)	4.0	6.3	6.0	6.0	6.0	6.3	5.8
11 Banner (C.F.)	5.7	7.0	5.7	4.7	5.7	5.7	5.7
12 Koket (C.F.)	6.0	5.3	5.7	4.7	6.0	5.7	5.6
13 Sabre (<i>Poa trivialis</i>)	5.0	6.3	6.7	4.3	4.0	6.3	5.4
14 Rebel II (T.F.)	5.0	5.7	5.7	5.7	5.7	5.0	5.4
15 Reliant (H.F.)	5.7	5.7	5.0	4.7	5.7	5.7	5.4
16 Wintergreen (C.F.)	5.7	6.3	5.3	5.0	4.7	4.7	5.3
17 Rebel (T.F.)	5.7	5.7	6.0	5.0	5.0	4.7	5.3
18 Highlight (C.F.)	6.7	5.7	5.3	4.0	5.3	4.3	5.2
19 Ensylva (C.R.F.)	6.0	5.0	5.0	4.3	5.3	5.3	5.2
20 Estica (C.R.F.)	5.3	5.0	4.3	4.7	6.0	5.7	5.2
21 St-2 (SR3000) (H.F.)	5.3	4.7	4.7	4.0	6.0	5.7	5.1
22 Midnight (K.B.)	4.3	4.7	5.0	5.3	4.0	4.0	4.6
23 Spartan (H.F.)	3.7	4.3	4.7	4.3	5.0	5.3	4.6
24 Biljart (H.F.)	3.3	5.0	4.0	4.0	5.0	5.0	4.4
25 Apache (T.F.)	5.3	5.0	3.3	4.7	3.3	3.7	4.2
26 Bonanza (T.F.)	5.0	5.3	3.7	4.0	4.0	3.0	4.2
27 Falcon (T.F.)	4.7	4.7	4.3	4.3	4.0	3.0	4.2
28 Arid (T.F.)	4.7	4.0	3.7	4.3	4.3	3.0	4.0
29 Scaldis (H.F.)	3.0	4.7	3.7	3.7	3.7	3.4	3.7
30 Coventry (K.B.)	3.3	4.7	4.0	3.3	3.0	2.3	3.4
31 Ram I (K.B.)	4.3	3.7	3.0	3.0	2.3	2.7	3.2
32 Bristol (K.B.)	5.0	3.3	3.0	2.7	2.3	2.0	3.1
33 Glade (K.B.)	3.3	3.0	3.0	2.3	2.7	1.7	2.7
34 Nassau (K.B.)	4.0	2.3	2.0	2.0	2.0	2.0	2.4
35 Chateau (K.B.)	1.7	2.3	2.3	2.3	2.3	1.7	2.1
LSD _{0.05}	2.6	2.2	1.9	1.9	1.4	2.0	1.5

¹Visual quality was assessed using a scale of 9 to 1 with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality.

Table 2. 1998 Visual quality¹ data for turfgrass cultivars in the Shade Trial established in 1994.

	Cultivar	May	June	July	August	September	October	Mean
1	Cypress (<i>Poa trivialis</i>)	5.0	5.0	5.3	4.0	4.3	5.0	4.8
2	Sabre (<i>Poa trivialis</i>)	4.3	5.3	5.7	3.7	4.3	5.0	4.7
3	SR5100 (C.F.)	4.7	4.7	4.3	3.7	5.0	5.0	4.6
4	Southport (C.F.)	4.7	4.7	4.0	3.3	4.0	4.7	4.2
5	Shadow (C.F.)	5.0	5.3	4.3	2.3	3.3	4.3	4.1
6	Bonanza II (T.F.)	4.3	4.3	4.7	3.0	3.7	4.0	4.0
7	Midnight (K.B.)	4.3	3.7	4.3	3.7	4.0	3.7	3.9
8	Bridgeport (C.F.)	5.0	5.0	3.0	3.0	4.3	3.3	3.9
9	Molinda (C.F.)	4.7	5.3	4.3	2.3	3.3	3.3	3.9
10	Banner (C.F.)	4.3	4.0	4.3	3.3	3.0	4.0	3.8
11	Bonanza (T.F.)	3.7	4.7	4.0	3.3	4.0	3.3	3.8
12	Polder (<i>Poa trivialis</i>)	4.0	3.0	4.3	3.3	3.3	4.0	3.7
13	Silvana (H.F.)	3.7	4.0	2.7	3.3	4.3	4.0	3.7
14	Waldina (H.F.)	4.0	4.3	3.3	3.0	3.0	3.7	3.6
15	Victory (C.F.)	3.7	4.3	4.0	2.3	3.3	4.0	3.6
16	Shenandoah (T.F.)	3.3	3.7	3.7	4.0	2.7	4.0	3.6
17	Banner II (C.F.)	4.0	5.0	2.7	2.7	3.7	2.7	3.4
18	Arid (T.F.)	3.7	4.0	4.0	2.7	3.0	3.3	3.4
19	Rebel II (T.F.)	3.7	4.0	3.7	3.3	3.0	2.7	3.4
20	Ascot (K.B.)	3.0	3.3	3.3	2.7	3.0	3.3	3.1
21	Flyer (C.R.F.)	3.0	3.0	3.3	2.3	3.0	3.7	3.1
22	Glade (K.B.)	3.0	3.7	3.7	2.7	2.7	2.3	3.0
23	Adobe (T.F.)	2.7	3.0	3.0	2.3	2.3	2.3	2.6
24	Bristol (K.B.)	2.3	2.3	2.7	2.7	3.0	2.0	2.5
25	Coventry (K.B.)	2.3	2.7	2.3	2.7	2.3	2.3	2.4
26	Buckingham (K.B.)	3.0	2.7	2.3	1.7	2.3	2.0	2.3
27	Nordic (H.F.)	2.3	2.0	2.0	2.7	2.3	2.3	2.3
28	Aztec (T.F.)	2.0	2.3	2.0	2.7	2.7	2.0	2.3
29	Mirage (T.F.)	2.3	2.3	2.3	2.3	2.0	2.7	2.3
30	Spartan (H.F.)	2.3	2.3	2.3	2.3	2.3	1.7	2.2
31	Bonsai (T.F.)	3.0	2.3	2.3	2.0	2.0	1.7	2.2
32	Rebel (T.F.)	2.3	2.3	2.0	2.0	2.0	2.0	2.1
33	Falcon II (T.F.)	1.3	2.3	1.7	1.7	1.7	2.0	1.8
34	Supranova (<i>Poa supina</i>)	1.7	1.7	2.0	1.7	1.0	1.7	1.6
35	Brigade (H.F.)	1.0	2.0	1.3	1.3	1.0	1.3	1.3
	LSD _{0.05}	2.4	2.2	2.1	NS	NS	2.0	1.8

¹Visual quality was assessed using a scale of 9 to 1 with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality.

Table 3. The average quality ratings for grasses in the Shade Trial: 1991 - 1998.

Cultivar	1991	1992	1993	1994	1995	1996	1997	1998	Ave.*
1 Victor (C.F.)	4.3	5.9	7.2	7.1	6.6	6.6	7.1	7.0	6.50
2 Waldorf (C.F.)	5.5	7.3	5.9	6.2	5.8	6.1	6.6	6.1	6.18
3 ST-2 (SR 3000) (H.F.)	5.1	6.3	5.7	6.1	6.1	5.5	5.8	5.1	6.15
4 Mary (C.F.)	3.9	6.4	6.7	6.6	6.7	6.3	6.2	5.8	6.13
5 BAR FO 81-225 (H.F.)	4.9	6.5	5.5	6.1	6.5	5.7	5.9	5.8	6.05
6 Jamestown (C.F.)	4.2	6.0	6.5	6.6	6.2	5.9	6.1	6.1	6.03
7 Shadow (C.F.)	4.7	6.0	6.6	6.6	5.9	5.9	6.6	6.3	6.02
8 Atlanta (C.F.)	4.9	6.1	5.8	5.7	5.5	6.7	6.6	5.9	5.93
9 Waldina (H.F.)	4.1	5.5	5.5	5.8	5.8	5.1	5.9	6.4	5.89
10 Pennlawn (C.R.F.)	4.7	6.2	6.3	5.5	5.5	5.9	6.2	5.8	5.84
11 Rebel (T.F.)	5.3	6.0	6.9	5.9	5.7	4.6	4.5	5.3	5.83
12 Sabre (Poa trivialis)	6.9	6.4	7.4	6.2	4.8	4.9	5.0	5.4	5.80
13 Estica (C.R.F.)	4.1	5.6	6.6	6.1	5.6	4.3	4.3	5.2	5.77
14 Banner (C.F.)	4.5	5.0	6.0	5.6	5.3	6.2	6.3	5.7	5.74
15 Bonanza (T.F.)	6.5	6.9	6.3	6.2	5.2	4.2	4.1	4.2	5.65
16 Biljart (H.F.)	5.1	6.1	5.0	5.1	5.1	4.8	5.1	4.4	5.63
17 Rebel II (T.F.)	5.3	5.6	6.1	6.2	5.1	4.3	4.1	5.4	5.59
18 Falcon (T.F.)	5.3	6.0	6.5	6.3	5.2	4.2	4.2	4.2	5.56
19 Agram (C.F.)	3.9	5.9	5.4	5.3	5.1	5.5	5.6	6.0	5.48
20 Apache (T.F.)	6.0	6.0	6.3	5.4	5.3	3.7	3.2	4.2	5.47
21 Wintergreen (C.F.)	4.6	5.9	5.0	5.0	5.0	6.0	5.9	5.3	5.45
22 Spartan (H.F.)	3.5	4.2	4.7	5.1	4.9	5.0	4.8	4.6	5.32
23 Arid (T.F.)	6.0	7.1	6.7	5.6	4.7	2.9	2.7	4.0	5.28
24 Ensylva (C.R.F.)	4.0	5.1	5.9	5.4	4.4	5.3	4.9	5.2	5.26
25 Koket (C.F.)	4.2	5.2	5.2	5.7	4.6	4.6	5.4	5.6	5.19
26 Scaldis (H.F.)	3.7	5.2	4.6	4.4	4.8	4.1	4.6	3.7	4.90
27 Highlight (C.F.)	3.5	4.6	5.0	4.8	4.7	4.9	5.1	5.2	4.78
28 Coventry (K.B.)	5.7	5.4	6.0	4.7	3.8	3.9	3.5	3.4	4.72
29 Midnight (K.B.)	5.9	5.5	6.4	4.6	4.4	4.0	3.9	4.6	4.56
30 RAM I (K.B.)	5.0	5.0	5.9	4.3	3.3	2.8	2.7	3.2	4.52
31 Reliant (H.F.)	3.1	3.5	4.2	4.9	4.8	4.9	5.0	5.4	4.43
32 Chateau (K.B.)	6.2	5.5	5.2	4.1	3.0	2.2	1.9	2.1	4.26
33 Glade (K.B.)	5.5	4.8	5.3	3.3	2.8	2.8	2.3	2.7	4.12
34 Bristol (K.B.)	3.9	3.9	5.0	4.1	3.6	2.8	2.4	3.1	3.87
35 Nassau (K.B.)	3.4	3.8	4.3	3.3	2.4	2.1	2.0	2.4	3.25

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

*Average includes 1988, 1989, and 1990 data (not listed).

Compiled by Gary Peterson, ISU Extension Commercial Horticulture Field Specialist

Fairway Height Bentgrass Cultivar Trials - Established 1993

Nick E. Christians and James R. Dickson

This is the final 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 was maintained at a 0.5-inch mowing height. This was a National Turfgrass Evaluation (NTEP) trial and was conducted at several research stations in the U.S. It contained 21 of the newest seeded cultivars and a number of experimentals. The cultivars were maintained with 4 lbs of N/1000 ft²/growing season. Fungicides are used as needed in a preventative program. Herbicides and insecticides were applied as needed.

Visual quality ratings were taken from May through August 1998 (Table 1). Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality. Genetic color (Color), spring greenup (Green), and leaf texture (Leaf) were evaluated in August 1998. Genetic color was based on a 9 to 1 scale with 9 = dark green and 1 = light green. Spring greenup was evaluated using a 9 to 1 scale with 9 = best and 1 = worst greenup. Leaf texture was estimated using a 9 to 1 scale with 9 = fine and 1 = coarse texture.

A new Fairway Height Bentgrass Cultivar trial was established in September 1998. It contains 26 cultivars and the study will be maintained under the same guidelines as the 1993 study. The only data taken for this study in 1998 were for fall percentage living cover (Table 2).

Table 1. 1998 visual quality and other physical ratings for cultivars in the 1993 Fairway Height Bentgrass Trial.

	Cultivar	Color	Green	Leaf	Quality				Mean
					May	June	July	Aug	
1	Trueline	7.7	5.7	6.7	7.0	7.0	7.0	7.3	7.1
2	BAR Ws 42102	6.0	5.3	6.7	7.7	7.0	7.0	6.0	6.9
3	Southshore	6.0	6.3	7.7	7.7	7.3	6.7	6.0	6.9
4	18th Green	6.3	6.0	6.7	6.7	6.7	7.0	7.0	6.8
5	Penn G-6	5.7	5.7	7.0	6.7	7.7	7.0	6.0	6.8
6	Penn G-2	6.0	5.7	6.3	7.3	6.7	7.0	5.7	6.7
7	Lopez	5.7	5.7	6.0	6.7	6.7	6.3	6.3	6.5
8	Crenshaw	6.0	6.3	7.3	7.0	6.0	6.7	6.0	6.4
9	Seaside II (DF-1)	5.7	5.7	7.3	6.7	6.0	7.0	5.7	6.3
10	Providence	5.7	6.3	6.0	6.3	7.0	6.0	5.3	6.2
11	Seaside	7.7	4.7	5.0	6.0	6.0	6.0	6.3	6.1
12	Cato	5.3	6.7	7.3	6.7	6.3	6.3	5.0	6.1
13	PRO/CUP	7.0	6.0	6.0	6.0	6.3	5.7	6.3	6.1
14	Penncross	7.0	5.3	5.3	6.0	6.0	5.7	6.7	6.1
15	Penneagle	6.3	6.3	7.0	6.3	6.3	6.0	5.7	6.1
16	BAR As 492	6.0	5.3	5.7	6.0	6.0	5.7	6.0	5.9
17	ISI-At-90162*	6.0	5.7	5.3	6.3	6.0	5.3	5.3	5.8
18	Pebble*	7.0	5.0	5.3	5.7	5.3	5.7	6.0	5.7
19	Exeter	6.0	5.3	5.7	5.3	5.3	5.3	6.0	5.5
20	Tendenz*	6.3	5.0	5.0	5.3	4.7	5.3	5.7	5.3
21	SR 7100*	6.0	5.3	5.0	5.3	5.0	4.7	5.3	5.1
	LSD _(0.05)	1.3	P>F=0.07	1.0	NS	1.3	P>F=0.07	NS	NS
			1.1				1.6		

* Colonial Bentgrass

Color (Genetic color): 9 = dark green and 1 = light green. Green (Greenup): 9 = best and 1 = worst greenup. Leaf (Leaf texture): 9 = fine and 1 = coarse.

Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

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

Table 2. Percentage fall living cover data¹ for cultivars in the 1998 Fairway Height Bentgrass Trial.

	Cultivar	Percentage fall cover (%)
1	Backspin	78.3
2	Century	78.3
3	Penneagle	76.7
4	SR 1119	73.3
5	Trueline	71.7
6	Providence	70.0
7	Penn G-6	70.0
8	Imperial	68.3
9	Grand Prix	66.7
10	Seaside II	66.7
11	PST-9HG*	65.0
12	Penncross	65.0
13	Princevill	63.3
14	Tiger	63.3
15	PST-OVN	63.3
16	SRX 1BPAA	61.7
17	L-93	58.3
18	Seaside	58.3
19	SRX 1120	58.3
20	GolfStar**	58.3
21	ABT-Col-2*	56.7
22	SRX 7MOBB*	55.0
23	PST-9PM*	53.3
24	ISI At-5*	50.0
25	SR 7100*	50.0
26	SRC 7MODD*	45.0
	LSD _(0.05)	17.0

¹These figures represent the percentage area per plot covered by bentgrass.

*Colonial Bentgrass

** Idaho Bentgrass

Green Height Bentgrass Cultivar Trial - Established 1993

Nick E. Christians and James R. Dickson

This is the final 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 was a National Turfgrass Evaluation Program (NTEP) trial and was conducted at several research stations in the U.S. It contained 28 seeded cultivars, including a number of experimentals.

The cultivars were maintained with a fertilizer program of 1/4 lb N applied at 14-day intervals with a total of 4 lbs of N/1000 ft²/growing season. Fungicides were used as needed in a preventive program. Herbicides and insecticides were applied as needed.

A new Green Height Bentgrass Cultivar trial was begun in September 1998. Twenty-six cultivars including numerous experimentals are being screened. The only data collected from this study in 1998 were estimates of the percentage of green ground cover taken in the fall.

Table 1. 1998 visual quality and other physical ratings for cultivars in the 1993 Green Height Bentgrass Trial.

Cultivar	Color	Green	Leaf	Quality				Mean
				May	June	July	Aug	
1 Penn G-2 (G-2)	6.3	6.0	7.7	7.3	8.0	7.7	7.0	7.5
2 Crenshaw	7.0	6.7	6.7	7.0	6.7	7.3	7.0	7.0
3 Imperial (Syn 92-5)	6.0	6.0	7.3	7.0	7.7	7.3	6.0	7.0
4 Penn A-1 (A-1)	6.7	6.3	7.7	6.3	7.0	7.3	7.3	7.0
5 Penn G-6 (G-6)	6.3	6.0	6.3	7.0	7.0	7.7	6.0	6.9
6 Penn A-4 (A-4)	5.7	5.7	7.3	6.7	7.0	6.7	6.0	6.6
7 BAR Ws 42102	6.0	5.0	6.3	6.7	7.0	6.7	5.7	6.5
8 Century (Syn 92-1)	5.3	5.7	7.0	6.7	6.7	6.7	6.0	6.5
9 Backspin (Syn 92-2)	5.7	6.0	7.0	6.7	7.0	6.3	5.7	6.4
10 Regent	6.0	5.0	6.0	6.3	6.0	7.0	6.0	6.3
11 Cato	5.3	6.0	6.3	6.0	6.3	7.0	5.7	6.3
12 Southshore	5.7	5.3	6.7	6.3	6.0	6.7	6.3	6.3
13 Providence	6.7	5.3	6.3	5.7	5.3	7.0	7.0	6.3
14 SR 1020	4.7	5.7	7.3	6.3	6.3	6.7	6.0	6.3
15 Loft's L-93 (L-93)	6.0	5.3	6.0	6.0	6.3	6.3	6.3	6.3
16 PRO/CUP	5.7	5.0	5.0	6.0	6.0	6.0	6.0	6.0
17 Pennlinks	6.0	5.0	6.0	6.0	6.0	5.7	6.3	6.0
18 18th Green	6.0	6.0	6.0	5.7	6.0	6.0	6.0	5.9
19 ISI-Ap-89150	6.0	5.7	5.7	5.3	5.7	6.0	6.7	5.9
20 BAR As 492	6.0	5.7	5.7	5.7	5.3	6.0	6.3	5.8
21 Trueline	5.0	4.3	6.0	5.7	6.0	5.7	5.7	5.8
22 Penncross	5.7	5.3	5.3	5.7	6.0	5.3	6.0	5.8
23 DG-P	6.0	5.0	5.7	6.0	5.3	6.0	5.7	5.8
24 MSUEB	5.7	5.0	6.0	5.7	6.0	6.0	5.7	5.8
25 Lopez	5.7	4.3	5.7	5.7	6.0	5.7	5.7	5.8
26 Mariner (Syn-1-88)	6.3	5.0	6.0	5.3	5.7	6.3	5.7	5.8
27 Tendenz*	6.0	5.3	5.3	5.3	4.7	5.0	5.3	5.1
28 Seaside	5.3	4.7	5.0	5.0	5.0	4.7	5.0	4.9
LSD _(0.05)	NS	1.1	1.0	NS	1.4	1.1	NS	1.0

* Colonial Bentgrass

Color (Genetic color): 9 = dark green and 1 = light green. Green (Greenup): 9 = best and 1 = worst greenup. Leaf (Leaf texture): 9 = fine and 1 = coarse.

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

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

Table 2. Percentage fall living cover data¹ for cultivars in the 1998 Green Height Bentgrass Trial.

	Cultivar	Percentage fall cover (%)
1	Backspin	81.7
2	Penn A-4	78.3
3	Imperial	76.7
4	Providence	76.7
5	ISI Ap-5	75.0
6	Pennlinks	75.0
7	Penncross	75.0
8	Penn A-2	75.0
9	L-93	73.3
10	Syn 96-2	73.3
11	SR 1119	73.3
12	ABT-CRB-1	71.7
13	BAR AS 8FUS2	71.7
14	SR 7200*	71.7
15	Penn G-1	71.7
16	Penn A-1	71.7
17	Bavaria*	70.0
18	Pick CB 13-94	70.0
19	SRX 1BPAA	70.0
20	Century	68.3
21	BAR CB 8US3	68.3
22	Pick MVB*	68.3
23	Syn 96-1	68.3
24	SRX 1120	68.3
25	SRX 1NJH	68.3
26	Crenshaw	66.7
27	PST-A2E	66.7
28	Penn G-6	66.7
29	Syn 96-3	65.0
	LSD _(0.05)	NS

¹These figures represent the percentage area per plot covered by bentgrass.

*Velvet Bentgrass

Overseeding of Northern Turfgrass Sports Fields with Bermudagrass

David D. Minner, Roch Gaussoin, and Steve Keeley

Objective:

To determine if seeded bermudagrass can be established in the summer and then used for intensely trafficked sport fields in late summer/early fall.

Procedure:

This is a cooperative research project with Dr. Roch Gaussoin, University of Nebraska, and Dr. Steve Keeley, Kansas State University. Field plots were also established in Kansas and Nebraska, but only the Iowa data is reported at this time. This field research project was established at the Iowa State University Horticulture Research Station, Ames, IA. On 19 June 1998 the study area was prepared by treating the existing stand of grass and weeds with glyphosate. Eleven days later all of the vegetation was dead and approximately 50 percent of the area was showing exposed soil. On 2 July 1998 the test area was verticut in two directions to a depth of 0.5 inches. The area was immediately fertilized, seeded, and watered. One pound of N, P₂O₅, and K₂O was applied per 1000 sq. ft. Six bermudagrass varieties (3 lbs. seed /1000 sq. ft.) and Bright Star perennial ryegrass (15 lbs. Seed/1000 sq. ft.) were established in 8 foot by 15 foot whole-plots. Grass was watered and mowed to a two-inch cutting height. Plots were rated on 24 August and then half of each bermudagrass whole-plot was slit seeded with Bright Star perennial ryegrass (10 lbs/1000 sq. ft.) to provide a 4-foot by 15-foot split-plot. The experimental design was a randomized complete block with seven whole-plot treatments (bermudagrasses: Sultan, Numex Sahara, SWI-10, Blend C, Mirage, and Pyramid), two split-plot treatments (with or without perennial ryegrass), and three replications.

Traffic was applied with a Brouwer roller that was modified with football cleats to supply differential-slip-type traffic. Fifteen passes over the test area were made with the traffic simulator between 27 August and 15 September 1998.

Table 1. Percent turf cover for six bermudagrass selections and one perennial ryegrass. Grass was seeded on 2 July and evaluated on 24 August 1998.

Grass	Avg.
Sultan	94.6
NuMex Sahara	94.6
Mohawk	97.6
Blend C ²	93.3
Mirage	95.0
Pyramid	96.3
Bright Star	23.3

² Blend C contains Princes 50%, SWI-10 25%, and Sultan 25%.

Table 2. Turfgrass color, quality, and cover average ratings of 16 Oct 1998.

Grass	Color	Quality	Cover
Sultan	3	6	75
Sultan + PR	4	6	73
NuMex Sahara	3	6	73
NuMex Sahara + PR	4	6	72
Mohawk	3	6	75
Mohawk + PR	4	6	73
Blend C	3	6	73
Blend C + PR	4	6	73
Mirage	3	6	72
Mirage + PR	4	6	73
Pyramid	3	6	72
Pyramid + PR	4	6	75
Bright Star PR	8	5	52

Results:

Table 1 shows the advantage of establishing a warm season grass like bermudagrass during the summer compared with perennial ryegrass. On 24 August all of the bermudagrass selections had greater than 90% turf cover, while perennial ryegrass had only 23% turf cover. This resulted in a substantial advantage that would coincide with the beginning of a normal fall football season. Even with an additional perennial ryegrass seeding on 24 August, the bermudagrasses provided more turf cover than perennial ryegrass at the end of the football season. Bermudagrass cover was approximately 75% compared with 52% for perennial ryegrass (Table 2).

All of the bermudagrass cultivars retained 100% of their green color on 15 September. By 1 October the bermudagrasses were showing signs of winter dormancy and green color retention was approximately 60 percent. By 16 October 1998 bermudagrass leaves were mostly brown with only about 30% green tissue present. Table 2 shows that there was a slight improvement in turf color on 16 October when bermudagrass was overseeded with perennial ryegrass. By 16 October the perennial ryegrass only treatment had much better color than the bermudagrass or the bermudagrass/overseeded with rye treatments.

Preemergent Annual Grass Control Study

Barbara R. Bingaman, Melissa C. McDade, Michael B. Faust, and Nick E. Christians

In this study various preemergent herbicide and herbicide plus fertilizer formulations were screened for efficacy in controlling annual grass weed species in turfgrass. The study was conducted at the Iowa State University Horticulture Research Station near Ames, IA in established 'Nassau' Kentucky bluegrass that had a heavy crabgrass infestation in 1997. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.35%, a pH of 6.85, 5 ppm P, and 93 ppm K.

The study was arranged as a randomized complete block. Individual plot size was 5 x 5 ft with three replications. Thirty-three treatments were included in single and split applications with a fertilized control and an untreated control (Table 1).

Preemergent applications were made on April 29, 1998 before crabgrass germination. It was 54° F with overcast skies and a northeast wind at 10 mph. Crabgrass was detected in the untreated controls on June 10. Sequential (POST) applications of treatments 2 - 9 were made on June 16 (6 to 8 weeks after initial applications). Temperatures were in the mid 70's and it was mostly sunny with a light NW wind. The crabgrass plants in the untreated controls were in the 1- to 2-leaf stage. On July 1, sequential applications of treatments 10-15 and 21-25 were made. It was 80° F and mostly sunny with northwest winds at 5-10 mph. Crabgrass in the untreated controls was in the 1- to 4-leaf stage.

Liquid formulations were applied at 30 psi with a carbon dioxide backpack sprayer equipped with TeeJet® #8006 flat fan nozzles. Liquids were diluted into 287 ml of water which translates to an application rate of three gal/1000 ft². Granular materials were applied using 'shaker dispensers'.

Visual turf quality data were taken weekly from May 5 through September 2 (Tables 2 and 3). Quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality. The plot was checked for phytotoxicity on each of these dates and none was detected.

Annual grass populations were estimated as percentage crabgrass cover per plot. These data were taken weekly from July 7 through September 2 (Table 4). Annual grass control was determined by calculating percentage reductions in crabgrass cover as compared with the untreated controls (Table 5). Broadleaf population data for oxalis, clover, dandelion, and black medic were taken on September 2 (Table 6).

All data were analyzed using the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference (LSD) tests were used to compare means separation.

The quality of turf treated with herbicide plus fertilizer formulations was better than the untreated controls on May 5 (Table 2). By June 4, most of the fertilizer effects on quality were gone. Improved quality also was detected in turf receiving sequential applications of herbicide plus fertilizer formulations on either June 16 or July 1. Nineteen of the materials produced significantly better mean quality than the untreated controls (Table 3).

There were significant differences in percentage crabgrass cover on all data collection dates (Table 4). Seventeen of the materials maintained percentage crabgrass cover $\leq 5.3\%$ for the duration of the study and twenty materials suppressed cover to $\leq 10\%$ for this period. Twenty-four herbicide formulations produced mean percentage cover $\leq 8.7\%$.

Crabgrass cover reductions were significantly different on all collection dates (Table 5). Twenty herbicides reduced crabgrass cover by $\geq 95\%$ as compared with the untreated controls on July 7 and 10 herbicides provided 100% control on that date. By July 29, the level of control had decreased for some of the formulations but 21 herbicides were still providing $\geq 90\%$ control. By September 2, 16 herbicides were still reducing crabgrass cover $\geq 90\%$ as compared with the untreated controls. Thirteen herbicides provided $\geq 90.0\%$ crabgrass control for the duration of the study (Table 5).

Dandelion was the only broadleaf weed species that was distributed among all of the plots (Table 6). There were significantly fewer dandelions in turf treated with eight of the herbicides as compared with the untreated controls. Some of the largest dandelion populations were found in turf treated with herbicides that provided excellent control

of crabgrass. In these areas, dandelions could more easily establish because of less competition from crabgrass and other weed species.

Oxalis, black medic, and clover distributions were sporadic. The efficacy of the tested herbicides in controlling these species, therefore, could not be determined from these data.

Table 1. Materials and rates for the 1998 Pre- & Postemergent Annual Weed Control Study.

Material		(PRE) Rate (g product/ft ²)	(POST) Rate (g product/ft ²)
1.	Untreated control	N/A	N/A
2.	S-8096 ¹	2.06	none
3.	S-8096 ¹	2.06	2.06
4.	S-8097 ¹	2.06	none
5.	S-8097 ¹	2.06	2.06
6.	S-8162 ¹	1.56	none
7.	S-8162 ¹	1.56	1.56
8.	S-8161 ¹	1.53	none
9.	S-8161 ¹	1.53	1.53
		(PRE) Rate lb a.i./A	(POST) Rate lb a.i./A
10.	Team Pro NAF-324 0.86GR ²	1.5	1.5
11.	Team Pro NAF-324 0.86GR ²	2.0	none
12.	Pendimethalin 0.86GR ²	1.5	1.5
13.	Pendimethalin 0.86GR ²	2.0	none
14.	Dimension 0.10 GR ²	0.38	none
15.	Barricade 0.22 GR ²	0.5	none
		Rate lb a.i./A	Timing of application
16.	BAS051434H Drive 75DF ³	0.75	PRE
17.	BAS051434H Drive 75DF ³	0.50	PRE
18.	BAS 514 0.57GR ³	0.75	PRE
19.	BAS 514 0.57GR ³	0.50	PRE
20.	Pendimethalin 60WDG ^{3*}	3.00	PRE
21.	BAS051434H Drive 75DF + MSO ³	0.75 1.0%	POST
22.	BAS051434H Drive 75DF + MSO ³	0.50 1.0%	POST
23.	BAS 514 0.57GR ³	0.75	POST
24.	BAS 514 0.57GR ³	0.50	POST
25.	Dimension 1EC + NIS ³	0.50 0.50%	POST
26.	Dimension 1EC ⁴	0.25	PRE
27.	Dimension 0.164FG AND445 ⁴	0.25	PRE
28.	Dithiopyr 1.06XF 98-025 ⁴	0.25	PRE
29.	Dithiopyr 0.89XF 98-026 ⁴	0.25	PRE
30.	Dithiopyr 2.20XF 98-029 ⁴	0.25	PRE
31.	Dimension 40WP ⁴	0.25	PRE
32.	Fertilized control ⁴	N/A	PRE

¹These materials are being screened for The Scotts Company.

²These materials are being screened for Dow AgriSciences.

³These materials are being screened for BASF.

⁴These materials are being screened for Rohm and Haas and were applied with methylene urea (39-0-0) at 4 lb/1000 ft².

Initial applications (PRE) were made on April 29, Scott's (trt 2-9) sequential applications at 6 to 8 WAT on June 16, Dow (trt 10-15) sequential applications at 8 to 10 WAT on July 1, and BASF (trt 21-25) POST applications on July 1.

Table 2. Visual quality¹ of Kentucky bluegrass treated for the 1998 Pre- & Postemergent Annual Weed Control Study (May 5 - July 7).

Material	May 5	May 13	May 19	May 27	June 4	June 10	June 16	June 24	June 30	July 7
1. Untreated control	7.0	7.0	6.3	6.0	6.0	5.3	5.7	6.0	6.0	6.0
2. S-8096	8.7	7.0	7.7	7.7	6.3	6.7	7.3	6.0	6.7	6.3
3. S-8096	8.7	7.0	7.3	7.7	6.0	6.7	7.7	8.0	9.0	8.7
4. S-8097	8.3	7.3	8.0	7.7	6.7	7.0	7.3	6.0	6.3	7.3
5. S-8097	8.3	7.7	8.0	9.0	6.7	7.0	7.3	8.0	8.7	8.0
6. S-8162	7.3	6.7	6.3	7.0	6.3	5.7	6.7	6.0	6.0	6.0
7. S-8162	8.0	6.7	6.3	6.7	6.0	5.7	7.3	8.0	8.0	6.7
8. S-8161	7.0	7.0	7.3	8.0	6.7	6.0	6.3	6.0	6.3	6.7
9. S-8161	8.7	7.7	7.0	7.0	6.3	6.3	6.3	8.0	8.0	7.0
10. Team Pro NAF-324 0.86GR	7.3	7.7	7.7	7.7	6.7	6.0	7.3	6.0	6.3	8.7
11. Team Pro NAF-324 0.86GR	9.0	7.0	7.7	7.7	6.0	6.0	7.0	6.0	6.3	6.3
12. Pendimethalin 0.86GR	8.7	6.7	7.7	8.3	6.7	6.7	7.3	6.0	6.3	8.3
13. Pendimethalin 0.86GR	8.0	6.7	8.0	8.7	6.0	7.0	7.7	6.0	7.0	6.3
14. Dimension 0.10 GR	8.3	7.0	8.0	8.3	6.7	6.7	7.7	6.0	6.7	6.3
15. Barricade 0.22 GR	9.0	7.0	7.0	7.0	6.0	6.3	7.3	6.0	6.3	6.0
16. BAS051434H Drive 75DF	7.3	6.0	5.7	5.3	6.0	5.0	5.0	6.0	5.7	6.3
17. BAS051434H Drive 75DF	7.7	6.3	5.7	5.7	6.0	5.0	5.7	6.0	6.3	6.0
18. BAS 514 0.57GR	8.0	7.0	6.0	5.7	6.0	5.0	5.7	6.0	6.0	6.0
19. BAS 514 0.57GR	8.0	6.7	6.0	6.0	6.0	5.3	6.3	6.0	6.0	6.0
20. Pendimethalin 60WDG	8.0	6.7	6.0	6.7	6.0	5.3	6.3	6.0	6.0	6.0
21. BAS051434H Drive 75DF	7.7	7.0	6.3	6.7	6.0	5.3	6.3	6.0	6.0	6.3
22. BAS051434H Drive 75DF	7.3	6.7	6.3	6.0	6.3	5.3	6.3	6.0	6.0	6.0
23. BAS 514 0.57GR	8.0	6.7	6.3	6.0	6.3	5.0	5.7	6.0	6.0	6.3
24. BAS 514 0.57GR	7.3	7.0	6.0	6.3	6.0	5.0	5.0	6.0	6.0	6.0
25. Dimension IEC + NIS	7.0	7.0	6.0	6.0	6.0	5.3	5.7	6.0	6.0	6.0
26. Dimension IEC	8.3	7.7	7.3	9.0	6.3	7.7	9.0	6.0	7.3	6.7
27. Dimension 0.164FG AND445	7.7	7.3	7.3	8.3	7.0	7.3	8.3	6.0	7.3	7.3
28. Dithiopyr 1.06XF 98-025	8.7	7.0	7.0	8.7	6.3	7.3	7.7	6.0	7.7	7.0
29. Dithiopyr 0.89XF 98-026	8.0	7.0	7.0	8.0	6.0	7.0	8.7	6.0	8.0	7.0
30. Dithiopyr 2.20XF 98-029	7.7	7.3	7.7	8.3	6.3	7.7	8.3	6.0	7.7	7.0
31. Dimension 40WP	7.3	7.7	7.3	8.3	7.0	7.3	8.0	6.0	7.0	7.7
32. Fertilized control	8.0	7.0	7.0	8.3	6.7	8.3	8.3	6.0	7.3	6.3
LSD _{0.05}	1.0	NS	1.1	1.0	0.6	1.1	1.4	—	0.9	1.1

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable and 1 = worst quality.

Initial applications (PRE) were made on April 29, Scott's (trt 2-9) sequential applications at 6 to 8 WAT on June 16, Dow (trt 10-15) sequential applications at 8 to 10 WAT on July 1, and BASF (trt 21-25) POST applications on July 1.

NS = means are not significant at the 0.05 level.

-- = means comparisons tests are not valid for these data.

Table 3. Visual quality¹ of Kentucky bluegrass treated for the 1998 Pre- & Postemergent Annual Weed Control Study (July 14 - September 2).

Material	July 14	July 29	Aug 4	Aug 11	Aug 18	Aug 27	Sept 2	Mean
1. Untreated control	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.4
2. S-8096	6.0	7.3	7.0	7.0	7.0	7.0	6.0	6.9
3. S-8096	7.0	7.3	7.3	7.0	7.0	7.0	6.0	7.4
4. S-8097	6.3	7.0	7.0	7.0	7.0	7.0	6.0	7.0
5. S-8097	6.7	7.3	7.3	7.0	7.0	7.0	6.0	7.5
6. S-8162	6.3	7.0	7.0	7.0	7.0	7.0	6.0	6.5
7. S-8162	6.3	7.0	7.0	7.0	7.0	7.0	6.0	6.9
8. S-8161	6.3	7.0	7.0	7.0	7.0	7.0	6.0	6.7
9. S-8161	6.7	7.0	7.3	7.0	7.0	7.0	6.0	7.1
10. Team Pro NAF-324 0.86GR	7.0	7.7	8.0	7.0	7.0	7.0	6.0	7.1
11. Team Pro NAF-324 0.86GR	6.3	7.0	7.0	7.0	7.0	7.0	6.0	6.8
12. Pendimethalin 0.86GR	7.0	7.3	7.7	7.0	7.0	7.0	6.0	7.2
13. Pendimethalin 0.86GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	7.0
14. Dimension 0.10 GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	7.0
15. Barricade 0.22 GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.8
16. BAS051434H Drive 75DF	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.2
17. BAS051434H Drive 75DF	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.3
18. BAS 514 0.57GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.4
19. BAS 514 0.57GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.4
20. Pendimethalin 60WDG	6.3	7.0	7.0	7.0	7.0	7.0	6.0	6.5
21. BAS051434H Drive 75DF	6.3	7.0	7.0	7.0	7.0	7.0	6.0	6.5
22. BAS051434H Drive 75DF	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.4
23. BAS 514 0.57GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.4
24. BAS 514 0.57GR	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.3
25. Dimension IEC + NIS	6.0	7.0	7.0	7.0	7.0	7.0	6.0	6.4
26. Dimension IEC	6.7	7.0	7.0	7.0	7.0	7.0	6.0	7.2
27. Dimension 0.164FG AND445	6.3	7.0	7.0	7.0	7.0	7.0	6.0	7.1
28. Dithiopyr 1.06XF 98-025	6.7	7.0	7.0	7.0	7.0	7.0	6.0	7.1
29. Dithiopyr 0.89XF 98-026	7.0	7.0	7.0	7.0	7.0	7.0	6.0	7.1
30. Dithiopyr 2.20XF 98-029	6.7	7.3	7.7	7.0	7.0	7.0	6.0	7.2
31. Dimension 40WP	6.7	7.3	7.3	7.0	7.0	7.0	6.0	7.2
32. Fertilized control	6.7	7.0	7.3	7.0	7.0	7.0	6.0	7.1
LSD _{0.05}	0.7	NS	0.5	—	—	—	—	0.3

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable and 1 = worst quality.

Initial applications (PRE) were made on April 29, Scott's (trt 2-9) sequential applications at 6 to 8 WAT on June 16, Dow (trt 10-15) sequential applications at 8 to 10 WAT on July 1, and BASF (trt 21-25) POST applications on July 1.

NS = means are not significant at the 0.05 level.

-- = means comparisons tests are not valid for these data.

Table 4. Percentage crabgrass cover¹ in Kentucky bluegrass treated for the 1998 Pre- & Postemergent Annual Weed Control Study.

Material	July 7	July 14	July 24	July 29	Aug 4	Aug 11	Aug 18	Aug 27	Sept 2	Mean
	%									
1. Untreated control	13.3	14.0	26.7	26.7	33.3	25.0	35.0	38.3	53.3	29.5
2. S-8096	0.7	0.7	1.0	0.3	2.0	2.7	2.3	2.3	3.7	1.7
3. S-8096	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.1
4. S-8097	0.0	0.0	0.7	0.3	0.7	0.7	0.0	3.3	3.7	1.0
5. S-8097	0.3	0.0	0.0	0.0	0.7	0.3	0.3	1.0	1.0	0.4
6. S-8162	0.0	0.3	1.7	1.7	2.0	0.3	3.7	5.0	5.3	2.2
7. S-8162	0.0	0.0	0.3	0.0	0.3	0.0	1.0	0.0	1.7	0.4
8. S-8161	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.0	2.0	0.4
9. S-8161	0.0	0.7	0.7	0.7	0.7	1.0	1.7	0.7	1.7	0.9
10. Team Pro NAF-324 0.86GR	0.3	0.3	0.0	2.0	0.3	0.3	0.7	0.7	1.7	0.7
11. Team Pro NAF-324 0.86GR	0.0	0.0	0.3	1.0	1.0	1.0	2.7	2.3	3.7	1.3
12. Pendimethalin 0.86GR	1.7	2.0	8.3	6.7	5.0	3.3	6.7	5.0	12.0	5.6
13. Pendimethalin 0.86GR	0.3	1.3	2.7	1.3	5.3	4.3	6.7	8.3	8.3	4.3
14. Dimension 0.10 GR	0.3	0.0	0.0	0.0	0.0	1.0	1.7	2.0	2.0	0.8
15. Barricade 0.22 GR	0.3	0.7	2.7	1.3	1.0	1.0	2.0	2.3	3.7	1.7
16. BAS051434H Drive 75DF	9.0	4.0	25.7	18.3	16.7	21.7	20.0	33.3	36.7	20.6
17. BAS051434H Drive 75DF	11.7	13.3	21.7	18.3	23.3	20.0	25.0	35.0	41.7	23.3
18. BAS 514 0.57GR	2.0	7.0	10.3	10.7	13.7	9.3	13.3	21.7	26.7	12.7
19. BAS 514 0.57GR	11.7	9.3	25.0	28.3	28.3	23.3	30.0	41.7	56.7	28.3
20. Pendimethalin 60WDG	0.0	0.3	1.7	1.3	3.3	0.7	2.0	2.0	3.7	1.7
21. BAS051434H Drive 75DF	0.0	0.0	0.7	1.0	0.0	0.0	1.3	2.3	2.3	0.9
22. BAS051434H Drive 75DF	0.0	0.0	0.3	0.0	2.0	1.0	4.3	4.0	4.0	1.7
23. BAS 514 0.57GR	0.3	0.7	3.3	0.7	3.7	3.0	6.7	7.0	10.0	3.9
24. BAS 514 0.57GR	3.0	6.3	10.0	8.3	11.7	9.3	18.3	26.7	35.0	14.3
25. Dimension 1EC + NIS	2.3	2.3	3.0	1.0	3.7	2.0	5.3	2.3	3.7	2.9
26. Dimension 1EC	0.7	1.0	4.3	1.7	2.3	2.3	6.3	10.0	12.0	4.5
27. Dimension 0.164FG AND445	0.3	0.0	1.0	0.7	1.7	0.7	2.0	0.7	3.7	1.2
28. Dithiopyr 1.06XF 98-025	6.7	6.7	7.0	16.7	12.0	12.0	10.3	13.7	20.0	11.7
29. Dithiopyr 0.89XF 98-026	2.0	3.7	7.7	7.3	8.7	4.3	6.3	10.3	13.3	7.1
30. Dithiopyr 2.20XF 98-029	1.0	1.3	8.7	5.7	12.0	6.7	11.7	13.3	18.3	8.7
31. Dimension 40WP	0.7	1.7	3.7	3.7	4.0	2.3	5.3	6.7	8.3	4.0
32. Fertilized control	5.3	6.0	20.0	16.7	16.7	13.3	18.3	30.0	31.7	17.6
LSD _{0.05}	5.8	6.9	10.1	9.3	11.8	8.7	9.8	14.1	16.0	9.0

¹These figures represent the area per plot covered by crabgrass.

Initial applications (PRE) were made on April 29, Scott's (trt 2-9) sequential applications at 6 to 8 WAT on June 16, Dow (trt 10-15) sequential applications at 8 to 10 WAT on July 1, and BASF (trt 21-25) POST applications on July 1.

Table 5. Percentage crabgrass cover reductions¹ in Kentucky bluegrass treated for the 1998 Pre- & Postemergent Annual Weed Control Study.

Material	July 7	July 14	July 24	July 29	Aug 4	Aug 11	Aug 18	Aug 27	Sept 2	Mean
	%									
1. Untreated control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. S-8096	95.0	95.2	96.3	98.8	94.0	89.3	93.3	93.9	93.1	94.3
3. S-8096	100.0	100.0	100.0	100.0	100.0	100.0	99.0	99.1	99.4	99.7
4. S-8097	100.0	100.0	97.5	98.8	98.0	97.3	100.0	91.3	93.1	97.3
5. S-8097	97.5	100.0	100.0	100.0	98.0	98.7	99.0	97.4	98.1	98.7
6. S-8162	100.0	97.6	93.8	93.8	94.0	98.7	89.5	86.9	90.0	93.8
7. S-8162	100.0	100.0	98.8	100.0	99.0	100.0	97.1	100.0	96.9	99.1
8. S-8161	100.0	100.0	100.0	100.0	100.0	100.0	98.1	97.4	96.2	99.1
9. S-8161	100.0	95.2	97.5	97.5	98.0	96.0	95.2	98.3	96.9	97.2
10. Team Pro NAF-324 0.86GR	97.5	97.6	100.0	92.5	99.0	98.7	98.1	98.3	96.9	97.6
11. Team Pro NAF-324 0.86GR	100.0	100.0	98.8	96.3	97.0	96.0	92.4	93.9	93.1	96.4
12. Pendimethalin 0.86GR	87.5	85.7	68.8	75.0	85.0	86.7	81.0	86.9	77.5	81.6
13. Pendimethalin 0.86GR	97.5	90.5	90.0	95.0	84.0	82.7	81.0	78.2	84.4	87.0
14. Dimension 0.10 GR	97.5	100.0	100.0	100.0	100.0	96.0	95.2	94.8	96.2	97.8
15. Barricade 0.22 GR	97.5	95.2	90.0	95.0	97.0	96.0	94.3	93.9	93.1	94.7
16. BAS051434H Drive 75DF	32.3	71.4	3.9	31.3	50.0	13.3	42.9	13.0	31.2	32.1
17. BAS051434H Drive 75DF	12.3	4.8	18.9	31.3	30.0	20.0	28.6	8.6	21.8	19.6
18. BAS 514 0.57GR	85.0	50.0	61.3	60.0	59.0	62.7	61.9	43.4	50.0	59.2
19. BAS 514 0.57GR	12.3	33.3	6.4	0.0	14.9	6.7	14.3	0.0	0.0	7.4
20. Pendimethalin 60WDG	100.0	97.6	93.8	95.0	90.0	97.3	94.3	94.8	93.1	95.1
21. BAS051434H Drive 75DF	100.0	100.0	97.5	96.3	100.0	100.0	96.2	93.9	95.6	97.7
22. BAS051434H Drive 75DF	100.0	100.0	98.8	100.0	94.0	96.0	87.6	89.6	92.5	95.4
23. BAS 514 0.57GR	97.5	95.2	87.5	97.5	89.0	88.0	81.0	81.7	81.2	88.7
24. BAS 514 0.57GR	77.4	54.8	62.5	68.8	65.0	62.7	47.6	30.4	34.3	55.9
25. Dimension 1EC + NIS	82.5	83.3	88.8	96.3	89.0	92.0	84.8	93.9	93.1	89.3
26. Dimension 1EC	95.0	92.9	83.8	93.8	93.0	90.7	81.9	73.9	77.5	86.9
27. Dimension 0.164FG AND445	97.5	100.0	96.3	97.5	95.0	97.3	94.3	98.3	93.1	96.6
28. Dithiopyr 1.06XF 98-025	50.0	52.4	73.8	37.6	64.0	52.0	70.5	64.3	62.5	58.5
29. Dithiopyr 0.89XF 98-026	85.0	73.8	71.3	72.5	74.0	82.7	81.9	73.0	75.0	76.6
30. Dithiopyr 2.20XF 98-029	92.5	90.5	67.5	78.8	64.0	73.3	66.7	65.2	65.6	73.8
31. Dimension 40WP	95.0	88.1	86.3	86.3	88.0	90.7	84.8	82.6	84.4	87.3
32. Fertilized control	59.9	57.1	25.1	37.6	50.0	46.7	47.6	21.7	40.6	42.9
LSD _{0.05}	43.5	49.1	37.8	35.0	35.5	34.6	28.0	36.7	30.0	31.8

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

Initial applications (PRE) were made on April 29, Scott's (trt 2-9) sequential applications at 6 to 8 WAT on June 16, Dow (trt 10-15) sequential applications at 8 to 10 WAT on July 1, and BASF (trt 21-25) POST applications on July 1.

Table 6. The number of dandelions, oxalis, black medic, and percentage clover cover¹ in Kentucky bluegrass treated for the 1998 Pre- & Postemergent Annual Weed Control Study (data taken September 2).

	Material	Dandelion	Counts Oxalis	Black Medic	Percentage cover Clover
1.	Untreated control	25.3	0.7	0.0	6.7
2.	S-8096	19.7	0.3	0.3	1.7
3.	S-8096	6.3	0.0	0.7	8.3
4.	S-8097	26.3	0.0	6.3	1.7
5.	S-8097	6.0	0.7	1.7	0.0
6.	S-8162	15.7	0.0	1.7	1.7
7.	S-8162	12.3	0.0	0.0	1.7
8.	S-8161	20.0	0.7	1.7	5.0
9.	S-8161	14.0	0.3	1.0	1.7
10.	Team Pro NAF-324 0.86GR	21.0	0.0	0.0	0.3
11.	Team Pro NAF-324 0.86GR	15.3	0.0	0.0	3.3
12.	Pendimethalin 0.86GR	14.0	0.0	1.0	8.7
13.	Pendimethalin 0.86GR	15.3	0.0	0.0	6.7
14.	Dimension 0.10 GR	12.7	0.0	1.0	0.0
15.	Barricade 0.22 GR	16.7	0.0	0.0	0.0
16.	BAS051434H Drive 75DF	15.0	2.3	0.0	0.3
17.	BAS051434H Drive 75DF	21.3	0.7	0.0	0.3
18.	BAS 514 0.57GR	16.7	0.7	0.0	0.0
19.	BAS 514 0.57GR	19.7	0.7	2.7	0.0
20.	Pendimethalin 60WDG	13.3	0.3	0.3	5.0
21.	BAS051434H Drive 75DF + MSO	1.7	1.0	0.0	0.0
22.	BAS051434H Drive 75DF + MSO	3.0	2.0	0.0	0.3
23.	BAS 514 0.57GR	1.7	0.7	1.0	0.0
24.	BAS 514 0.57GR	8.3	0.3	0.3	0.3
25.	Dimension IEC + NIS	14.3	0.3	0.7	16.7
26.	Dimension IEC	17.3	0.0	0.0	5.0
27.	Dimension 0.164FG AND445	24.7	0.3	2.0	0.0
28.	Dithiopyr 1.06XF 98-025	12.7	0.0	0.3	0.3
29.	Dithiopyr 0.89XF 98-026	14.0	0.0	0.0	10.0
30.	Dithiopyr 2.20XF 98-029	18.0	0.0	0.3	13.3
31.	Dimension 40WP	17.7	0.3	0.3	0.0
32.	Fertilized control	12.0	0.0	0.0	10.3
	LSD _{0.05}	12.6	NS	2.6	NS

¹These values represent the number of dandelion, black medic, and oxalis plants per plot. Percentage clover cover data represent the area covered by clover per plot.

Initial applications (PRE) were made on April 29, Scott's (trt 2-9) sequential applications at 6 to 8 WAT on June 16, Dow (trt 10-15) sequential applications at 8 to 10 WAT on July 1, and BASF (trt 21-25) POST applications on July 1.

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

Postemergent Annual Weed Control Study

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

The efficacy of experimental postemergence herbicides for the control of annual grass and broadleaf weed species in turf was evaluated in this study. It was conducted at the Iowa State University Horticulture Research Station north of Ames, IA in an area of 'common' Kentucky bluegrass. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.4% organic matter, 38 ppm P, 145 ppm K, and a pH of 7.0. Turf mowing height was consistent with a high (home lawn) mowing regime of 2 to 3" for Kentucky bluegrass.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with 3 replications. There were fourteen treatments including an untreated control (Table 1). Treatments were applied early postemergence (EARLY POST) when crabgrass was in the 1- to 4-leaf stage and mid-postemergence (MID POST) when crabgrass had 1 to 3 tillers. EARLY POST treatments included Dimension 1EC at 1.5 oz/1000 ft², Acclaim Extra 0.57EW at 0.06 lb a.i./1000 ft² and Preclaim 3.09EC at 1.5 and 2.0 lb a.i./1000 ft². Preclaim 3.09EC also was applied MID POST at 2.0 and 3.0 lb a.i./1000 ft². Bas514 50WP was applied MID POST at 0.55 oz/1000 ft. Experimental formulations L-0051, L-0260, L-0289, L-0259, and L-0261 were applied MID POST at 3.0 lb a.i./1000 ft². In addition, L-0051 was applied MID POST at 4.0 lb a.i./1000 ft².

Early postemergence applications were made on July 1, 1998 and the MID POST on July 14. Liquids were applied using a carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles at 30 psi. The herbicides were diluted into 283 ml of water that translates to an application volume of 3 gal/1000 ft².

Kentucky bluegrass phytotoxicity was evaluated weekly beginning July 9. Phytotoxicity was rated using a 9 to 1 scale with 9 = no damage, 6 = some symptoms and 1 = dead turf. Turf quality was determined weekly beginning July 9. Quality was rated visually using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

Crabgrass damage was assessed on July 29, August 4, and August 11 by estimating the percentage living crabgrass per plot (Table 2). Damage was determined by estimating the amount of damage to the crabgrass plants within each plot using a 0 to 100% scale with 0 = no damage and 100% = dead plants. To assess crabgrass mortality, the percentage of area per plot covered by crabgrass was estimated on July 9, August 18, August 26, September 4, September 9, September 16, and September 21 using a 0 to 100% scale (Table 3). Percentage reductions in cover were calculated by comparing the cover in treated turf to the untreated controls (Table 4).

Broadleaf weed control was determined through population counts on July 21. The number of oxalis, spurge, and dandelion plants per plot was counted. Clover populations were determined by estimating the percentage of area per plot covered by clover (Table 5). In addition, because of the large numbers of small plants in some plots, percentage cover data also were taken for dandelion.

All data were analyzed using the Statistical Analysis System (SAS, version 6.12) and the Analysis of Variance (ANOVA) procedure. Differences among the means were examined with Fisher's Least Significant Difference (LSD) means separation test.

There was no bluegrass phytotoxicity detected following either the EARLY POST or MID POST applications. There was a slight yellow tint observed on bluegrass following treatment with Preclaim 3.09EC but this discoloration disappeared after 24 hours. There were no visual quality differences among the treated and untreated plots throughout the season.

On July 9, virtually all of the crabgrass was dead in turf treated with the EARLY POST materials (Table 3 and 4). The MID POST treatments began to cause damage on July 17, three days after application. Symptoms included curling of leaves, collapsed plants, and leaf discoloration. Two weeks after the MID POST applications, crabgrass plants were exhibiting a wide range of damage from slightly damaged to moderately damaged (Table 2). Damage was severe in most treated plots by August 11.

There were significant differences in percentage crabgrass cover for August 18 through September 21 (Table 3). All materials significantly reduced crabgrass cover as compared with the controls on August 18, September 4, and September 9 (Table 4). On August 18, there was at least 55% crabgrass cover reduction in turf treated with the MID POST materials as compared with the untreated controls. Turf treated with the EARLY POST materials had $\geq 93\%$ reductions in crabgrass cover as compared with the controls on August 18. After September 9, some of the materials were no longer providing significant reductions in crabgrass cover as compared with the untreated controls. The EARLY POST materials (treatments 9-11 and 14), however, provided $\geq 81\%$ reductions in crabgrass for the duration of the study.

The mean crabgrass reduction data show that all materials significantly reduced crabgrass cover as compared with the untreated controls. Mean reductions were $> 50\%$ for all materials. Two EARLY POST materials, Dimension 1EC at 1.5 oz/1000 ft² and Preclaim 3.09EC at 2.0 lb a.i./A, provided reductions in crabgrass cover $> 96\%$. The other EARLY POST materials (Preclaim 3.09EC at 1.5 lb a.i./A and Acclaim Extra 0.57EW at 0.06 lb a.i./A) and Preclaim 3.09EC at 2.0 and 3.0 lb a.i./A MID POST produced mean reductions $> 86\%$.

This study did not produce any hard evidence concerning the efficacy of these materials for controlling broadleaf weeds. There were numerical differences in oxalis and spurge populations found in the treated and untreated turf but the differences were not statistically different (Table 5). Most treated turf contained more oxalis plants than the untreated controls. Clover was found only in turf treated with either the EARLY POST materials or Preclaim MID POST. These results can probably be attributed to the decrease in competition in turf where the crabgrass was killed.

Dandelion counts were significantly different but no product significantly reduced dandelion populations as compared with the untreated control (Table 5). The largest dandelion populations were found in treated turf where the removal of crabgrass had reduced competition as compared to the untreated turf.

Table 1. Materials used in the 1998 Postemergence Annual Weed Study.

	Materials	Rate lb/1000 ft ²	Timing of applications
1	Untreated control	N/A	N/A
2	L-0051 ¹	3.00	MID POST
3	L-0051 ¹	4.00	MID POST
4	L-0260 ¹	3.00	MID POST
5	L-0289 ¹	3.00	MID POST
6	L-0259 ¹	3.00	MID POST
7	L-0261 ¹	3.00	MID POST
8	BAS514 50WP ¹	0.55 oz	MID POST
9	Dimension 1EC ¹	1.50 oz	EARLY POST
		Rate lb a.i./A	
10	Preclaim 3.09 EC ²	1.50	EARLY POST
11	Preclaim 3.09 EC ²	2.00	EARLY POST
12	Preclaim 3.09 EC ²	2.00	MID POST
13	Preclaim 3.09 EC ²	3.00	MID POST
14	Acclaim Extra 0.57EW ^{1&2}	0.06	EARLY POST

These materials are being screened for LESCO¹ and AgrEvo².

Early post applications were made on July 1 when the crabgrass was in the 1 to 4 leaf stage and mid post applications on July 14 when the crabgrass had 1 to 3 tillers.

Table 2. Percentage living crabgrass per plot¹ in Kentucky bluegrass treated for the 1998 Postemergence Annual Weed Study.

Materials		July 29	August 4	August 11	Mean
		%			
1	Untreated control	100.0	80.0	38.3	72.8
2	L-0051	45.0	41.7	25.0	37.2
3	L-0051	63.3	58.3	11.7	44.4
4	L-0260	76.7	58.3	18.3	51.1
5	L-0289	66.7	68.3	10.0	48.3
6	L-0259	85.0	68.3	16.7	56.7
7	L-0261	53.3	60.0	13.7	42.3
8	BAS514 50WP	53.3	61.7	3.7	40.0
9	Dimension IEC	0.0	30.0	0.0	10.0
10	Preclaim 3.09 EC	0.0	66.7	6.7	24.4
11	Preclaim 3.09 EC	0.0	0.0	0.0	0.0
12	Preclaim 3.09 EC	16.7	8.3	2.0	9.0
13	Preclaim 3.09 EC	36.7	8.3	1.7	15.6
14	Acclaim Extra 0.57EW	0.0	0.0	1.0	0.3
LSD _{0.05}		42.2	48.0	17.3	28.2

¹These figures represent the percentage of crabgrass per plot that was green and healthy.**Table 3.** Percentage crabgrass cover¹ in Kentucky bluegrass treated for the 1998 Postemergence Annual Weed Study.

Materials		July 9	August 18	August 26	Sept 4	Sept 9	Sept 16	Sept 21	Mean cover
		%							
1	Untreated control	9.3	71.7	58.3	66.7	58.3	70.0	76.7	58.7
2	L-0051	12.0	32.0	33.7	32.0	23.3	35.0	41.7	30.0
3	L-0051	25.0	26.7	25.0	18.3	16.7	43.3	61.7	31.0
4	L-0260	13.7	31.7	31.7	7.0	12.0	43.3	43.3	26.1
5	L-0289	7.7	16.7	25.0	20.0	23.3	33.3	53.3	25.6
6	L-0259	11.7	16.7	18.3	25.3	25.0	35.0	55.0	26.7
7	L-0261	19.3	20.0	21.7	23.7	13.7	28.3	53.3	25.7
8	BAS514 50WP	18.3	23.3	25.0	28.3	23.7	25.0	26.7	24.3
9	Dimension IEC	0.0	2.0	1.7	0.7	0.3	5.0	5.0	2.1
10	Preclaim 3.09 EC	0.0	5.0	8.3	6.7	8.3	13.3	2.0	6.2
11	Preclaim 3.09 EC	0.0	0.7	2.0	0.3	0.3	3.3	3.7	1.5
12	Preclaim 3.09 EC	17.3	3.7	8.3	8.7	6.7	1.7	16.7	9.0
13	Preclaim 3.09 EC	32.3	3.3	3.7	3.7	5.3	10.0	5.0	9.0
14	Acclaim Extra 0.57EW	0.3	2.0	5.3	5.0	8.3	13.3	20.0	7.8
LSD _{0.05}		NS	27.2	27.9	29.8	27.0	32.4	43.1	26.8

¹These figures represent the area per plot covered by crabgrass.

EARLY POST applications were made on July 1 and MID POST applications on July 14.

Table 4. Percentage crabgrass cover reductions¹ in Kentucky bluegrass treated for the 1998 Postemergence Annual Weed Study.

Materials		July 9	August 18	August 26	Sept 4	Sept 9	Sept 16	Sept 21	Mean reduction ²
		%							
1	Untreated control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	L-0051	0.0	55.4	42.3	52.0	60.0	50.0	45.7	50.8
3	L-0051	0.0	62.8	57.1	72.5	71.4	38.1	19.6	52.3
4	L-0260	0.0	55.8	45.7	89.5	79.4	38.1	43.5	57.9
5	L-0289	17.9	76.7	57.1	70.0	60.0	52.4	30.4	57.2
6	L-0259	0.0	76.7	68.6	62.0	57.1	50.0	28.3	56.3
7	L-0261	0.0	72.1	62.9	64.5	76.6	59.5	30.4	60.0
8	BAS514 50WP	0.0	67.4	57.1	57.5	59.4	64.3	65.2	62.1
9	Dimension 1EC	100.0	97.2	97.1	99.0	99.4	92.9	93.5	96.4
10	Preclaim 3.09 EC	100.0	93.0	85.7	90.0	85.7	81.0	97.4	89.4
11	Preclaim 3.09 EC	100.0	99.1	96.6	99.5	99.4	95.2	95.2	97.5
12	Preclaim 3.09 EC	0.0	94.9	85.7	87.0	88.6	97.6	78.3	88.6
13	Preclaim 3.09 EC	0.0	95.3	93.7	94.5	90.9	85.7	93.5	92.3
14	Acclaim Extra 0.57EW	96.4	97.2	90.9	92.5	85.7	81.0	73.9	86.8
LSD _{0.05}		NS	37.9	47.9	44.6	46.2	46.3	56.2	42.7

¹These figures represent reductions in crabgrass cover in treated turf as compared with the untreated control.

²Mean reductions include data from August 18 through September 21. Mean reductions for the EARLY POST treatments (trts 9-11 and 14) include values from July 9 through September 21.

EARLY POST applications were made on July 1 and MID POST applications on July 14.

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

Table 5. Broadleaf weed species populations¹ on September 21 in Kentucky bluegrass treated for the 1998 Postemergence Annual Weed Study.

Materials		Oxalis	Spurge	Dandelion		Clover
		Counts	Counts	Counts	Percentage cover (%)	Percentage cover (%)
1	Untreated control	1.7	2.3	16.0	6.7	0.0
2	L-0051	7.3	3.7	13.3	5.0	0.0
3	L-0051	13.3	0.0	7.0	3.7	0.0
4	L-0260	3.3	0.3	13.3	8.3	0.0
5	L-0289	12.3	0.7	15.7	8.3	0.0
6	L-0259	4.7	1.0	7.0	3.7	0.0
7	L-0261	7.0	1.0	10.0	3.7	0.0
8	BAS514 50WP	2.7	0.3	13.7	6.7	0.0
9	Dimension 1EC	7.3	2.0	31.3	20.0	1.7
10	Preclaim 3.09 EC	1.0	0.3	32.3	18.3	8.3
11	Preclaim 3.09 EC	3.0	2.0	19.3	11.7	5.0
12	Preclaim 3.09 EC	2.3	1.3	12.3	7.0	0.3
13	Preclaim 3.09 EC	1.7	0.7	28.7	20.0	5.0
14	Acclaim Extra 0.57EW	7.3	5.7	31.3	21.7	10.0
LSD _{0.05}		NS	NS	16.0	14.2	NS

P > F = 0.08

¹Count data represent the number of Oxalis, Spurge, and Dandelion per plot. Percentage cover data represent the area per plot covered by Dandelion and Clover.

Early post applications were made on July 1 when the crabgrass was in the 1-to 4-leaf stage and mid post applications on July 14 when the crabgrass had 1 to 3 tillers.

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

Postemergent Broadleaf Weed Control Study

Barbara R. Bingaman, Melissa C. McDade, Michael B. Faust, and Nick E. Christians

The efficacy of Drive 75DF applied alone postemergently (POST) and in combination with other postemergence broadleaf herbicides was evaluated. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, IA in 'common' Kentucky bluegrass with a dense population of red clover, white clover, dandelions, plantain, and other assorted broadleaf weed species. The soil in this plot was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 4.45% organic matter, 26 ppm P, 257 ppm K, and a pH of 6.65. The experimental design was a randomized complete block. The individual plots were 5 x 10 ft with 3 replications.

There were eight treatments including an untreated control. Drive 75DF was applied at 0.25, 0.50, and 0.75 lb a.i./A (Table 1). Drive 75DF also was applied at these same rates as a tank mix with 2, 4-D Amine 4.1SL at 0.75 lb a.i./A. Trimec Classic 3.32EC at 1.5 lb a.i./A and an untreated control were included for comparisons. Methylated soy oil (MSO) was added to all treatments as a carrier at 1.0% V/V.

All materials were applied POST on June 5, 1998 after the broadleaf weeds were well established. Application was made at 30 psi with a carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles. The materials were diluted into 567 ml of water that translates to an application rate of 3 gal/1000 ft².

The study was checked for phytotoxicity and visual quality differences weekly beginning June 10 (Table 1). Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality. Phytotoxicity was quantified using a 9 to 1 scale with 9 = no damage, 6 = moderate damage, and 1 = dead turf.

Weed control was evaluated for all broadleaf and grass species found. Dandelion and clover damage ratings were taken on June 10, 24, and 30 (Table 2). Damage was assessed using a 9 to 1 scale with 9 = no damage, 5 = plants 50% dead, 1 = dead plants. Dandelion counts were taken on July 8 and July 30 and these figures represent the number of dandelions per plot (Table 3). Because of the large numbers of small dandelion plants, percentage dandelion cover data were taken on July 15 and July 30 (Table 4). In plots with large numbers of dandelions, the number in a portion of the plot was counted and this number was then adjusted to represent the entire plot. Percentage clover cover data were taken on July 8, July 15, and July 30 (Table 5). Percentage cover data represent the area per plot covered by clover. Population assessments were made of all weed species in each plot on July 30 (Table 6). The number of crabgrass, spurge, plantain, purslane, and oxalis was counted per plot.

All data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Treatment effects were compared with Fisher's Least Significant Difference (LSD) test.

No phytotoxic symptoms were found on any treated turf as compared with the untreated controls. None of the materials reduced the quality of the treated turf as compared with the untreated controls (Table 1).

Some materials were causing damage to dandelion and clover as early as 5 days after treatment on June 10 (Table 2). By June 24, all treated dandelion and clover were damaged and by June 30, dead clover was found in turf treated with Drive 75DF at 0.25, 0.50, and 0.75 lb a.i./A (treatments 5-7).

All materials significantly reduced dandelion counts (Table 3). Drive 75DF at 0.25, 0.50, and 0.75 lb a.i./A in tank mix with 2,4-D Amine 4.1SL and Drive 75DF at 0.75 lb a.i./A alone reduced dandelion populations $\geq 92.5\%$ on July 8 and $\geq 86.2\%$ on July 30 as compared with the untreated controls.

Percentage dandelion cover was significantly lower in all treated turf as compared with the untreated controls (Table 4). On July 15 and July 30, Drive 75DF plus 2,4-D Amine 4.1SL tank mixes and Drive 75DF alone at 0.50 and 0.75 lb a.i./A reduced dandelion cover by $\geq 90.0\%$ as compared with the untreated controls.

All treatments significantly reduced percentage clover cover as compared with the untreated controls (Table 5). Cover was reduced at least 95.9% in all treated turf for July 8, July 15, and July 30 as compared with the untreated controls.

The distribution of spurge, plantain, purslane and oxalis were quite sporadic. Populations of these broadleaves were not significantly different in the treated and untreated controls (Table 6).

The distribution of crabgrass was more uniform and there was more crabgrass in all treated turf than in the untreated controls (Table 6). There were significantly more crabgrass plants in turf treated with Drive 75DF at 0.25 lb a.i./A plus 2,4-D Amine 4.1SL and Trimec Classic 3.32EC at 1.5 lb a.i./A than in the untreated controls. The small crabgrass numbers in the untreated turf can be explained by the competition from the large populations of clover and dandelion. In the treated turf, crabgrass moved into bare areas created where dandelion and clover were killed.

Table 1. Visual turf quality¹ of turf in the 1998 Postemergence Broadleaf Weed Control Study.

Material ²		Rate (lb a.i./A)	June 10	June 24	June 30	July 8	July 15	July 24	July 30
1.	Untreated control	N/A	9	7	7	7	7	7	7
2.	Drive 75DF	0.25	9	7	7	7	7	7	7
3.	Drive 75DF	0.50	9	7	7	7	7	7	7
4.	Drive 75DF	0.75	9	7	7	7	7	7	7
5.	Drive 75DF	0.25	9	7	7	7	7	7	7
	+ 2,4-D Amine 4.1SL	0.75							
6.	Drive 75DF	0.50	9	7	7	7	7	7	7
	+ 2,4-D Amine 4.1SL	0.75							
7.	Drive 75DF	0.75	9	7	7	7	7	7	7
	+ 2,4-D Amine 4.1SL	0.75							
8.	Trimec Classic 3.32EC	1.50	9	7	7	7	7	7	7
LSD _{0.05}			--	--	--	--	--	--	--

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable & 1 = worst quality.

²MSO was added to all treatments at 1.0% V/V. POST applications were made on June 5, 1998.

-- = means comparisons tests are not valid for these data.

Table 2. Dandelion and clover damage¹ following treatment for the 1998 Postemergence Broadleaf Weed Control Study.

Material ²		Rate (lb a.i./A)	Dandelion damage			Clover damage		
			June 10	June 24	June 30	June 10	June 24	June 30
1.	Untreated control	N/A	9.0	9.0	9.0	9.0	9.0	9.0
2.	Drive 75DF	0.25	8.7	7.3	4.3	8.7	7.3	2.3
3.	Drive 75DF	0.50	9.0	8.0	4.7	8.3	5.0	2.0
4.	Drive 75DF	0.75	8.7	7.0	5.0	8.0	7.0	2.0
5.	Drive 75DF	0.25	9.0	7.0	3.3	8.3	7.0	1.0
	+ 2,4-D Amine 4.1SL	0.75						
6.	Drive 75DF	0.50	8.3	6.3	2.7	7.7	4.0	1.0
	+ 2,4-D Amine 4.1SL	0.75						
7.	Drive 75DF	0.75	8.7	7.0	2.0	8.0	7.0	1.0
	+ 2,4-D Amine 4.1SL	0.75						
8.	Trimec Classic 3.32EC	1.50	7.0	7.3	3.3	7.3	7.3	1.7
LSD _{0.05}			1.0	1.5	2.1	NS	2.5	1.7

¹Damage was assessed using a 9 to 1 scale with 9 = no damage, 5 = plants 50% dead, 1 = dead plants.

²MSO was added to all treatments at 1.0% V/V.

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

Table 3. Dandelion counts¹ and reductions in dandelion counts² following treatment for the 1998 Postemergence Broadleaf Weed Control Study.

Material ³	Rate (lb a.i./A)	Dandelion counts			Count reductions		
		July 8	July 30	Mean	July 8	July 30	Mean
1. Untreated control	N/A	476.7	210.0	343.3	0.0	0.0	0.0
2. Drive 75DF	0.25	123.3	95.0	109.2	74.1	54.8	68.2
3. Drive 75DF	0.50	74.3	65.0	69.7	84.4	69.0	79.7
4. Drive 75DF	0.75	36.0	29.0	32.5	92.5	86.2	90.5
5. Drive 75DF	0.25	6.3	8.3	7.3	98.7	96.0	97.9
+ 2,4-D Amine 4.1SL	0.75						
6. Drive 75DF	0.50	3.0	3.0	3.0	99.4	98.6	99.1
+ 2,4-D Amine 4.1SL	0.75						
7. Drive 75DF	0.75	1.7	1.0	1.3	99.7	99.5	99.6
+ 2,4-D Amine 4.1SL	0.75						
8. Trimec Classic 3.32EC	1.50	107.0	71.7	89.3	77.6	65.9	74.0
LSD _{0.05}		79.7	67.7	56.5	16.7	32.3	16.5

¹These figures represent the number of dandelions per plot. In plots with large populations, dandelion counts were estimated by counting the number of dandelions in a portion of the plot. Smaller counts in the untreated controls were recorded on July 30 than on July 15. This could be explained by the large increase in the percentage clover cover and the difficulty in finding dandelions in a dense clover cover.

²Reductions in dandelion counts are expressed as percentages of the untreated controls.

³MSO was added to all treatments at 1.0% V/V.

POST applications were made on June 5, 1998.

Table 4. Percentage dandelion cover¹ and reductions in cover² following treatment for the BASF Postemergence Broadleaf Study.

Material ³	Rate (lb a.i./A)	Percentage dandelion cover			Cover reductions		
		July 15	July 30	Mean	July 15	July 30	Mean
		%					
1. Untreated control	N/A	23.3	25.0	24.2	0.0	0.0	0.0
2. Drive 75DF	0.25	6.7	6.7	6.7	71.4	73.3	72.5
3. Drive 75DF	0.50	2.3	2.3	2.3	90.0	90.7	90.4
4. Drive 75DF	0.75	0.7	2.3	1.5	97.1	90.7	93.8
5. Drive 75DF	0.25	0.3	1.0	0.7	98.6	96.0	97.2
+ 2,4-D Amine 4.1SL	0.75						
6. Drive 75DF	0.50	0.3	0.7	0.5	98.6	97.3	97.9
+ 2,4-D Amine 4.1SL	0.75						
7. Drive 75DF	0.75	0.0	0.7	0.3	100.0	97.3	98.6
+ 2,4-D Amine 4.1SL	0.75						
8. Trimec Classic 3.32EC	1.50	5.3	4.0	4.7	77.1	84.0	80.7
LSD _{0.05}		4.0	4.5	4.0	17.1	17.9	16.4

¹Percentage dandelion cover was determined by estimating the area per plot covered by dandelions. These estimations were made to more accurately depict the dandelion populations in treated plots.

²Reductions in dandelion cover are expressed as percentages of the untreated controls.

³MSO was added to all treatments at 1.0% V/V.

POST applications were made on June 5, 1998.

Table 5. Percentage clover cover¹ and reductions in clover cover² following treatment for the BASF Postemergence Broadleaf Study.

Material ³	Rate (lb a.i./A)	Percentage clover cover				Cover reductions			
		July 8	July 15	July 30	Mean	July 8	July 15	July 30	Mean
		%							
1. Untreated control	N/A	56.7	56.7	73.3	62.2	0.0	0.0	0.0	0.0
2. Drive 75DF	0.25	2.3	2.0	2.3	2.2	95.9	96.5	96.8	96.4
3. Drive 75DF	0.50	0.0	0.7	0.7	0.4	100.0	98.8	99.1	99.3
4. Drive 75DF	0.75	0.7	0.0	0.3	0.3	98.8	100.0	99.5	99.5
5. Drive 75DF	0.25	1.3	0.3	2.3	1.3	97.6	99.4	96.8	97.9
+ 2,4-D Amine 4.1SL	0.75								
6. Drive 75DF	0.50	0.3	0.0	0.3	0.2	99.4	100.0	99.5	99.6
+ 2,4-D Amine 4.1SL	0.75								
7. Drive 75DF	0.75	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0
+ 2,4-D Amine 4.1SL	0.75								
8. Trimec Classic 3.32EC	1.50	1.7	2.0	0.7	1.4	97.1	96.5	99.1	97.7
LSD _{0.05}		6.9	12.5	7.1	8.0	12.2	22.1	9.7	12.9

¹Percentage clover cover was determined by estimating the area per plot covered by clover.²Reductions in clover cover are expressed as percentages of the untreated controls.³MSO was added to all treatments at 1.0% V/V.

POST applications were made on June 5, 1998.

Table 6. Crabgrass, spurge, plantain, purslane, and oxalis counts¹ following treatment for the BASF Postemergence Broadleaf Study.

Material ²	Rate (lb a.i./A)	Crabgrass	Spurge	Plantain	Purslane	Oxalis
1. Untreated control	N/A	2.0	0.0	1.7	0.0	0.0
2. Drive 75DF	0.25	4.3	1.3	0.3	0.0	0.0
3. Drive 75DF	0.50	4.7	3.7	0.3	0.7	0.3
4. Drive 75DF	0.75	3.3	2.7	0.3	0.0	0.3
5. Drive 75DF	0.25	13.7	2.3	0.0	0.0	0.3
+ 2,4-D Amine 4.1SL	0.75					
6. Drive 75DF	0.50	7.3	2.3	0.0	0.3	0.3
+ 2,4-D Amine 4.1SL	0.75					
7. Drive 75DF	0.75	4.7	2.3	0.0	1.3	0.3
+ 2,4-D Amine 4.1SL	0.75					
8. Trimec Classic 3.32EC	1.50	12.3	0.7	0.0	0.3	0.0
LSD _{0.05}		7.4	NS	NS	NS	NS

¹ These figures represent the number of plants per plot.²MSO was added to all treatments at 1.0% V/V.

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

Postemergent Granular & Sprayable Broadleaf Weed Control Study

Barbara R. Bingaman, Melissa C. McDade, Michael B. Faust, and Nick E. Christians

A field study was initiated to compare the efficacy of several new granular broadleaf weed and feed products to the standard herbicides in applications made to both damp and dry foliage. Sprayable formulations also were screened to: 1) determine the efficacy of Millenium Ultra, Horsepower, DTDA, XRM-5202, and other research numbered compounds to traditional 3-way herbicides; 2) determine the efficacy differential between the optical and racemic isomers of 2, 4-DP and MCPP; 3) determine the efficacy of Confront as compared to traditional 3-way herbicides.

This study was conducted at the Iowa State University Horticulture Research Station north of Ames, IA in an area of common bluegrass with a heavy infestation of red clover, white clover, dandelions, and assorted broadleaf weed species. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 4.45%, a pH of 6.65, 26 ppm P, and 257 ppm K. The experimental plots were 5 x 10 ft with three replications and two rows per replication.

The study was comprised of 34 treatments including eight granular materials applied to both wet and dry foliage (Table 1). Those plots receiving the granular materials were split into two 2 1/2 x 10 ft plots. The northern one was wet with water just prior to application and the southern was kept dry. Half of the total material for these plots was applied to the wet foliage and half to the dry.

The sprayable materials included Millenium Ultra, Horsepower, DTDA, XRM 5202, Confront, RDL202, RDL211, and RDL414. Super Trimec and Trimec Classic were included as industry standards and Triplet as a 3-way herbicide standard. The racemic (R) and optical (O) formulations of Dissolve, MCPP, and 2,4-DP also were screened. An untreated control was included.

Granular materials were applied using cardboard containers as 'shaker dispensers'. Sprayables were applied at 30-35 psi using a carbon dioxide backpack sprayer equipped with TeeJet® #8006 flat fan nozzles. The liquids were diluted into 567 ml of water. This translates to an application rate of 3 gal/1000 ft². All products were applied postemergently after dandelions, clover, and other broadleaf species were well established. Applications were made on June 5, 1998. The plot was neither irrigated nor mowed for 24 hours following application.

Turf quality and phytotoxicity data were taken from June 10 through July 30 (Table 2). Visual quality was assessed using a scale from 9 to 1 with 9 = best, 6 = lowest acceptable, and 1 = worst quality. Phytotoxicity was recorded as present or absent.

Broadleaf and grass weed species were monitored. Weed damage data were taken on June 10 (Table 3). Damage to dandelions and clover was assessed using a 9 to 1 scale with 9 = no damage, 5 = 50% of plants showing damage, and 1 = 100% of plants exhibiting damage. The symptoms of damage included foliage discoloration, wilting, and curling. Percentage dandelion and clover mortality data were taken on June 24 and June 30 (Table 4). Mortality was assessed by estimating the number of living plants per plot and comparing to the untreated controls. Dandelion counts (Table 5) and percentage clover cover (Table 7) data were collected on July 7, July 14, July 24, and July 30. For these data, the number of dandelions was counted and the percentage clover cover was estimated for each plot. Reductions were calculated as percentages of the untreated controls on each collection date for dandelion (Table 6) and clover (Table 8).

Percentage crabgrass cover data were taken on July 7, July 14, July 24, and July 30 (Table 9). Reductions were not calculated since there was more crabgrass in many of the treated plots than in the untreated controls. The only other weed species with a widespread distribution was spurge. The number of spurge per plot was counted (Table 10). Reductions in numbers were not calculated because there were no spurge plants in the untreated controls.

All data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference (LSD) test was utilized for means comparisons.

No phytotoxicity was found during this study. Visual quality of turf treated with the herbicide plus fertilizer formulations was better than the untreated and unfertilized turf (Table 2). The numerical differences were not statistically significant. The turf treated with the herbicide plus fertilizer materials had consistently improved quality over the entire duration of the study as compared with the untreated and unfertilized turf.

Many of the sprayable materials were causing significant levels of damage to dandelion and clover as compared with the untreated control on June 10 (Table 3). Dandelion and clover treated with the granular formulations were not exhibiting significant damage on this date.

By June 30, six of the sprayable materials had caused dandelion mortality $\geq 90\%$ as compared with the untreated control (Table 4). On this date, 11 of the sprayable formulations and two granulars (applied to wet foliage) had killed all of the clover.

Sixteen of the sprayable materials significantly decreased dandelion counts on July 7 and all sprayables significantly suppressed dandelions July 14 through July 30 as compared to the untreated controls (Table 5). Treatment with the granular formulations applied to either wet or dry foliage resulted in significantly fewer dandelions from July 7 through July 30 as compared to the untreated controls.

On July 7, 12 sprayable herbicides reduced dandelion populations $> 94\%$ as compared with the untreated control (Table 6). By July 30, only eight sprayables were providing this level of reduction. The mean level of control was $\geq 91.4\%$ for 10 sprayable materials as compared with the untreated control.

One granular formulation reduced dandelion populations $> 90\%$ and two granulars produced reductions $> 83.4\%$ as compared with the untreated controls on July 7 (Table 6). Three granulars provided dandelion control that was $\geq 80.5\%$ on July 30. For some of the granular materials, significantly better control was achieved when the material was applied to wet foliage than to dry (Table 11). Mean dandelion control was significantly better for five of the granular materials when applied to wet foliage than to dry.

All sprayable and granular herbicides significantly suppressed clover cover July 7 through July 30 as compared with the untreated controls (Table 7). Twenty-three materials kept clover cover below 5.0% on July 7 as compared to the untreated control. The mean clover cover was $< 5.0\%$ for 20 of the materials and 12 of these kept clover cover $\leq 1.0\%$ for the entire duration of the study.

Twenty-three materials reduced clover cover $\geq 92\%$ on July 7 as compared with the untreated control and 11 of these killed all clover (Table 8). Mean clover cover reductions were $> 94\%$ for 20 of the herbicide formulations.

Clover control was similar for most granular materials applied on wet and on dry foliage (Table 12). There were numerical differences in reduction of clover cover between the dry and wet applications but they were not statistically significant.

Percentage crabgrass cover was significantly higher in turf treated with nine of the sprayable materials than in the untreated controls on July 14 (Table 9). By July 30, crabgrass cover was $> 20\%$ in turf treated with 13 of the herbicides and was $< 1\%$ in the untreated control. The crabgrass populations in the treated turf can be explained by the reduced competition from dandelion and clover as compared with competition in the untreated turf.

Spurge numbers were significantly higher in some treated turf as compared with the untreated control (Table 10). These populations also can be explained by the reduced competition in the treated turf as compared with the untreated turf.

Table 1. Herbicides applied on June 5 for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	Rate oz/1000 ft ²	Formulation	Dry or wet foliage
1	Untreated control	N/A	N/A
2	Millenium Ultra 47.10%	0.92	sprayable
3	Horsepower 50.40%	0.92	sprayable
4	DTDA 47.30%	0.92	sprayable
5	XRM 5202 55.80%	1.29	sprayable
6	Confront 45.10%	0.74	sprayable
7	Triplet (std) 49.67%	1.20	sprayable
8	RDL202 89.76%DF	0.61	sprayable
9	RDL211 55.98%	1.10	sprayable
10	RDL414 55.48%	1.10	sprayable
11	MCPP (R) 51.90%	1.10	sprayable
12	MCPP (O) 25.96%	1.10	sprayable
13	2,4-DP (R) 50.00%	1.10	sprayable
14	2,4-DP (O) 25.00%	1.10	sprayable
15	Dissolve (R) 57.70%	1.50	sprayable
16	Dissolve (O) 43.31%	1.50	sprayable
17	Super Trimec	1.10	sprayable
18	Trimec Classic 3.4SL	1.50	sprayable

Material	Rate lb/1000 ft ²	Formulation	Dry or wet foliage
19	Millenium Ultra W & F -18 ¹	3.60	granular
20	Trupower W & F -18 ¹	3.60	granular
21	Dissolve W & F -18 ¹	3.60	granular
22	Dissolve Ultra W & F -18 ¹	3.60	granular
23	Horsepower W & F -18 ¹	3.60	granular
24	XRM 5202 W & F -18 ¹	3.60	granular
25	Turf Builder + 2 ¹	2.94	granular
26	Fertilized control ¹	3.60	granular
27	Millenium Ultra W & F -18 ¹	3.60	granular
28	Trupower W & F -18 ¹	3.60	granular
29	Dissolve W & F -18 ¹	3.60	granular
30	Dissolve Ultra W & F -18 ¹	3.60	granular
31	Horsepower W & F -18 ¹	3.60	granular
32	XRM 5202 W & F -18 ¹	3.60	granular
33	Turf Builder + 2 ¹	2.94	granular
34	Fertilized control ¹	3.60	granular

¹The 5 x 10 ft plots for these treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.

Table 2. Visual quality¹ of turf treated on June 5 for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	June 10	June 24	June 30	July 7	July 14	July 24	July 30
1	Untreated control	7	7	7	6	6	6
2	Millenium Ultra 47.10%	7	7	7	6	6	6
3	Horsepower 50.40%	7	7	7	6	6	6
4	DTDA 47.30%	7	7	7	6	6	6
5	XRM 5202 55.80%	7	7	7	6	6	6
6	Confront 45.10%	7	7	7	6	6	6
7	Triplet (std) 49.67%	7	7	7	6	6	6
8	RDL202 89.76%DF	7	7	7	6	6	6
9	RDL211 55.98%	7	7	7	6	6	6
10	RDL414 55.48%	7	7	7	6	6	6
11	MCPP (R) 51.90%	7	7	7	6	6	6
12	MCPP (O) 25.96%	7	7	7	6	6	6
13	2,4-DP (R) 50.00%	7	7	7	6	6	6
14	2,4-DP (O) 25.00%	7	7	7	6	6	6
15	Dissolve (R) 57.70%	7	7	7	6	6	6
16	Dissolve (O) 43.31%	7	7	7	6	6	6
17	Super Trimec	7	7	7	6	6	6
18	Trimec Classic 3.4SL	7	7	7	6	6	6
19	Millenium Ultra W & F -18 ²	8	8	8	7	7	7
20	Trupower W & F -18 ²	8	8	8	7	7	7
21	Dissolve W & F -18 ²	8	8	8	7	7	7
22	Dissolve Ultra W & F -18 ²	8	8	8	7	7	7
23	Horsepower W & F -18 ²	8	8	8	7	7	7
24	XRM 5202 W & F -18 ²	8	8	8	7	7	7
25	Turf Builder + 2 ²	8	8	8	7	7	7
26	Fertilized control ²	8	8	8	7	7	7
27	Millenium Ultra W & F -18 ²	8	8	8	7	7	7
28	Trupower W & F -18 ²	8	8	8	7	7	7
29	Dissolve W & F -18 ²	8	8	8	7	7	7
30	Dissolve Ultra W & F -18 ²	8	8	8	7	7	7
31	Horsepower W & F -18 ²	8	8	8	7	7	7
32	XRM 5202 W & F -18 ²	8	8	8	7	7	7
33	Turf Builder + 2 ²	8	8	8	7	7	7
34	Fertilized control ²	8	8	8	7	7	7

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot. LSD's were not included because means comparisons were not appropriate for these data.

Table 3. Dandelion and clover damage¹ on June 10 in turf treated on June 5 for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	Dandelion	Clover
1 Untreated control	9.0	9.0
2 Millenium Ultra 47.10%	5.7	7.0
3 Horsepower 50.40%	5.7	6.7
4 DTDA 47.30%	5.7	5.7
5 XRM 5202 55.80%	7.0	7.0
6 Confront 45.10%	5.0	7.7
7 Triplet (std) 49.67%	6.0	6.3
8 RDL202 89.76%DF	5.3	6.0
9 RDL211 55.98%	5.7	5.7
10 RDL414 55.48%	5.3	4.3
11 MCP (R) 51.90%	8.0	8.7
12 MCP (O) 25.96%	7.0	7.3
13 2,4-DP (R) 50.00%	8.3	8.7
14 2,4-DP (O) 25.00%	8.0	7.3
15 Dissolve (R) 57.70%	7.0	7.3
16 Dissolve (O) 43.31%	6.7	7.0
17 Super Trimec	5.0	6.3
18 Trimec Classic 3.4SL	7.0	8.0
19 Millenium Ultra W & F -18 ²	8.7	8.3
20 Trupower W & F -18 ²	8.7	8.0
21 Dissolve W & F -18 ²	8.3	8.3
22 Dissolve Ultra W & F -18 ²	8.0	7.7
23 Horsepower W & F -18 ²	8.7	8.7
24 XRM 5202 W & F -18 ²	8.3	8.0
25 Turf Builder + 2 ²	8.0	8.3
26 Fertilized control ²	9.0	9.0
27 Millenium Ultra W & F -18 ²	8.3	8.3
28 Trupower W & F -18 ²	8.7	8.0
29 Dissolve W & F -18 ²	8.3	8.3
30 Dissolve Ultra W & F -18 ²	8.0	7.7
31 Horsepower W & F -18 ²	8.7	8.7
32 XRM 5202 W & F -18 ²	8.3	8.0
33 Turf Builder + 2 ²	8.0	8.3
34 Fertilized control ²	9.0	9.0
LSD _{0.05}	1.7	1.8

¹Damage was assessed using a 9 to 1 scale with 9 = no damage, 5 = 50% of plants showing damage, and 1 = 100% of plants exhibiting damage. Symptoms of damage included foliage discoloration, wilting, and curling.

²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.

Table 4. Percentage dandelion and clover cover¹ reductions in turf treated on June 5 for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	Dandelion cover			Clover cover		
	June 24	June 30	Mean	June 24	June 30	Mean
1 Untreated control	0.0	0.0	0.0	0.0	0.0	0.0
2 Millenium Ultra 47.10%	56.7	86.7	71.7	63.3	100.0	81.7
3 Horsepower 50.40%	70.0	73.3	71.7	46.7	100.0	73.3
4 DTDA 47.30%	53.3	86.7	70.0	33.3	60.0	46.7
5 XRM 5202 55.80%	36.7	83.3	60.0	36.7	100.0	68.3
6 Confront 45.10%	73.3	100.0	86.7	66.7	100.0	83.3
7 Triplet (std) 49.67%	46.7	80.0	63.3	43.3	100.0	71.7
8 RDL202 89.76%DF	40.0	100.0	70.0	40.0	100.0	70.0
9 RDL211 55.98%	53.3	100.0	76.7	46.7	100.0	73.3
10 RDL414 55.48%	73.3	90.0	81.7	70.0	100.0	85.0
11 MCP (R) 51.90%	46.7	36.7	41.7	23.3	50.0	36.7
12 MCP (O) 25.96%	26.7	43.3	35.0	20.0	10.0	15.0
13 2,4-DP (R) 50.00%	40.0	30.0	35.0	30.0	56.7	43.3
14 2,4-DP (O) 25.00%	56.7	36.7	46.7	26.7	40.0	33.3
15 Dissolve (R) 57.70%	63.3	80.0	71.7	43.3	83.3	63.3
16 Dissolve (O) 43.31%	73.3	76.7	75.0	53.3	100.0	76.7
17 Super Trimec	73.3	100.0	86.7	63.3	100.0	81.7
18 Trimec Classic 3.4SL	70.0	93.3	81.7	76.7	100.0	88.3
19 Millenium Ultra W & F -18 ²	43.3	56.7	50.0	36.7	100.0	68.3
20 Trupower W & F -18 ²	43.3	63.3	53.3	60.0	100.0	80.0
21 Dissolve W & F -18 ²	30.0	20.0	25.0	20.0	33.3	26.7
22 Dissolve Ultra W & F -18 ²	33.3	23.3	28.3	33.3	0.0	16.7
23 Horsepower W & F -18 ²	33.3	10.0	21.7	33.3	0.0	16.7
24 XRM 5202 W & F -18 ²	36.7	60.0	48.3	40.0	66.7	53.3
25 Turf Builder + 2 ²	53.3	43.3	48.3	26.7	16.7	21.7
26 Fertilized control ²	0.0	0.0	0.0	0.0	0.0	0.0
27 Millenium Ultra W & F -18 ²	30.0	46.7	38.3	30.0	76.7	53.3
28 Trupower W & F -18 ²	30.0	33.3	31.7	53.3	76.7	65.0
29 Dissolve W & F -18 ²	6.7	0.0	3.3	13.3	33.3	23.3
30 Dissolve Ultra W & F -18 ²	23.3	16.7	20.0	23.3	0.0	11.7
31 Horsepower W & F -18 ²	33.3	0.0	16.7	30.0	0.0	15.0
32 XRM 5202 W & F -18 ²	36.7	26.7	31.7	40.0	20.0	30.0
33 Turf Builder + 2 ²	40.0	30.0	35.0	26.7	16.7	21.7
34 Fertilized control ²	0.0	0.0	0.0	0.0	0.0	0.0
LSD _{0.05}	28.0	28.7	6.8	33.4	41.5	25.6

¹These figures represent percentage reductions in percentage dandelion and clover cover per plot as compared with the untreated controls.

²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.

Table 5. Dandelion counts¹ in turf treated for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	July 7	July 14	July 24	July 30	Mean count
1 Untreated control	298.0	316.7	366.7	390.0	342.8
2 Millenium Ultra 47.10%	2.3	2.3	1.7	1.3	1.9
3 Horsepower 50.40%	9.7	35.0	66.7	77.7	47.3
4 DTD 47.30%	16.7	23.3	36.7	41.7	29.6
5 XRM 5202 55.80%	2.0	15.0	26.7	25.7	17.3
6 Confront 45.10%	0.3	2.3	5.7	5.7	3.5
7 Triplet (std) 49.67%	10.7	21.7	73.3	44.7	37.6
8 RDL202 89.76%DF	2.3	10.0	15.0	15.0	10.6
9 RDL211 55.98%	4.0	11.7	15.0	18.3	12.3
10 RDL414 55.48%	3.3	8.3	13.3	13.7	9.7
11 MCP (R) 51.90%	112.0	125.0	141.7	151.7	132.6
12 MCP (O) 25.96%	185.0	173.3	183.3	191.3	183.3
13 2,4-DP (R) 50.00%	205.3	216.7	200.0	216.7	209.7
14 2,4-DP (O) 25.00%	222.7	216.7	200.0	210.0	212.3
15 Dissolve (R) 57.70%	7.0	13.3	18.3	20.3	14.8
16 Dissolve (O) 43.31%	80.0	90.0	125.0	123.0	104.5
17 Super Trimec	9.0	8.7	9.7	13.0	10.1
18 Trimec Classic 3.4SL	4.3	12.0	16.7	20.0	13.3
19 Millenium Ultra W & F -18 ²	10.7	36.7	46.7	44.7	34.7
20 Trupower W & F -18 ²	49.3	63.3	106.7	111.3	82.7
21 Dissolve W & F -18 ²	166.7	200.0	166.7	186.7	180.0
22 Dissolve Ultra W & F -18 ²	103.3	100.0	100.0	110.0	103.3
23 Horsepower W & F -18 ²	70.0	73.3	73.3	76.0	73.2
24 XRM 5202 W & F -18 ²	69.3	66.7	63.3	91.3	72.7
25 Turf Builder + 2 ²	40.0	63.3	90.0	41.3	58.7
26 Fertilized control ²	265.3	266.7	366.7	360.0	314.7
27 Millenium Ultra W & F -18 ²	76.7	93.3	143.3	133.3	111.7
28 Trupower W & F -18 ²	164.7	200.0	250.0	253.3	217.0
29 Dissolve W & F -18 ²	179.7	226.7	283.3	286.7	244.1
30 Dissolve Ultra W & F -18 ²	215.3	223.3	233.3	230.0	225.5
31 Horsepower W & F -18 ²	216.7	230.0	290.0	260.0	249.2
32 XRM 5202 W & F -18 ²	138.0	180.0	216.7	226.7	190.3
33 Turf Builder + 2 ²	104.7	133.3	113.3	108.7	115.0
34 Fertilized control ²	281.3	316.7	333.3	366.7	324.5
LSD _{0.05}	78.8	85.7	76.4	77.2	70.7

¹These figures represent the number of dandelions per plot.²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.**Table 6.** Percentage reductions in dandelion counts¹ in treated turf as compared with the untreated controls of the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study

Material	July 7	July 14	July 24	July 30	Mean reduction
%					
1 Untreated control	0.0	0.0	0.0	0.0	0.0
2 Millenium Ultra 47.10%	99.2	99.3	99.5	99.7	99.4
3 Horsepower 50.40%	96.8	88.9	81.8	80.1	86.2
4 DTD 47.30%	94.4	92.6	90.0	89.3	91.4
5 XRM 5202 55.80%	99.3	95.3	92.7	93.4	94.9
6 Confront 45.10%	99.9	99.3	98.5	98.5	99.0
7 Triplet (std) 49.67%	96.4	93.2	80.0	88.5	89.0
8 RDL202 89.76%DF	99.2	96.8	95.9	96.2	96.9
9 RDL211 55.98%	98.7	96.3	95.9	95.3	96.4
10 RDL414 55.48%	98.9	97.4	96.4	96.5	97.2
11 MCP (R) 51.90%	62.4	60.5	61.4	61.1	61.3
12 MCP (O) 25.96%	37.9	45.3	50.0	50.9	46.5
13 2,4-DP (R) 50.00%	31.1	31.6	45.5	44.4	38.8
14 2,4-DP (O) 25.00%	25.3	31.6	45.5	46.2	38.1
15 Dissolve (R) 57.70%	97.7	95.8	95.0	94.8	95.7
16 Dissolve (O) 43.31%	73.2	71.6	65.9	68.5	69.5
17 Super Trimec	97.0	97.3	97.4	96.7	97.1
18 Trimec Classic 3.4SL	98.5	96.2	95.5	94.9	96.1
19 Millenium Ultra W & F -18 ²	96.4	88.4	87.3	88.5	89.9
20 Trupower W & F -18 ²	83.4	80.0	70.9	71.5	75.9
21 Dissolve W & F -18 ²	44.1	36.8	54.5	52.1	47.5
22 Dissolve Ultra W & F -18 ²	65.3	68.4	72.7	71.8	69.9
23 Horsepower W & F -18 ²	76.5	76.8	80.0	80.5	78.7
24 XRM 5202 W & F -18 ²	76.7	78.9	82.7	76.6	78.8
25 Turf Builder + 2 ²	86.6	80.0	75.5	89.4	82.9
26 Fertilized control ²	11.0	15.8	0.0	7.7	8.2
27 Millenium Ultra W & F -18 ²	74.3	70.5	60.9	65.8	67.4
28 Trupower W & F -18 ²	44.7	36.8	31.8	35.0	36.7
29 Dissolve W & F -18 ²	39.7	28.4	22.7	26.5	28.8
30 Dissolve Ultra W & F -18 ²	27.7	29.5	36.4	41.0	34.2
31 Horsepower W & F -18 ²	27.3	27.4	20.9	33.3	27.3
32 XRM 5202 W & F -18 ²	53.7	43.2	40.9	41.9	44.5
33 Turf Builder + 2 ²	64.9	57.9	69.1	72.1	66.5
34 Fertilized control ²	5.6	0.0	9.1	6.0	5.3
LSD _{0.05}	26.5	27.1	20.8	19.8	20.6

¹These figures represent percentage reductions in dandelion numbers per plot as compared with the untreated controls.²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.

Table 7. Percentage clover cover¹ in turf treated for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	July 7	July 14	July 24	July 30	Mean cover
	%				
1 Untreated control	50.0	61.7	65.0	78.3	63.8
2 Millenium Ultra 47.10%	0.3	0.0	0.0	0.0	0.1
3 Horsepower 50.40%	0.0	0.0	0.0	0.0	0.0
4 DTDA 47.30%	1.7	0.7	3.3	3.3	2.3
5 XRM 5202 55.80%	0.0	0.0	0.7	0.7	0.3
6 Confront 45.10%	0.0	0.3	0.3	0.3	0.3
7 Triplet (std) 49.67%	0.0	0.3	2.0	2.0	1.1
8 RDL202 89.76%DF	0.0	0.0	8.3	0.0	2.1
9 RDL211 55.98%	0.0	0.3	0.3	0.3	0.3
10 RDL414 55.48%	0.0	0.3	0.0	0.0	0.1
11 MCP (R) 51.90%	5.3	12.0	18.3	21.7	14.3
12 MCP (O) 25.96%	13.3	18.7	28.7	33.7	23.6
13 2,4-DP (R) 50.00%	3.7	8.7	15.3	13.7	10.3
14 2,4-DP (O) 25.00%	17.3	25.3	27.0	31.7	25.3
15 Dissolve (R) 57.70%	0.7	0.7	0.7	2.0	1.0
16 Dissolve (O) 43.31%	0.3	0.7	1.0	1.0	0.8
17 Super Trimec	0.0	0.0	0.3	0.3	0.2
18 Trimec Classic 3.4SL	0.0	0.3	0.3	0.7	0.3
19 Millenium Ultra W & F -18 ²	0.0	0.0	6.7	0.0	1.7
20 Trupower W & F -18 ²	0.7	0.7	0.7	0.7	0.7
21 Dissolve W & F -18 ²	18.7	12.0	13.7	17.0	15.3
22 Dissolve Ultra W & F -18 ²	8.3	13.3	20.0	20.0	15.4
23 Horsepower W & F -18 ²	2.3	2.3	4.3	4.3	3.3
24 XRM 5202 W & F -18 ²	2.0	2.3	5.3	5.3	3.8
25 Turf Builder + 2 ²	4.0	5.7	13.3	15.0	9.5
26 Fertilized control ²	26.7	23.3	38.3	41.7	32.5
27 Millenium Ultra W & F -18 ²	0.0	0.0	0.0	0.0	0.0
28 Trupower W & F -18 ²	0.7	0.3	0.3	0.3	0.4
29 Dissolve W & F -18 ²	27.0	28.7	33.7	35.3	31.2
30 Dissolve Ultra W & F -18 ²	13.3	13.3	26.7	35.0	22.1
31 Horsepower W & F -18 ²	4.3	7.0	14.0	15.7	10.3
32 XRM 5202 W & F -18 ²	1.7	1.0	3.7	3.7	2.5
33 Turf Builder + 2 ²	10.0	11.7	21.7	28.3	17.9
34 Fertilized control ²	26.7	20.3	53.3	56.7	39.3
LSD _{0.05}	16.3	19.7	21.2	24.1	19.1

¹These figures the area per plot covered by clover.²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.Table 8. Percentage clover cover reductions¹ in treated turf as compared with the untreated controls of the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	July 7	July 14	July 24	July 30	Mean
	%				
1 Untreated control	0.0	0.0	0.0	0.0	0.0
2 Millenium Ultra 47.10%	99.3	100.0	100.0	100.0	99.9
3 Horsepower 50.40%	100.0	100.0	100.0	100.0	100.0
4 DTDA 47.30%	96.7	98.9	94.9	95.7	96.5
5 XRM 5202 55.80%	100.0	100.0	99.0	99.1	99.5
6 Confront 45.10%	100.0	99.5	99.5	99.6	99.6
7 Triplet (std) 49.67%	100.0	99.5	96.9	97.4	98.3
8 RDL202 89.76%DF	100.0	100.0	87.2	100.0	96.7
9 RDL211 55.98%	100.0	99.5	99.5	99.6	99.6
10 RDL414 55.48%	100.0	99.5	100.0	100.0	99.9
11 MCP (R) 51.90%	89.3	80.6	71.8	72.3	77.5
12 MCP (O) 25.96%	73.3	69.7	55.9	57.0	63.0
13 2,4-DP (R) 50.00%	92.7	86.0	76.4	82.5	83.8
14 2,4-DP (O) 25.00%	65.3	58.9	58.5	59.6	60.3
15 Dissolve (R) 57.70%	98.7	98.9	99.0	97.4	98.4
16 Dissolve (O) 43.31%	99.3	98.9	98.5	98.7	98.8
17 Super Trimec	100.0	100.0	99.5	99.6	99.7
18 Trimec Classic 3.4SL	100.0	99.5	99.5	99.1	99.5
19 Millenium Ultra W & F -18 ²	100.0	100.0	89.7	100.0	97.4
20 Trupower W & F -18 ²	98.7	98.9	99.0	99.1	99.4
21 Dissolve W & F -18 ²	62.7	80.6	79.0	78.3	75.9
22 Dissolve Ultra W & F -18 ²	83.3	78.4	69.2	74.5	75.8
23 Horsepower W & F -18 ²	95.3	96.2	93.3	94.5	94.8
24 XRM 5202 W & F -18 ²	96.0	96.2	91.8	93.2	94.1
25 Turf Builder + 2 ²	92.0	90.8	79.5	80.8	85.1
26 Fertilized control ²	46.7	62.2	41.0	46.8	49.0
27 Millenium Ultra W & F -18 ²	100.0	100.0	100.0	100.0	100.0
28 Trupower W & F -18 ²	98.7	99.5	99.5	99.6	99.3
29 Dissolve W & F -18 ²	46.0	53.5	48.2	54.9	51.1
30 Dissolve Ultra W & F -18 ²	73.3	78.4	59.0	55.3	65.4
31 Horsepower W & F -18 ²	91.3	88.7	78.5	80.0	83.9
32 XRM 5202 W & F -18 ²	96.7	98.4	94.4	95.3	96.1
33 Turf Builder + 2 ²	80.0	81.1	66.7	63.8	71.9
34 Fertilized control ²	46.7	67.0	18.0	27.6	38.4
LSD _{0.05}	32.5	31.9	32.6	30.7	29.9

¹These figures represent percentage reductions in clover cover per plot as compared with the untreated controls.²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.

Table 9. Percentage crabgrass cover¹ in treated turf for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	July 7	July 14	July 24	July 30	Mean
			%		
1 Untreated control	0.3	0.7	5.7	0.7	1.8
2 Millenium Ultra 47.10%	18.7	30.0	30.0	38.3	29.3
3 Horsepower 50.40%	5.3	13.3	26.7	30.0	18.8
4 DTDA 47.30%	0.7	13.3	21.7	25.0	15.2
5 XRM 5202 55.80%	3.7	11.7	16.7	28.3	15.1
6 Confront 45.10%	3.7	5.3	15.0	12.0	9.0
7 Triplet (std) 49.67%	0.7	5.7	15.0	15.0	9.1
8 RDL202 89.76%DF	5.3	10.3	16.7	18.3	12.7
9 RDL211 55.98%	10.7	20.0	25.0	30.0	21.4
10 RDL414 55.48%	10.3	13.3	23.3	23.3	17.6
11 MCPP (R) 51.90%	0.3	5.3	15.0	11.7	8.1
12 MCPP (O) 25.96%	1.0	5.0	18.3	18.3	10.7
13 2,4-DP (R) 50.00%	0.7	5.3	11.7	8.7	6.6
14 2,4-DP (O) 25.00%	1.7	8.3	18.3	20.0	12.1
15 Dissolve (R) 57.70%	2.0	7.0	7.3	12.7	7.3
16 Dissolve (O) 43.31%	10.3	13.3	31.7	31.7	21.8
17 Super Trimec	4.0	16.7	23.3	26.7	17.7
18 Trimec Classic 3.4SL	5.3	2.3	10.0	3.7	5.3
19 Millenium Ultra W & F -18 ²	5.0	7.0	23.3	28.3	15.9
20 Trupower W & F -18 ²	3.7	9.0	28.3	27.0	17.0
21 Dissolve W & F -18 ²	6.7	10.0	28.3	18.7	15.9
22 Dissolve Ultra W & F -18 ²	7.0	11.7	28.3	30.0	19.3
23 Horsepower W & F -18 ²	0.3	1.0	6.7	5.7	3.4
24 XRM 5202 W & F -18 ²	0.7	8.7	13.3	21.7	11.1
25 Turf Builder + 2 ²	2.0	2.0	13.3	6.7	6.0
26 Fertilized control ²	0.0	3.7	10.0	10.3	6.0
27 Millenium Ultra W & F -18 ²	0.3	4.0	15.3	15.3	8.8
28 Trupower W & F -18 ²	3.7	5.3	23.3	13.3	11.4
29 Dissolve W & F -18 ²	6.7	6.7	5.0	3.7	5.5
30 Dissolve Ultra W & F -18 ²	2.3	6.7	16.7	17.0	10.7
31 Horsepower W & F -18 ²	0.0	0.7	6.7	10.0	4.3
32 XRM 5202 W & F -18 ²	0.3	3.7	8.3	12.0	6.1
33 Turf Builder + 2 ²	0.7	3.7	8.3	6.7	4.8
34 Fertilized control ²	0.0	2.0	4.0	4.3	2.6
LSD _{0.05}	8.8	10.6	NS	NS	14.2

¹These figures represent the area per plot covered by crabgrass.²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.**Table 10.** Spurge counts¹ in turf treated on June 5 for the 1998 Postemergence Granular and Sprayable Broadleaf Weed Control Study.

Material	Spurge counts
1 Untreated control	0.0
2 Millenium Ultra 47.10%	4.0
3 Horsepower 50.40%	8.3
4 DTDA 47.30%	6.0
5 XRM 5202 55.80%	7.0
6 Confront 45.10%	4.3
7 Triplet (std) 49.67%	3.7
8 RDL202 89.76%DF	1.0
9 RDL211 55.98%	0.0
10 RDL414 55.48%	0.7
11 MCPP (R) 51.90%	1.3
12 MCPP (O) 25.96%	0.0
13 2,4-DP (R) 50.00%	1.7
14 2,4-DP (O) 25.00%	0.3
15 Dissolve (R) 57.70%	1.3
16 Dissolve (O) 43.31%	1.3
17 Super Trimec	4.0
18 Trimec Classic 3.4SL	3.0
19 Millenium Ultra W & F -18 ²	1.0
20 Trupower W & F -18 ²	4.7
21 Dissolve W & F -18 ²	0.0
22 Dissolve Ultra W & F -18 ²	0.7
23 Horsepower W & F -18 ²	0.7
24 XRM 5202 W & F -18 ²	0.0
25 Turf Builder + 2 ²	0.0
26 Fertilized control ²	0.0
27 Millenium Ultra W & F -18 ²	1.3
28 Trupower W & F -18 ²	4.7
29 Dissolve W & F -18 ²	0.0
30 Dissolve Ultra W & F -18 ²	0.0
31 Horsepower W & F -18 ²	0.0
32 XRM 5202 W & F -18 ²	1.3
33 Turf Builder + 2 ²	0.0
34 Fertilized control ²	0.0
LSD _{0.05}	4.4

¹These figures represent the number of spurge per plot.²The 5 x 10 ft plots for these granular treatments were split into two 2 1/2 x 10 ft subplots. One-half of each material was applied to a dry and a wet subplot.

Table 11. Percentage reductions in dandelion counts¹ in turf treated with granular herbicides applied on wet vs. dry foliage for the 1998 Postemergence Granular and sprayable Broadleaf Herbicide Study.

Material	July 7		July 14		July 24		July 30		Mean	
	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Untreated control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Millenium Ultra W & F -18	74.3	96.4	70.5	88.4	60.9	87.3	65.8	88.5	67.4	89.9
Trupower W & F -18	44.7	83.4	36.8	80.0	31.8	70.9	35.0	71.5	36.7	75.9
Dissolve W & F -18	39.7	44.1	28.4	36.8	22.7	54.5	26.5	52.1	28.8	47.5
Dissolve Ultra W & F -18	27.7	65.3	29.5	68.4	36.4	72.7	41.0	71.8	34.2	69.9
Horsepower W & F -18	27.3	76.5	27.4	76.8	20.9	80.0	33.3	80.5	27.3	78.7
XRM 5202 W & F -18	53.7	76.7	43.2	78.9	40.9	82.7	41.9	76.6	44.5	78.8
Turf Builder + 2	64.9	86.6	57.9	80.0	69.1	75.5	72.1	89.4	66.5	82.9
Fertilized control	5.6	11.0	0.0	15.8	9.1	0.0	6.0	7.7	5.3	8.2
LSD _{0.05}	26.5		27.1		20.8		19.8		20.6	

¹These figures represent percentage reductions in dandelion numbers per plot as compared with the untreated controls.

Table 12. Percentage reductions in clover cover¹ in turf treated with granular herbicides applied on dry vs. wet foliage for the 1998 Postemergence Granular and sprayable Broadleaf Herbicide Study.

Material	July 7		July 14		July 24		July 30		Mean	
	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Untreated control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Millenium Ultra W & F -18	100.0	100.0	100.0	100.0	100.0	89.7	100.0	100.0	100.0	97.4
Trupower W & F -18	98.7	98.7	99.5	98.9	99.5	99.0	99.6	99.1	99.3	99.4
Dissolve W & F -18	46.0	62.7	53.5	80.6	48.2	79.0	54.9	78.3	51.1	75.9
Dissolve Ultra W & F -18	73.3	83.3	78.4	78.4	59.0	69.2	55.3	74.5	65.4	75.8
Horsepower W & F -18	91.3	95.3	88.7	96.2	78.5	93.3	80.0	94.5	83.9	94.8
XRM 5202 W & F -18	96.7	96.0	98.4	96.2	94.4	91.8	95.3	93.2	96.1	94.1
Turf Builder + 2	80.0	92.0	81.1	90.8	66.7	79.5	63.8	80.8	71.9	85.1
Fertilized control	46.7	46.7	67.0	62.2	18.0	41.0	27.6	46.8	38.4	49.0
LSD _{0.05}	32.5		32.0		32.6		30.7		29.9	

¹These figures represent reductions in clover cover per plot as compared with the untreated controls.

Postemergence Ground Ivy Weed Control Study at Veenker

Barbara R. Bingaman, Melissa C. McDade, Michael B. Faust, and Nick E. Christians

The efficacy of Trimec experimental formulations in the control of ground ivy (creeping charlie) was examined in this study. It was conducted at Veenker Memorial Golf Course, Ames IA, in a common bluegrass and perennial ryegrass area heavily infested with ground ivy. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 7.0% organic matter, 56 ppm P, 368 ppm K, and a pH of 7.2.

The study was designed as a randomized complete block. Individual plot size was 5 x 5 ft with three replications. A pretreatment survey of the area showed the presence of ground ivy in each of the individual plots. There were seven Trimec experimental treatments plus an untreated control. Trimec Classic was applied at 1.5 fl oz/1000 ft² and NB20680 (substituted for EH1349), NB 30137, NB30138, NB30139, NB30140, and NB30141 were applied at 3.0 fl oz/1000 ft² (Table 2).

Applications were made postemergently on July 14, 1998 after ground ivy was established. A carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles at 30 psi was used. The materials were diluted into 90 ml of water. This translates to a rate of 1 gallon/1000 ft².

Ground ivy control evaluations were made on July 21, July 30, August 6, and August 12. Control was assessed as the percentage of living ground ivy per individual plot.

All data were analyzed with the Statistical Analysis System (SAS Version 6.12) using the Analysis of Variance procedure (ANOVA). Fisher's Least Significant Difference means separation test (LSD) was used to compare means.

No phytotoxicity was observed in any treated turf. On July 21, treated ground ivy exhibited different degrees of damage and symptoms (Table 1).

All materials significantly reduced ground ivy populations (Table 2). Some of the materials worked faster than others. On July 21, virtually all of the ground ivy was dead in turf treated with NB30141 and slightly less mortality was observed in turf treated with NB20680, NB30139, and NB30140. By August 6, all of experimental materials had killed at least 95% of the ground ivy (Table 3).

Table 1. Ground ivy damage and phytotoxic symptoms observed on July 21.

REP 1

1	2	3	4	5	6
NB30141 dead plants	NB30139 dead plants	NB20680 dead plants	Trimec Classic plants curled & collapsed	Untreated no damage	NB30138 plants curled

REP 2

7	8	1	2	3	4
NB30140 dead plants	NB30137 dead plants	NB20680 dead plants	NB30138 dead plants	Untreated no damage	NB30137 dead plants

REP 3

5	6	7	8	1
NB30140 dead plants	NB30139 burnt leaves	Trimec Classic plants curled	NB30141 dead plants	NB30137 burnt leaves

2	3	4	5	6	7	8
NB30140 dead plants	Trimec Classic plants curled	NB30139 dead plants	NB30138 dead plants	NB30141 dead plants	NB20680 plants collapsed	Untreated no damage

Table 2. Percentage living ground ivy cover in turf plots of the 1998 PBI Gordon Ground Ivy Study.

Materials	Rate [fl oz] product /1000 ft ²	July 21	July 30	August 6	August 12	Mean
1. Untreated control	NA	63.3	60.0	65.0	66.7	63.8
2. NB20680 ***	3.0	5.7	2.3	1.7	0.3	2.5
3. NB30137	3.0	11.0	3.0	2.7	5.7	5.6
4. NB30138	3.0	11.3	3.3	0.7	1.7	4.3
5. NB30139	3.0	5.7	2.3	1.0	1.0	2.5
6. NB30140	3.0	5.7	6.0	1.0	1.0	3.4
7. NB30141	3.0	1.0	1.7	2.0	0.7	1.3
8. Trimec Classic	1.5	58.3	18.3	20.0	8.0	26.2
LSD _{0.05}		19.9	9.7	17.8	11.4	12.8

**NB20680 used instead of EH1349.

Table 3. Percentage reduction in living ground ivy cover¹ in turf plots of the 1998 PBI Gordon Ground Ivy Study.

Materials	July 21	July 30	August 6	August 12	Mean
1. Untreated control	0.0	0.0	0.0	0.0	0.0
2. NB20680 ***	91.0	96.1	97.4	99.5	96.1
3. NB30137	82.6	95.0	95.9	91.5	91.2
4. NB30138	82.1	94.4	99.0	97.5	93.3
5. NB30139	91.0	96.1	98.5	98.5	96.1
6. NB30140	91.0	90.0	98.5	98.5	94.6
7. NB30141	98.4	97.2	96.9	99.0	97.9
8. Trimec Classic	7.8	69.4	69.2	88.0	59.0
LSD _{0.05}	31.5	16.2	27.4	17.1	20.0

¹These values represent reductions in living ground ivy cover as compared with the untreated controls.

LCO Weed Control Study

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

This study was designed to evaluate full season weed control with Drive 75DF delayed lawn care (LCO) programs compared to standard LCO programs. It was conducted at the Iowa State University Horticulture Research Station at Ames, IA in an established area of 'Park' Kentucky bluegrass. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.9% organic matter, 3.5 ppm P, 116 ppm K, and a pH of 7.3.

The study was arranged as a randomized complete block with three replications. Individual plot size was 10 x 5 ft with treatments randomly assigned within replications. There were four treatments with combinations of pre- (PRE), early post (EPOST), post (POST), late postemergent (LPOST) applications, and an untreated control (Table 1). One treatment combination included Pendimethalin 60WDG applied at the label rate PRE and Trimec Classic 3.32EC at 1.5 lb a.i./A applied POST and LPOST. Drive 75DF at 0.75 lb a.i./A was applied EPOST in a tank mix with Pendimethalin 60WDG at 2/3 label rate and was applied LPOST with 2,4-D Amine 4.1SL at 0.75 lb a.i./A. The fourth treatment was a tank mix of Drive 75DF at 0.75 lb a.i./A plus 2, 4-D Amine 4.1SL at 0.75 lb a.i./A applied EPOST and LPOST. Methylated soy soil (MSO) was added to all treatments as a carrier at 1.0% V/V.

Preemergent applications were made May 6, 1998 before crabgrass germination. Early post applications were made as delayed LCO pre- postemergent treatments on June 16. Postemergence applications were made following standard POST broadleaf timing schedules on July 14. Late postemergence treatments were applied as standard LPOST broadleaf materials on September 1, 1998.

The products were applied at 30 psi using a carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles. The materials were mixed into 567 ml water that translates to an application volume of 3 gal/1000 ft².

Turf quality and phytotoxicity were assessed from May 13 through October 1 (Tables 2 - 4). Turf quality was estimated by making visual rankings using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality. Phytotoxicity was quantified using a 9 to 1 scale with 9 = no injury, 6 = moderate damage, and 1 = dead turf. Dandelion and clover damage were determined on June 30, July 7, and July 23 following the EPOST and POST applications (Table 5). Damage was estimated using a 9 to 1 scale with 9 = no damage, 6 = 50% dead, 1 = 100% dead. Damage symptoms included collapsed, discolored, and curled leaves. Percentage cover data were taken for dandelion (Tables 6 - 7), clover (Tables 8 - 9), and crabgrass (Tables 10 - 11) from July 15 through October 1. These data represent the percentage of area per plot covered by each weed species.

All data were analyzed using the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance Procedure (ANOVA). Differences among means were compared with Fisher's Least Significant Difference (LSD) Test.

The only significant differences in turf quality were observed on July 15, one day after the POST applications (Tables 2 - 4). There were numerical differences in quality on June 24 (8 days after the EPOST applications), on August 18, on September 16 (15 days after the LPOST applications), and on September 23. No phytotoxicity was detected.

On June 30 (15 days after the EPOST materials were applied), Drive 75DF plus either Pendimethalin 60WDG or 2,4-D Amine 4.1SL was causing severe levels of damage to dandelion and clover (Table 5). By July 15, the Drive 75DF tank mixes had reduced the percentage dandelion cover to $\leq 1.0\%$ and the clover cover to $\leq 0.3\%$ as compared to 16.7% dandelion cover and 6.7% clover cover in the untreated controls (Tables 6 - 8). On July 23, seven days after the POST treatments, the pendimethalin 60WDG tank mix was causing severe damage to the dandelion and clover and by July 29, the percentage cover for both species was significantly reduced as compared with the untreated controls. After July 29, all of the herbicides provided significant reductions in dandelion and clover populations as compared with the untreated controls (Tables 6 - 9).

Crabgrass was first detected in the untreated turf on July 15 and in the treated turf on July 23 (Tables 10 - 11). Crabgrass populations in the treated turf were reduced as compared with the untreated controls for the duration of the trial. The reductions were not statistically significant for all of the collection dates.

Table 1. Materials and application information for the 1998 LCO Weed Control Study.

	Material	Rate lb a.i./A	Timing of application
1.	Untreated control	N/A	N/A
2.	Pendimethalin 60WDG*	1.50	PRE
	Trimec Classic 3.32EC	1.50	POST
	Trimec Classic 3.32EC	1.50	LATE POST
3.	Drive 75DF	0.75	EARLY POST
	+ Pendimethalin 60WDG*	1.00	EARLY POST
	+ MSO	1.00%	EARLY POST
	Drive 75DF	0.75	LATE POST
	+ 2, 4-D Amine 4.1SL	0.75	LATE POST
	+ MSO	1.00%	LATE POST
4.	Drive 75DF	0.75	EARLY POST
	+ 2, 4-D Amine 4.1SL	0.75	EARLY POST
	+ MSO	1.00%	EARLY POST
	Drive 75DF	0.75	LATE POST
	+ 2, 4-D Amine 4.1SL	0.75	LATE POST
	+ MSO	1.00%	LATE POST

PRE applied on May 6, EARLY POST on June 16, POST on July 14, and LATE POST on September 1, 1998

*Pendimethalin (Pre-M 60WDG) was substituted for Pendulum 3.3EC per Dave Eastman.

Table 2. Visual turf quality¹ in turf treated for the 1998 LCO Weed Control Study (May 13 - July 7).

	Material	May 13	May 18	May 27	June 16	June 24	June 30	July 7
1.	Untreated control	9.0	9.0	9.0	9.0	7.0	7.0	7.0
2.	Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	9.0	9.0	9.0	9.0	6.3	7.0	7.0
3.	Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	9.0	9.0	9.0	9.0	5.7	7.0	7.0
4.	Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	9.0	9.0	9.0	9.0	5.0	7.0	7.0
	LSD _{0.05}	-	-	-	-	NS	-	-

¹Visual quality was assessed with a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = best quality.

-- = means separation tests are not appropriate for these data.

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

Table 3. Visual turf quality¹ in turf treated for the 1998 LCO Weed Control Study (July 15 - August 26).

Material	July 15	July 23	July 29	Aug 5	Aug 11	Aug 18	Aug 26
1. Untreated control	8.0	7.0	7.0	7.0	7.0	8.0	7.0
2. Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	6.3	7.0	7.0	7.0	7.0	7.0	7.0
3. Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	7.0	7.0	7.0	7.0	7.0	7.0	7.0
4. Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	7.0	7.0	7.0	7.0	7.0	7.0	7.0
LSD _{0.05}	1.2	-	-	-	-	-	-

¹Visual quality was assessed with a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = best quality.

-- = means separation tests are not appropriate for these data.

Table 4. Visual turf quality¹ in turf treated for the 1998 LCO Weed Control Study (Sept. 4 - Oct. 1).

Material	Sept 4	Sept 9	Sept 16	Sept 23	Oct 1	Mean
1. Untreated control	7.0	6.0	6.7	8.0	6.0	7.5
2. Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	7.0	6.0	6.3	7.0	6.0	7.2
3. Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	7.0	6.0	6.0	7.0	6.0	7.2
4. Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	7.0	6.0	6.0	7.0	6.0	7.2
LSD _{0.05}	-	-	NS	NS	-	0.1

¹Visual quality was assessed with a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = best quality.

-- = means separation tests are not appropriate for these data.

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

Table 5. Dandelion and clover damage¹ following treatment for the 1998 LCO Weed Control Study.

Material	Dandelion			Clover		
	June 30	July 7	July 23	June 30	July 7	July 23
1. Untreated control	9.0	9.0	9.0	9.0	9.0	9.0
2. Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	8.3	8.3	2.7	9.0	9.0	9.0
3. Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	3.3	3.7	9.0	2.3	1.7	9.0
4. Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	3.0	2.0	9.0	2.7	1.0	9.0
LSD _{0.05}	1.8	1.6	1.2	2.7	1.2	-

¹Damage was estimated using a 9 to 1 scale with 9 = no damage, 6 = 50% dead, 1 = 100% dead.

-- = means separation tests are not appropriate for these data.

Table 6. Percentage dandelion cover¹ in turf treated for the 1998 LCO Weed Control Study (July 15 - Aug. 26).

	Material	July 15	July 23	July 29	Aug 5	Aug 11	Aug 18	Aug 26
1.	Untreated control	16.7	23.3	21.7	30.0	25.0	21.7	23.3
2.	Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	18.3	18.3	4.7	1.0	0.3	0.7	1.0
3.	Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	1.0	0.7	1.0	2.3	3.7	6.7	8.3
4.	Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.0	0.0	0.3	0.7	0.3	2.0	2.3
	LSD _{0.05}	12.5	8.5	6.0	9.5	2.2	7.6	7.3

¹These figures represent the area per plot covered by dandelion.**Table 7.** Percentage dandelion cover¹ in turf treated for the 1998 LCO Weed Control Study (Sept. 4 - Oct. 1).

	Material	Sept 4	Sept 9	Sept 16	Sept 23	Oct 1	Mean cover
1.	Untreated control	10.0	20.0	16.7	25.0	30.0	21.9
2.	Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	2.3	2.3	2.0	2.3	2.3	4.6
3.	Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	6.7	8.3	2.3	0.3	0.0	3.4
4.	Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	2.3	2.3	2.0	1.7	0.0	1.2
	LSD _{0.05}	4.3	7.4	7.7	3.9	2.3	3.7

¹These figures represent the area per plot covered by dandelion.

PRE applied on May 6, EARLY POST on June 16, POST on July 14, and LATE POST on September 1, 1998

Table 8. Percentage clover cover¹ in turf treated for the 1998 LCO Weed Control Study (July 15 - Aug. 26).

	Material	July 15	July 23	July 29	Aug 5	Aug 11	Aug 18	Aug 26
1.	Untreated control	6.7	18.3	16.7	18.3	8.3	26.7	23.3
2.	Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	20.0	20.0	2.0	2.0	0.3	0.0	2.3
3.	Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.3	0.0	0.0	0.3	0.7	0.3	0.3
4.	Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LSD _{0.05}	3.0	7.5	7.1	2.5	2.7	3.0	3.2

¹These figures represent the area per plot covered by clover.

Table 9. Percentage clover cover¹ in turf treated for the 1998 LCO Weed Control Study (Sept. 4 - Oct. 1).

Material	Sept 4	Sept 9	Sept 16	Sept 23	Oct 1	Mean cover
1. Untreated control	56.7	41.7	56.7	56.7	53.3	51.9
2. Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	2.7	1.0	2.0	0.7	0.0	1.4
3. Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.7	0.3	0.0	0.0	0.0	0.3
4. Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.3	0.3	0.0	0.0	0.0	0.1
LSD _{0.05}	6.3	14.3	14.7	11.5	5.8	4.4

¹These figures represent the area per plot covered by clover.

PRE applied on May 6, EARLY POST on June 16, POST on July 14, and LATE POST on September 1, 1998

Table 10. Percentage crabgrass cover¹ in turf treated for the 1998 LCO Weed Control Study (July 15 - Aug. 26).

Material	July 15	July 23	July 29	Aug 5	Aug 11	Aug 18	Aug 26
1. Untreated control	0.3	2.3	4.0	6.7	11.7	16.7	6.9
2. Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	0.0	0.7	1.7	0.7	5.3	2.3	1.8
3. Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.0	3.7	0.3	0.0	3.3	0.7	1.3
4. Drive 75DF + 2, 4-D Amine 4.1SL + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.0	0.7	0.0	0.3	2.0	0.7	0.6
LSD _{0.05}	NS	NS	NS	NS	2.7	P=0.07 7.4	P=0.07 13.3

¹These figures represent the area per plot covered by crabgrass

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

Table 11. Percentage crabgrass cover¹ in turf treated for the 1998 LCO Weed Control Study (Sept. 4 - Oct. 1).

Material	Sept 4	Sept 9	Sept 16	Sept 23	Oct 1	Mean cover
1. Untreated control	3.7	5.7	13.3	12.0	16.7	8.5
2. Pendimethalin 60WDG & Trimec Classic 3.32EC & Trimec Classic 3.32EC	2.3	0.3	5.0	2.0	0.0	1.8
3. Drive 75DF + Pendimethalin 60WDG + MSO & Drive 75DF + 2, 4-D Amine 4.1SL + MSO	0.0	0.3	0.0	0.0	0.0	0.8
4. Drive 75DF + 2, 4-D amine 4.1SL + MSO & Drive 75DF + 2, 4-D amine 4.1SL + MSO	0.7	0.0	0.0	0.3	0.0	0.5
LSD _{0.05}	NS	NS	P = 0.06 10.1	NS	NS	NS

¹These figures represent the area per plot covered by crabgrass

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

Poa annua Control Studies - 1998

Nick E. Christians

Prograss (ethofumate) is an herbicide that has been shown to selectively remove *Poa annua* from perennial ryegrass on golf course fairways. It is a postemergence material but also has some preemergence effects on susceptible species. While Prograss has been shown to be safe for use on perennial ryegrass, its usefulness on Kentucky bluegrass and creeping bentgrass fairways is less certain and there is a risk of damage to these species at higher rates of application.

Primo (trinexapath-ethyl) is a GA (gibberellic acid) inhibiting compound that is used as a growth retardant on golf course fairways. It has been promoted as both a prestress conditioning product to help *Poa annua* survive the stress conditions in summer and as a potential method of reducing *Poa annua* population in creeping bentgrass fairways.

The objectives of the 1998 *Poa annua* control studies were to observe the effects of Prograss and Primo on *Poa annua* populations in golf course fairways and to observe the effects of these compounds on a variety of species under controlled conditions at the Iowa State University turfgrass research area.

MATERIAL AND METHODS

The treatments listed in Table 1 were applied to the fairway plots monthly from May through November and data on *Poa annua* survival were taken in November of 1998. The plots were also observed through the season for any signs of damage from the treatments.

The studies were conducted on the following sites:

1. The 16th fairway at Otter Creek Golf Course in Ankeny, Iowa, which is located in the central part of the state. Species: Kentucky bluegrass, with 10 to 20% *Poa annua*.
2. The 13th fairway at Hyperion Country Club in Johnston, Iowa, also in central Iowa. Species: Creeping bentgrass (Penneagle) fairway with 55 to 70% *Poa annua*.
3. The 5th fairway (15th fairway for small plots) at Fort Dodge Country Club, Fort Dodge, Iowa, located in the northern and western part of the state. Perennial ryegrass/Kentucky bluegrass fairway (originally seeded to Fylking, Park and common) with 45 to 70% *Poa annua*.

There were two treated areas at each site. Large plots that measured 5 ft. wide and extended the full width of the fairway received treatments 1-10 (Table 1) monthly from May through November. The treatments were applied by course personnel with fairway sprayers that had only one boom section active.

A small plot area was also established on fairways at each course. These plots measured 3 x 5 ft. and all 11 treatments (Table 1) were applied in 3 replications. These treatments were applied monthly with a small plot sprayer by Steve Krantz of D&K Turf Products in Des Moines and myself, with help from Steve Davis of AgrEvo.

Data were collected on percentage *Poa annua* population at initiation of treatments in May of 1998 and at the end of the season in November. An analysis of variance was conducted on percentage *Poa annua* reduction in each plot. The treated plots were also observed on a regular basis for any signs of phytotoxicity (damage) from the treatments.

RESULTS

The results of treatments at each site are listed in Table 1. Notice that on the line marked LSD 0.05, NS means nonsignificant. Even though there appears to be treatment differences, these differences are due to chance because of the high degree of variability among replications. Where a number occurs in this line, such as the 17 under the Fort Dodge Fairway column, there are real differences among treatments. In this case, any treatment responses that are at least 17 units apart are considered to be significantly different. The study was very successful at Fort Dodge

Country Club and significant reductions of *Poa annua* were observed in response to several treatments. Otter Creek treatments on large plots were also effective in several cases. No treatment effects were observed at the end of the season at Hyperion and no data are listed for November, 1998 observations. In the spring of 1999, however, significant reductions in annual bluegrass were observed on plots treated with higher rates of Prograss.

Small plot treatments were also very effective at Fort Dodge Country Club. Because of mid-season flooding on the small plots at Otter Creek, there were no significant treatment effects. Small plots at Hyperion actually showed an increase in *Poa annua* populations in several treatments. The reason for this response is unknown.

At no times during the season were there any signs of phytotoxicity on any of the plots at the three golf courses.

Table 1. Percentage reduction in *Poa annua* in response to Prograss and Primo, 1998.

Treatment	Rate/1000 ft ²	Ft. Dodge Fairway, Fall-98	Ft. Dodge Fairway, Spring-99	Ft. Dodge Small Plot	Otter Creek Fairway, Fall-98	Otter Creek Fairway, Spring-99	Otter Creek Small Plot	Hyperion Fairway, Spring-99	Hyperion Small Plot, Fall-98
1. Control	0	17	22	14	0	5	39	0	9
2. Prograss EC+Sprint 330+46-0-0	.75 oz + 7.34 oz + .54 lb	19	38	60	14	79	62	3	+39
3. Prograss EC+Sprint 330+46-0-0	1.5 oz + 7.34 oz + .54 lb	53	74	82	0	35	73	18	+64
4. Primo EC+Sprint 330+46-0-0	.25 oz + 7.34 oz + .54 lb	11	22	14	39	24	60	5	0
5. Primo EC+Sprint 330+46-0-0	.5 oz + 7.34 oz + .54 lb	14	24	20	32	60	58	3	+26
6. Prograss EC+Sprint 330+46-0-0	.25 oz + 7.34 oz + .54 lb	13	17	17	6	13	49	5	+42
7. Prograss+Primo Sprint 330+46-0-0	.25 oz + .25 oz + 7.34 oz + .54 lb	15	24	11	7	63	55	10	+14
8. Prograss+Primo Sprint 330+46-0-0	.75 oz + .25 oz + 7.34 oz + .54 lb	24	30	58	49	42	54	0	+55
9. Prograss+Primo Sprint 330+46-0-0	1.5 oz + .25 oz + 7.34 oz + .54 lb	60	90	79	54	95	69	38	+116
10. Sprint 330 + 46-0-0	7.34 oz + .54 lb	19	19	28	19	36	46	3	+11
11. Prograss Alone	1.5 oz			28			45		+12
LSD 0.05		17	4	21	33	47	NS	12	58

There were no reductions in quality of fairway grasses at any of the sites during the season.

Effect of Beacon on the Germination of Kentucky Bluegrass and Creeping Bentgrass - 1998 Report

Barbara R. Bingaman, Nick E. Christians, Michael B. Faust, and Melissa C. McDade

In this study the effect of CGA #136872 (Beacon) on seed germination and establishment of Kentucky bluegrass and creeping bentgrass was evaluated. This study started in 1997 and concluded in 1998 at the Iowa State University Horticulture Research Station located north of Ames, IA. The experimental plot was a bare soil area that had been tilled, raked, and prepared for seeding. The soil in this plot was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.9%, a pH of 7.0, 3 ppm P, and 76 ppm K.

Individual plot size was 5 x 6 ft. There were three replications with 3 ft barrier rows between replications. CGA #136872 (Beacon) was applied at 20 and 40 g product/acre. Applications were made eight, four, and two weeks, and one day before seeding. The liquid materials were applied at 30 psi using a carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles. A methylated seed oil spreader (SCOIL MSO) was added at 0.25% V/V to all treatments except the control. CGA #136872 (Beacon) was mixed in 283 ml of water per plot which translates to an application rate of 3 gal/1000 ft².

Treatments were applied in 1997. The 'eight weeks before seeding' treatments were applied on July 14, the 'four weeks before seeding' on August 15, the 'two weeks before seeding' on August 28, and the 'one day before seeding' on September 11. Seeding took place on September 12, 1997.

There was a heavy infestation of weeds in the plots and border rows at the time of seeding. All weeds were cut off with a hoe and removed. The soil from individual plots was not mixed with adjacent plots. Light raking was performed to make shallow grooves in the soil for the seeds. The plots were split into two 5 x 3 ft subplots. One of these was seeded with 'Penneagle' creeping bentgrass at 1 lb/1000 ft² and the other with 'Award' Kentucky bluegrass at 1.5 lb/1000 ft². The seeding was done using a drop seeder. The plots were lightly raked following seeding to partially cover the seeds. Rainfall was sporadic during this period so the plot was irrigated daily.

Bentgrass seedlings were first observed on September 18, 1997. Kentucky bluegrass germination was noted on September 26. By October 2, differences in bentgrass cover were beginning to appear but the plants were so small that data were not taken. Germination was determined as the percentage of area per plot covered by each species. Percentage cover data were taken in 1997 on October 9, October 14, and November 11 (Table 1 and 2). Final 1997 data for this study were taken on November 11 because winter weather conditions had already set in. At this time, the bentgrass plants had matured but the bluegrass plants were still quite small.

Additional germination data were taken spring 1998. Percentage creeping bentgrass cover data were taken on April 22 and May 13, 1998 (Table 3). Data for Kentucky bluegrass were taken on May 13.

Data were analyzed with the Statistical Analysis System (SAS, version 6.12) and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

There were observable reductions in percentage cover of creeping bentgrass on October 9 and 14, 1997 even though the differences were not significant. The November 11 data show that the 'one day before seeding' treatment of CGA #136872 (Beacon) at 40 g product/A significantly reduced the percentage cover of bentgrass when compared with the untreated control. Although the 'one day before seeding' treatment of CGA #136872 (Beacon) at 20 g product/A did numerically reduce the bentgrass cover, the percentage cover was not significantly reduced from the untreated control (Table 1).

Because of the weather conditions in October 1997, the bluegrass did not mature. The plants were still quite small when the final data were taken. There were significant differences ($P \geq 0.06$) in bluegrass cover on November 11. The percentage cover of bluegrass treated with 20.0 g product/A at eight weeks, two weeks, and one day before seeding was significantly reduced when compared with the untreated control. In addition, significant reductions were recorded for bluegrass treated 2 weeks before seeding at 40 g product/A (Table 2). These were unusual results for the Kentucky bluegrass and observations will be made Spring 1998 to confirm these results.

In 1998, there were no significant reductions in either creeping bentgrass or Kentucky bluegrass percentage cover but there were numerical differences in bentgrass cover on both dates (Table 3). Percentage bentgrass cover was 10.0% on April 22 and 13.3% on May 13 in plots treated with CGA #136872 1 day before seeding as compared to 40.0 and 43.3% in the untreated plots. Kentucky bluegrass cover was similar in all untreated and treated plots in May 1998.

Table 1. Percentage cover¹ of 'Penneagle' creeping bentgrass in the 1997 Carryover Seeding Study.

	Material ²	Rate product/A.	Timing of application (before seeding)	October 9	October 14	November 11	Mean cover
				%			
1	Untreated Control	NA	NA	32	35	55	41
2	CGA #136872	20.0 g	8 weeks	40	45	73	53
3	CGA #136872	20.0 g	4 weeks	43	43	75	54
4	CGA #136872	20.0 g	2 weeks	30	32	72	44
5	CGA #136872	20.0 g	1 day	22	27	40	29
6	CGA #136872	40.0 g	8 weeks	33	35	65	44
7	CGA #136872	40.0 g	4 weeks	20	20	45	28
8	CGA #136872	40.0 g	2 weeks	20	23	53	32
9	CGA #136872	40.0 g	1 day	5	5	12	7
	LSD _{0.05}			NS	NS	38	NS

¹Percentage cover was estimated as the area per plot covered by creeping bentgrass.

²CGA #136872 was applied with SCOIL MSO at 0.25% V/V.

'Eight-weeks before seeding' materials were applied on July 14, '4-weeks' on August 15, '2-weeks' on August 28, and '1-day' on September 11, 1997. Seeding took place on September 12, 1997.

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

Table 2. Percentage cover¹ of 'Award' Kentucky bluegrass in the 1997 Carryover Seeding Study.

	Material ²	Rate product/A.	Timing of application (before seeding)	October 9	October 14	November 11	Mean % cover
				%			
1	Untreated Control	NA	NA	13	15	53	27
2	CGA #136872	20.0 g	8 weeks	12	17	32	20
3	CGA #136872	20.0 g	4 weeks	17	18	48	28
4	CGA #136872	20.0 g	2 weeks	12	15	25	17
5	CGA #136872	20.0 g	1 day	12	12	35	19
6	CGA #136872	40.0 g	8 weeks	15	17	50	27
7	CGA #136872	40.0 g	4 weeks	12	15	40	22
8	CGA #136872	40.0 g	2 weeks	12	15	35	21
9	CGA #136872	40.0 g	1 day	10	10	40	20
	LSD _{0.05}			NS	NS	(p ≥ 0.06) 18	NS

¹Percentage cover was estimated as the area per plot covered by Kentucky bluegrass.

²CGA #136872 was applied with SCOIL MSO at 0.25% V/V.

'Eight-weeks before seeding' materials were applied on July 14, '4-weeks' on August 15, '2-weeks' on August 28, and '1-day' on September 11, 1997. Seeding took place on September 12, 1997.

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

Table 3. Spring 1998 percentage cover¹ of 'Penneagle' creeping bentgrass and 'Award' Kentucky bluegrass data for the 1997 Carryover Seedling Study.

			Creeping bentgrass			Kentucky bluegrass
Material ²	Rate product/A.	Timing of application (before seeding)	April 22	May 13	Mean cover	May 13
			----- % -----			
1	Untreated Control	NA	40.0	43.3	41.7	11.7
2	CGA #136872	20.0 g	53.3	53.3	53.3	11.7
3	CGA #136872	20.0 g	60.0	63.3	61.7	15.0
4	CGA #136872	20.0 g	53.3	60.0	56.7	11.7
5	CGA #136872	20.0 g	38.3	40.0	39.2	8.3
6	CGA #136872	40.0 g	53.3	53.3	53.3	6.7
7	CGA #136872	40.0 g	28.3	33.3	30.8	8.3
8	CGA #136872	40.0 g	40.0	36.7	38.3	8.3
9	CGA #136872	40.0 g	10.0	13.3	11.7	11.7
LSD _{0.05}			NS	NS	NS	NS

¹Percentage cover was estimated as the area per plot covered by either creeping bentgrass or Kentucky bluegrass.

²CGA #136872 was applied with SCOIL MSO at 0.25% V/V.

'Eight-weeks before seeding' materials were applied on July 14, '4-weeks' on August 15, '2-weeks' on August 28, and '1-day' on September 11, 1997. Seeding took place on September 12, 1997.

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

Fairway Bentgrass Growth Regulator Study

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

'Penneagle' Creeping bentgrass maintained at fairway height (0.5 inches) was evaluated after treatment with Proxy 2SL (ethephon). This study was conducted at the Iowa State University Horticulture Research Station located north of Ames, IA.

The study was arranged as a randomized complete block with 3 replications. Individual plot size was 5 x 5 ft with 3 ft barrier rows between replications. Chipco Proxy was applied at 0, 4.7, 6.0, and 12.0 fl oz/1000 ft² (Table 1). There were four applications at these rates made at four week intervals. The first application was made on June 22, 1998 on Penneagle established on a native (Nicollet) soil. Because of construction in this area, the July, August, and September applications were made on a relocated plot of 'Penneagle' established on a soil composed of 1 part peat, 1 part Nicollet soil, and 1 part sand. Subsequent applications on the relocated site were made on July 23, August 20, and September 23. The Proxy was applied in 283 ml water/plot, which translates to an application rate of 3 gal/1000 ft². Applications were made at 30 psi with a carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles.

Turf quality and color data were evaluated on a weekly basis following all applications and for six weeks following the last application. Turf quality was based on color, uniformity, and turf density and was based on a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality. Visual observations of phytotoxicity were made weekly following all applications and for 6 weeks following the last application. Phytotoxicity was recorded as either present or absent. Fresh clipping weights were taken on a weekly basis when there was sufficient growth. Mowing height for collecting clippings was 0.5 in.

The data from the original and relocated plots were analyzed separately and are presented in discrete tables. All data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Treatment effects were examined with Fisher's Least Significant Difference means separation test (LSD).

Original Study

Turf quality data were taken from the original plot on June 30, July 7, July 15, July 23, and July 30 (Table 1). Clippings were gathered on June 30, July 7, and July 30 (Table 2).

On July 7, the bentgrass surfaces in the original plot were examined using a Clegg Impact Soil Tester that measured surface hardness. Readings of 'hardness' were taken at 3 and 6 inch drop heights. Six readings per plot were taken and the highest and lowest readings were deleted. The remaining 4 values were averaged for each plot and each height. The means for each plot were analyzed (Table 3).

The only significant differences in turf quality were recorded on July 15 (Table 1). All treated bentgrass had poorer quality than the untreated controls on July 15 but the quality was still above the lowest acceptable rating of 6.0.

There were no statistical differences in clipping weights on any of the collection dates (Table 2). On July 7, the numerical differences between the treated and untreated bentgrass were quite large. The clipping weight of turf treated with Proxy 2SL at 12.0 fl oz/1000 ft² was almost twice that of the untreated controls and Proxy at the lower rates produced at least a 150% increase in clippings as compared with untreated turf.

Measurements with the Clegg Impact Soil Tester showed very little difference in hardness of the bentgrass surface among the treatments (Table 3). Hardness was similar for treated and untreated turf at the 3 and 6 inch heights.

Relocated Study

Quality ratings were made for the relocated plot on August 5, August 12, August 20, August 27, September 4, September 11, September 17, September 23, October 2, October 9, October 15, October 22, and October 30 (Table 4-5). Clippings were taken from the relocated plot on August 12, September 4, September 11, September 23, and October 9 (Table 6).

There were no differences in visual quality between treated and untreated bentgrass until October 9 (Table 4-5). Significant reductions in quality were found in all treated bentgrass from October 9 through October 30. The quality of the treated turf during this period did not drop below the lowest acceptable rating of 6.0.

Clipping weights were not significantly reduced by the treatments as compared with the untreated controls at any of the test dates (Table 6).

Table 1. Visual quality¹ of 'Penneagle' creeping bentgrass treated in the 1998 Fairway Bentgrass Growth Regulator Study for June 30 through July 30 (on original site).

	Material	Rate (fl oz/1000 ft ²)	June 30	July 7	July 15	July 23	July 30	Mean
1	Untreated control	N/A	9.0	8.0	9.0	8.0	8.0	8.4
2	Chipco Proxy 2SL	4.7	7.0	8.0	7.7	8.0	8.0	7.7
3	Chipco Proxy 2SL	6.0	7.0	8.0	8.0	8.0	8.0	7.8
4	Chipco Proxy 2SL	12.0	7.0	8.0	8.0	8.0	8.0	7.8
	LSD _{0.05}		--	--	0.6	--	--	0.1

¹Visual quality assessments were made using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

-- = Fisher's Least Significant Difference means separation test is not valid for these data.

Table 2. Fresh clipping weights¹ of 'Penneagle' creeping bentgrass treated in the 1998 Fairway Bentgrass Growth Regulator Study (on original site).

	Material	Rate (fl oz/1000 ft ²)	June 30	July 7	July 30	Mean weight
					g	
1	Untreated control	N/A	12.1	22.0	23.4	19.2
2	Chipco Proxy 2SL	4.7	13.0	34.1	23.6	23.6
3	Chipco Proxy 2SL	6.0	19.7	33.2	24.2	25.7
4	Chipco Proxy 2SL	12.0	15.8	42.7	23.9	27.5
	LSD _{0.05}		NS	NS	NS	NS

¹Fresh clipping weights represent grams fresh tissue.

Applications were made on June 22.

-- = Fisher's Least Significant Difference means separation test is not valid for these data.

Table 3. Hardness of 'Penneagle' creeping bentgrass surfaces as measured with the Clegg Impact Soil Tester in the 1998 Fairway Bentgrass Growth Regulator Study (on original site).

	Material	Rate (fl oz/1000 ft ²)	3 inch height	6 inch height
1	Untreated control	N/A	28.8	42.5
2	Chipco Proxy 2SL	4.7	26.8	50.3
3	Chipco Proxy 2SL	6.0	28.8	44.1
4	Chipco Proxy 2SL	12.0	27.9	46.0
	LSD _{0.05}		NS	NS

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

Table 4. Visual quality¹ of 'Penneagle' creeping bentgrass treated in the 1998 Fairway Bentgrass Growth Regulator Study for August 5 - September 17 (on relocated site).

	Material	Rate (fl oz/1000 ft ²)	Aug 5	Aug 12	Aug 20	Aug 27	Sept 4	Sept 11	Sept 17
1	Untreated control	N/A	9.0	9.0	6.0	7.0	8.0	6.0	7.0
2	Chipco Proxy 2SL	4.7	9.0	9.0	6.0	7.0	8.0	6.0	7.0
3	Chipco Proxy 2SL	6.0	9.0	9.0	6.0	7.0	8.0	6.0	7.0
4	Chipco Proxy 2SL	12.0	9.0	9.0	6.0	7.0	8.0	6.0	7.0
	LSD _{0.05}		--	--	--	--	--	--	--

¹Visual quality assessments were made using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

-- = Fisher's Least Significant Difference means separation test is not valid for these data.

Table 5. Visual quality¹ of 'Penneagle' creeping bentgrass treated in the 1998 Fairway Bentgrass Growth Regulator Study for September 23 - October 30 (on relocated site).

	Material	Rate (fl oz/1000 ft ²)	Sept 23	Oct 2	Oct 9	Oct 15	Oct 22	Oct 30	Mean
1	Untreated control	N/A	9.0	8.0	9.0	9.0	8.0	8.0	8.4
2	Chipco Proxy 2SL	4.7	9.0	8.0	7.3	7.0	6.0	6.7	7.7
3	Chipco Proxy 2SL	6.0	9.0	8.0	7.0	7.3	6.0	6.3	7.8
4	Chipco Proxy 2SL	12.0	9.0	8.0	6.3	7.0	6.0	7.0	7.8
	LSD _{0.05}		--	--	1.7	0.6	0.7	1.0	0.1

¹Visual quality assessments were made using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

-- = Fisher's Least Significant Difference means separation test is not valid for these data.

Table 6. Fresh clipping weights¹ of 'Penneagle' creeping bentgrass treated in the 1998 Fairway Bentgrass Growth Regulator Study (on relocated site).

	Material	Rate (fl oz/1000 ft ²)	Aug 12	Sept 4	Sept 11	Sept 23	Oct 9	Oct 30	Mean
			g						
1	Untreated control	N/A	1.0	63.7	25.3	17.5	22.8	20.0	25.0
2	Chipco Proxy 2SL	4.7	1.4	62.3	30.0	13.8	23.5	15.7	24.4
3	Chipco Proxy 2SL	6.0	1.4	76.7	26.0	16.8	24.6	13.5	26.5
4	Chipco Proxy 2SL	12.0	1.6	98.3	42.0	12.9	21.9	16.5	32.2
	LSD _{0.05}		NS	NS	NS	NS	NS	NS	NS

¹Fresh clipping weights represent grams fresh tissue.

Applications were made on July 23, August 20, and September 23.

Effect of Trinexapac-ethyl on Kentucky Bluegrass Sod Establishment

Barbara R. Bingaman, Melissa C. McDade, Michael B. Faust, and Nick E. Christians

The growth regulator, Trinexapac-ethyl (Primo), was screened for effects on the establishment of 'Majestic' Kentucky bluegrass sod. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa in a 'Majestic' Kentucky bluegrass area where a similar sod study was conducted in 1996. The sod was cut in the opposite direction as the previous study to offset any possible carryover effects. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 4.5% organic matter, a pH of 7.12, 4 ppm P, and 93 ppm K.

Rainfall was sporadic throughout the duration of this study. Supplemental irrigation was used to maintain the bluegrass in good growing condition and to facilitate sod root development.

Individual plots were 5 x 5 ft and four replications were conducted. There were six Primo treatment regimes and an untreated control. All Primo applications were made at the label rate for Kentucky bluegrass (0.75 fl oz/1000 ft²). The timing of applications was in reference to sod cutting and establishment. The treatments included an application of Primo six and two weeks before sod establishment, two and six weeks after, two weeks before, two weeks after, six and two weeks before plus two and six weeks after, and two weeks before plus two weeks after (Table 1).

Primo 1EC was applied at 30 psi with a carbon dioxide powered backpack sprayer equipped with Teejet® #8006 flat fan nozzles. The Primo was mixed in 283 ml of water which translates to an application rate of 3 gal/1000 ft².

The six weeks before sod establishment treatments were applied on June 10, 1998 and the two weeks before were made on July 9. The two weeks after treatments were applied on August 5 and the six weeks after sod establishment treatments were made on September 2.

The bluegrass on the entire experimental plot was cut on July 23 using an 18-inch sod cutter. Within each individual plot, sod pieces were cut that matched the outside diameter of 12 x 12 in wooden frames that were constructed with bottoms of 18 mesh screen. The pieces were trimmed and transplanted into the frames and the frames with the sod pieces were returned to the holes and placed flush with the soil surface. There were four frames per individual plot, one in each of four quadrants. The study was watered thoroughly upon completion and was watered on a regular basis to prevent the sod from drying.

Root development was measured using a hydraulic sod pulling apparatus equipped with steel cables that could be attached to screw hooks on the corners of wooden frames (Figure 1). The tensile strength required to 'pull' a frame from the soil was measured in pounds per square inch (psi). One frame per plot was sampled on each of four collection dates beginning on August 4, two weeks after sod establishment. The other frames were harvested at two-week intervals on August 18, September 2, and September 16 (Table 4).

Visual quality data were taken on a weekly basis from June 16 through September 16 (Tables 2 and 3). Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

Data were analyzed using the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) means separation test.

On June 24 and July 17, numerical differences in visual quality were found. The Primo treated plots showed a slight phytotoxicity on June 24, two weeks after treatment. On July 17, the bluegrass that was treated on both June 10 and July 9 (treatments 2 and 6) had a better color than the other treated and untreated turf. The bluegrass treated on July 9 only (treatments 4 and 7) showed a slight phytotoxicity. The phytotoxicity was not detectable after a few days. There were no differences in turf quality after July 17 (Table 2).

There were numerical tensile strength differences in sod harvested on August 4, August 18, and September 2 but the treatment effects were not statistically different (Table 4). On September 16, the sod treated with Primo IEC two weeks before establishment had significantly more root development than sod treated two and six weeks before, two weeks before and after, sod treated two and six weeks after, and the untreated control. Root development was similar for sod treated six and two weeks before and two and six weeks after establishment and sod treated two weeks after establishment. The data from September 16 show that root tensile strength was 30% higher for sod treated with Primo IEC two weeks before establishment than for untreated sod.

Table 1. Timing of Primo applications for the 1998 Sod Establishment Study

	Material	Rate /plot	Timing of applications*			
			6 weeks before	2 weeks before	2 weeks after	6 weeks after
1	Untreated control	NA	NA	NA	NA	NA
2	Primo IEC	0.75 oz	yes	yes	no	no
3	Primo IEC	0.75 oz	no	no	yes	yes
4	Primo IEC	0.75 oz	no	yes	no	no
5	Primo IEC	0.75 oz	no	no	yes	no
6	Primo IEC	0.75 oz	yes	yes	yes	yes
7	Primo IEC	0.75 oz	no	yes	yes	no

*Timing is in reference to cutting of sod. Six and two weeks before cutting and two and six weeks after establishment. Sod Harvested on July 23. Six weeks before harvest applications made June 10, 2 weeks before on July 9, 2 weeks after on August 5, and 6 weeks after on September 2.

Frames were pulled on August 4, August 18, September 2, and September 16.

Table 2. Visual quality¹ of Kentucky bluegrass in the 1998 Sod Establishment Study (June 16 - August 4).

	Material	June 16	June 24	June 30	July 7	July 17	July 29	August 4
1	Untreated control	8.0	8.0	7.0	7.0	6.3	7.0	7.0
2	Primo IEC	8.0	5.0	7.0	7.0	7.5	7.0	7.0
3	Primo IEC	8.0	8.0	7.0	7.0	6.3	7.0	7.0
4	Primo IEC	8.0	6.0	7.0	7.0	6.0	7.0	7.0
5	Primo IEC	8.0	8.0	7.0	7.0	6.5	7.0	7.0
6	Primo IEC	8.0	5.0	7.0	7.0	6.8	7.0	7.0
7	Primo IEC	8.0	8.0	7.0	7.0	6.0	7.0	7.0
	LSD _{0.05}	--	NS	--	--	NS	--	--

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

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

-- = means comparison tests are not applicable to these data.

Table 3. Visual quality¹ of Kentucky bluegrass in the 1998 Sod Establishment Study (August 11 - September 16).

	Material	August 11	August 18	August 26	Sept 2	Sept 9	Sept 16	Mean quality
1	Untreated control	7.0	7.0	7.0	8.0	8.0	9.0	7.4
2	Primo IEC	7.0	7.0	7.0	8.0	8.0	9.0	7.3
3	Primo IEC	7.0	7.0	7.0	8.0	8.0	9.0	7.4
4	Primo IEC	7.0	7.0	7.0	8.0	8.0	9.0	7.2
5	Primo IEC	7.0	7.0	7.0	8.0	8.0	9.0	7.4
6	Primo IEC	7.0	7.0	7.0	8.0	8.0	9.0	7.2
7	Primo IEC	7.0	7.0	7.0	8.0	8.0	9.0	7.4
	LSD _{0.05}	-	-	-	-	-	-	0.1

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

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

-- = means comparison tests are not applicable to these data.

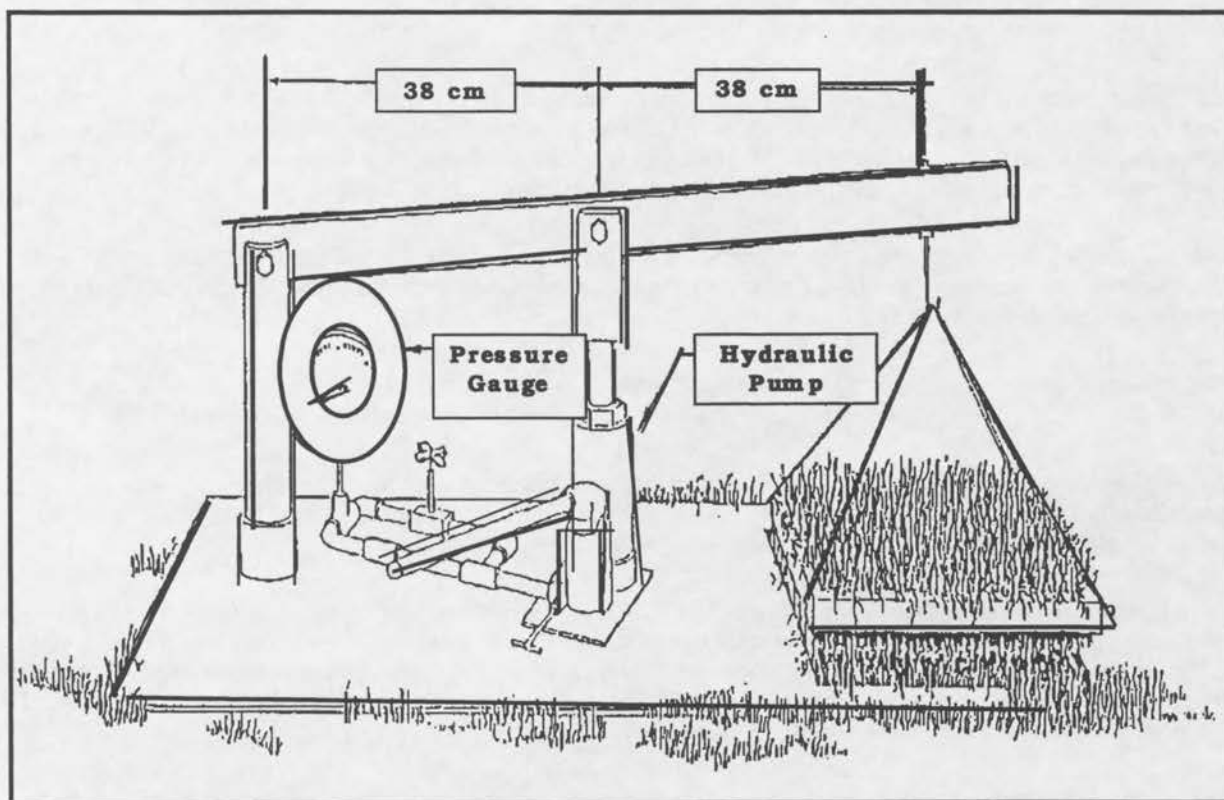
Table 4. Root tensile strength and knitting of Kentucky bluegrass sod growing in frames in the 1998 Sod Establishment Study as measured by the number of pounds per square inch (psi) to pull 1 ft² frames.

Material	August 4	August 18	September 2	September 16	Mean strength
	psi				
1 Untreated control	57.5	252.5	385.0	355.0	262.5
2 Primo IEC	37.5	285.0	395.0	385.0	275.6
3 Primo IEC	53.8	270.0	300.0	382.5	251.6
4 Primo IEC	18.8	298.8	346.3	460.0	280.9
5 Primo IEC	23.8	272.5	341.3	401.3	259.7
6 Primo IEC	35.0	315.0	331.3	415.0	274.1
7 Primo IEC	33.8	243.8	346.3	395.0	254.7
LSD _{0.05}	NS	NS	NS	63.0	NS

P > F = 0.07

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

Frames were pulled on August 4, August 18, September 2, and September 16.

Figure 1. The hydraulic sod pulling device used to measure root tensile strength of the sod in the 1998 Sod Establishment Study.

Effects of Trinexapac-ethyl on *Poa annua* Populations in Green Height Creeping Bentgrass

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

This study was designed to evaluate the growth regulator, Trinexapac-ethyl (Primo), for *Poa annua* control in creeping bentgrass maintained at green height following a fall conversion program. This study was conducted on a practice green at Veenker Memorial Golf Course in Ames, IA. The turf in this area consisted of creeping bentgrass with an infestation of *Poa annua* that ranged from 50 to 80% through the 1998 season.

The experimental design was a randomized complete block. Individual plot size was 5 x 5 ft with 3 replications. Treatments were applied to the same plots as in 1997. Primo 1EC was used at 0.3 fl oz/1000 ft² monthly from May through September. Initial application was made on May 14 and subsequent applications were made on June 17, July 14, August 19, and September 23, 1998. Primo 1EC was mixed with 283 ml of water (3 gal/1000 ft²) and was applied at 30 psi with a carbon dioxide backpack sprayer equipped with Teejet® #8006 flat fan nozzles. All applications were made between 6:30 and 7:00 a.m. Following applications, the plot was watered with the normal watering schedule in the late afternoon.

Visual turf quality data were taken from April 22 through October 27, 1998 (Tables 1 and 2). Visual turf quality was assessed with a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. On each of these dates, the plots were checked for phytotoxicity. Phytotoxicity was assessed using a 9 to 1 scale with 9 = no damage, 6 = moderate tip burn (browning) and 4 = severe tip burn.

Poa annua populations were estimated as the percentage of area per plot covered by *Poa annua*. Percentage cover data were taken on May 13, May 28, June 12, July 14, July 30, August 12, August 26, September 10, September 22, October 1, October 14, and October 27 (Table 3 and 4). *Poa annua* control is represented by calculating reductions in percentage cover as compared with the untreated control (Tables 5 and 6).

On May 16, 1998, the practice green was core aerified and topdressed. The effects of Primo on the recovery from this procedure were examined on May 28 by estimating the percentage bentgrass recovery. Estimations were based on bentgrass growth into the 'core areas'.

All data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Treatment effects were compared with Fisher's Least Significant Difference (LSD) test.

In general, quality differences between the treated and untreated bentgrass were found throughout the season approximately 14 days following Primo applications (Tables 1 and 2). In October, treated bentgrass consistently was darker green than the untreated bentgrass. No phytotoxicity was found.

Primo treated bentgrass had less *Poa annua* than the untreated control from May 28 through October 27 (Tables 4 and 5). The differences in percentage cover were significant on all data collection dates except July 30 and August 26. Mean percentage *Poa annua* cover also was significantly lower in treated bentgrass than untreated. Significant reductions in *Poa annua* cover ranged from 22.7 to 63.3% as compared with the untreated controls (Tables 5 and 6). The mean reduction in Primo treated bentgrass was 47.6%.

Primo treated bentgrass recovered from core aerification significantly slower than untreated bentgrass ($P > F = 0.0339$). On May 28, recovery in the Primo treated bentgrass was 65% as compared with 88.3% recovery for untreated bentgrass. By June 12, recovery was 100% for both treated and untreated bentgrass.

Additional percentage cover data will be taken spring 1999 beginning at greenup. Winter damage also will be assessed spring 1999.

Table 1. Visual quality¹ of green height creeping bentgrass treated for the 1997-98 Green Height *Poa annua* Conversion Study (April 22 - August 12, 1998).

	Material	Rate fl oz/ 1000 ft ²	April 22	May 13	May 28	June 12	June 30	July 14	July 30	Aug 12
1	Untreated control	N/A	6.0	7.0	6.7	6.7	7.0	7.0	7.0	7.0
2	Primo IEC ²	0.3	6.0	7.0	7.0	8.0	8.0	7.0	7.0	7.0
	LSD _{0.05}		—	—	NS	1.4	NS	—	—	—

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.²Primo IEC applications were made on May 14, June 17, July 14, August 19, and September 23.

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

-- = Means separation tests are not valid for these data.

Table 2. Visual quality¹ of green height creeping bentgrass treated 1998 Green Height *Poa annua* Conversion Study (August 26 - October 27, 1998).

	Material	Rate fl oz/ 1000 ft ²	Aug 26	Sept 10	Sept 22	Oct 1	Oct 14	Oct 27	Mean quality
1	Untreated control	N/A	7.0	7.0	7.0	7.0	7.0	6.3	6.8
2	Primo ²	0.3	8.0	7.0	7.0	9.0	9.0	9.0	7.6
	LSD _{0.05}		—	—	—	—	—	1.4	0.5

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

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

-- = Means separation tests are not valid for these data.

Table 3. Percentage *Poa annua* cover¹ in creeping bentgrass treated for the 1997-98 Green Height *Poa annua* Conversion Study (May 13 - August 26, 1998).

	Material	Rate fl oz/ 1000 ft ²	May 13	May 28	June 12	July 14	July 30	August 12	August 26
			%						
1	Untreated control	N/A	46.7	73.3	78.3	58.3	51.7	46.7	50.0
2	Primo ²	0.3	53.3	56.7	43.3	21.7	18.3	20.0	25.0
	LSD _{0.05}		NS	7.2	12.4	28.7	NS	28.7	NS

¹These values represent the area per plot covered by *Poa annua*.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

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

Table 4. Percentage *Poa annua* cover¹ in creeping bentgrass treated for the 1997-98 Green Height *Poa annua* Conversion Study (September 10 - October 27, 1998).

	Material	Rate fl oz/ 1000 ft ²	Sept 10	Sept 22	Oct 1	Oct 14	Oct 27	Mean Cover
			%					
1	Untreated control	N/A	43.3	46.7	50.0	53.3	63.3	46.7
2	Primo ²	0.3	23.3	21.7	18.3	21.7	23.3	20.0
	LSD _{0.05}		12.4	12.4	7.2	28.7	32.9	7.2

¹These values represent the area per plot covered by *Poa annua*.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

Table 5. Reductions in percentage *Poa annua* cover¹ in creeping bentgrass treated for the 1997-98 Green Height *Poa annua* Conversion Study (May 13 - August 26, 1998).

Material	Rate fl oz/ 1000 ft ²	May 13	May 28	June 12	July 14	July 30	August 12	August 26
		%						
1 Untreated control	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 Primo ²	0.3	0.0	22.7	44.7	62.8	64.5	57.2	50.0
LSD _{0.05}		NS	9.8	15.9	17.8	18.5	20.5	24.8

¹These values represent reductions in the area per plot covered by *Poa annua* as compared with the untreated controls.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

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

Table 6. Reductions in percentage *Poa annua* cover¹ in creeping bentgrass treated for the 1997-98 Green Height *Poa annua* Conversion Study (September 10 - October 27, 1998).

Material	Rate fl oz/ 1000 ft ²	Sept 10	Sept 22	Oct 1	Oct 14	Oct 27	Mean Cover
		%					
1 Untreated control	N/A	0.0	0.0	0.0	0.0	0.0	0.0
2 Primo ²	0.3	46.1	53.6	63.3	59.3	63.1	47.6
LSD _{0.05}		28.7	26.6	14.3	27.0	30.0	13.2

¹These values represent reductions in the area per plot covered by *Poa annua* as compared with the untreated controls.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

Effects of Trinexapac-ethyl on *Poa annua* Populations in Fairway Height Creeping Bentgrass

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

The growth regulator, Trinexapac-ethyl (Primo), was evaluated for *Poa annua* control in creeping bentgrass maintained at fairway height following a fall conversion program in this study. It was conducted on a fairway height area surrounding a practice green at Veenker Memorial Golf Course in Ames, IA. The turf in this area consisted of perennial ryegrass with an infestation of *Poa annua* that ranged from 20 to 0% through the 1998 season. The experimental design was a randomized complete block. Individual plot size was 5 x 5 ft with 3 replications. The plot was overseeded with perennial ryegrass in September 1998.

Treatments were applied to the same plots as in 1997. Primo IEC was used at 0.5 fl oz/1000 ft² monthly from May through September. Initial application was made on May 14 and subsequent applications were made on June 17, July 14, August 19, and September 23, 1998. Primo IEC was mixed with 283 ml of water (3 gal/1000 ft²) and was applied at 30 psi with a CO₂ backpack sprayer equipped with Teejet® #8006 Teeject flat fan nozzles. All applications were made between 6:30 and 7:00 a.m. Following applications, the plot was watered with the normal watering schedule in the late afternoon.

Visual turf quality data were taken from April 22 through October 27 (Tables 1 and 2). Visual turf quality was assessed with a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. On each of these dates, the plots were checked for phytotoxicity. Phytotoxicity was assessed using a 9 to 1 scale with 9 = no damage, 6 = moderate tip burn (browning) and 4 = severe tip burn.

All data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Treatment effects were examined with Fisher's Least Significant Difference means separation test (LSD).

Poa annua populations were estimated as the percentage of area per plot covered by *Poa annua*. Percentage cover data were taken on May 13, May 28, June 12, June 30, July 14, July 30, August 12, August 26, September 10, September 22, October 1, October 14, and October 27 (Tables 3 and 4). Additional percentage cover data will be taken spring 1999 beginning at greenup. Winter damage also will be assessed spring 1999.

Primo treated ryegrass had a darker green color than the untreated ryegrass on May 28 and June 12 approximately 2 - 4 weeks following the first Primo application (Table 1). No further quality differences were noted through the season until October 27 (Table 2). No phytotoxicity was found.

Primo treated ryegrass had less *Poa annua* than the untreated control from May 13 through July 30 (Tables 3 and 4). The reduction in *Poa annua* was significantly different on May 13. The reductions were numerically different from May 28 through July 30. By August 19, the *Poa annua* had all died in the experimental plot. Close examinations of the plot were made from August 19 through October 27 and no *Poa annua* was found.

Table 1. Visual quality¹ of perennial ryegrass treated for the 1997-98 Fairway Height *Poa annua* Conversion Study (April 22 - August 12, 1998).

Material	Rate fl oz/ 1000 ft ²	April 22	May 13	May 28	June 12	June 30	July 14	July 30	Aug 12
1 Untreated control	N/A	9.0	9.0	7.3	7.3	9.0	9.0	9.0	9.0
2 Primo IEC ²	0.5	9.0	9.0	8.7	8.7	9.0	9.0	9.0	9.0
LSD _{0.05}		—	—	1.4	1.4	—	—	—	—

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.²Primo IEC applications were made on May 14, June 17, July 14, August 19, and September 23.

-- = Means separation tests are not valid for these data.

Table 2. Visual quality¹ of perennial ryegrass treated 1998 Fairway Height *Poa annua* Conversion Study (August 26 - October 27, 1998).

Material	Rate fl oz/ 1000 ft ²	Aug 26	Sept 10	Sept 22	Oct 1	Oct 14	Oct 27	Mean quality
1 Untreated control	N/A	9.0	9.0	9.0	9.0	9.0	7.0	8.6
2 Primo ²	0.5	9.0	9.0	9.0	9.0	9.0	9.0	8.9
LSD _{0.05}		—	—	—	—	—	—	0.2

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

-- = Means separation tests are not valid for these data.

Table 3. Percentage *Poa annua* cover¹ in perennial ryegrass treated for the 1997-98 Fairway Height *Poa annua* Conversion Study (May 13 - August 26, 1998).

Material	Rate fl oz/ 1000 ft ²	May 13	May 28	June 12	June 30	July 14	July 30	Aug 19	Aug 26
%									
1 Untreated control	N/A	63.3	16.0	15.0	3.7	0.7	0.7	0.0	0.0
2 Primo ²	0.5	33.3	5.0	3.7	1.7	0.3	0.3	0.0	0.0
LSD _{0.05}		24.8	NS	NS	NS	NS	NS	—	—

¹These values represent the area per plot covered by *Poa annua*.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

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

-- = Means separation tests are not valid for these data.

Table 4. Percentage *Poa annua* cover¹ in perennial ryegrass treated for the 1997-98 Fairway Height *Poa annua* Conversion Study (September 10 - October 27, 1998).

Material	Rate fl oz/ 1000 ft ²	Sept 10	Sept 22	Oct 1	Oct 14	Oct 27	Mean Cover
%							
1 Untreated control	N/A	0.0	0.0	0.0	0.0	0.0	8.3
2 Primo ²	0.5	0.0	0.0	0.0	0.0	0.0	3.7
LSD _{0.05}		—	—	—	—	—	NS

¹These values represent the area per plot covered by *Poa annua*.²Primo applications were made on May 14, June 17, July 14, August 19, and September 23.

-- = Means separation tests are not valid for these data.

Evaluation of Fungicides for Control of Dollar Spot on Creeping Bentgrass - 1998

Mark L. Gleason, Nick E. Christians, and James R. Dickson

Trials were conducted at the Iowa State University Horticulture Research Farm near Gilbert, 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/1,000 ft². The experimental design was a randomized complete block with four replications. All plots measured 4 ft x 5 ft. Five days after inoculation of the entire plot with rye grain infested with the dollar spot pathogen, fungicide applications began on June 12. Subsequent applications were made on June 19, June 26 and on July 3, 10, 17, and 24.

Dollar spot symptoms were first observed on June 26. Disease development on untreated check plots was light on 29 Jun and moderately severe on July 10 and 16. Most, but not all, fungicide treatments exhibited significantly (LSD, $P=0.05$) less disease than the untreated check. Phytotoxicity (browning of tips of grass blades) on plots treated with AMV 300 became progressively worse during July, and was more severe at the 2 oz than the 1 oz rate.

Table 1. 1998 Dollar Spot Trial at ISU Horticulture Station.

Trt	Product	Rate/1,000 ft ²	Interval (days)	Mean % Plot Diseased		
				June 29	July 10	August 25
1	-----	-----	--	4.0	17.5	22.5
2	Chipco 26 GT	2 oz	14	0.0	0.0	0.0
	+ Cleary's 3336 F	2 fl oz				
3	Cleary 3336 50 WP	2 oz	14	0.0	0.0	0.0
4	Spectro 90 WDG	4 oz	14	0.0	0.0	0.0
5	Spectro 90 WDG	8 oz	14	1.5	0.0	0.0
6	WAC 75	5 oz	14	0.0	0.0	0.0
7	WAC 76	5.3 oz	14	0.0	0.0	0.0
8	Thalonil 90 DF	3.5 oz	14	2.2	2.8	4.0
9	TRA-0232	3.5 oz	14	2.1	4.8	5.8
10	BAS 505 50 DF	0.11 oz	14	0.2	0.3	0.0
11	BAS 505 50 DF	0.14 oz	14	0.3	0.1	0.3
12	BAS 505 50 DF	0.18 oz	14	0.1	0.0	0.0
13	BAS 505 50 DF	0.18 oz	28	0.0	1.5	1.9
14	BAS 505 50 DF	0.26 oz	28	0.1	1.1	1.2
15	BAS 510 4.17 SC	0.11 fl oz	14	2.8	13.0	14.5
16	BAS 510 4.17 SC	0.14 fl oz	14	2.4	0.4	0.2
17	BAS 510 4.17 SC	0.18 fl oz	14	4.1	3.3	1.8
18	BAS 510 4.17 SC	0.18 fl oz	28	3.6	18.0	20.8
19	BAS 510 4.17 SC	0.26 fl oz	28	1.5	8.0	9.0
20	Banner MAXX 1.24 MC	1.0 fl oz	21	0.0	0.0	0.0
	+ Thalonil 90 DF	6 oz				
21	Heritage 50 WP	0.2 oz	14	2.3	3.3	3.7
	+ Daconil Ultrex	3.8 oz				

Trt	Product	Rate/1,000 ft ²	Interval (days)	Mean % Plot Diseased		
				June 29	July 10	August 25
22	Daconil Ultrex	3.8 oz	14	2.0	3.3	8.3
23	Eagle 50 WP	0.5 oz	14	1.1	0.0	0.0
	4 th and later sprays:					
	Daconil Ultrex	3.8 oz	14			
24	Eagle 50 WP	1.2 oz	28	0.5	3.1	2.0
25	ZeroTol	0.5 fl oz/80 ft ²	7	4.0	18.3	21.3
26	Bayleton 50 DF	0.25 oz	14	2.4	0.3	0.3
	+ Daconil Ultrex	1.82 oz				
27	Lynx 45 WP	0.28 oz	14	0.9	0.1	0.0
	+ Daconil Ultrex	1.82 oz				
28	Bayleton 50 DF	0.25 oz	14	1.3	0.7	0.3
29	Lynx 45 WP	0.28 oz	14	0.3	0.1	0.0
30	AMV 300	1 oz	14	3.8	12.5	18.8
31	AMV 300	2 oz	14	3.5	17.5	20.5
32	UCC-A1562 20 SC	1 fl oz	21	1.0	0.3	2.3
33	UCC-A1562 20 SC	4 fl oz	21	0.1	0.3	0.0
34	UCC-A1562 20 SC	8 fl oz	21	0.0	0.0	0.0
35	Heritage 50 WG	0.4 oz	21	1.4	0.0	4.1
	Least Significant Difference ^a			1.8	8.9	8.4

^aP = 0.05. n = 4 replications.

Evaluation of Fungicides for Control of Pythium Blight on Perennial Ryegrass - 1998

Mark L. Gleason

Trials were conducted on perennial ryegrass, maintained at fairway height, at the Turfgrass Research Area of the ISU Horticulture Research Farm near Gilbert, IA. The entire plot was inoculated on June 23 and August 7 with rye grain infested with isolates of *Pythium aphanidermatum*. **NOTE:** The grain used for the June 23 inoculation was infested with two isolates of *P. aphanidermatum*, one of which was resistant to metalaxyl. The grain used for the August 7 inoculation was infested with four isolates of *P. aphanidermatum*, two of which were resistant to metalaxyl.

Immediately after the infested grain was applied, the inoculated area was covered by Seedguard geotextile fabric for several days (June 23-24 and August 7-10). Fungicide treatments were applied after the cover was removed. Fungicides were applied with a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1,000 ft². Fungicide applications after the first inoculation were made on June 25, then repeated at specified intervals on July 6, 9, 16, and 23. A single fungicide application, on August 14, was made after the second inoculation.

Weather conditions were conducive to Pythium blight during several periods after the June inoculation, but disease pressure was slight during June and July. Pythium blight symptoms appeared two weeks after the second inoculation. Disease development on August 25 was moderate. Ten treatments had significantly (LSD, $P=0.05$) less disease than the untreated check. No phytotoxicity was observed in any of the plots.

Table 1. 1998 Pythium blight trial on perennial ryegrass (fairway height).

Trt	Product	Rate/1,000 ft ²	Interval (days)	Mean number of infection centers		
				June 29	July 10	August 25
1	-----	-----	----	0.0	0.0	8.75
2	BAS 500 2.09 EC	0.7 fl oz	14	0.0	0.0	3.75
3	Subdue MAXX	1 fl oz	14	0.0	0.0	0.0
4	Subdue MAXX	0.5 fl oz	14	0.0	0.25	1.0
5	Banol 6 EC	1.6 oz	14	0.0	0.0	1.25
6	Aliette Signature	4.0 oz	14	0.0	0.0	0.0
7	Heritage 50 WG	0.2 oz	14	0.0	0.0	0.75
8	Subdue MAXX	0.5 oz	14	0.0	0.0	2.5
	+Banol	1.6 oz				
9	Subdue MAXX	0.5 oz	14	0.0	0.25	0.0
	+ Aliette Signature	4.0 oz				
10	Subdue MAXX	0.5 oz	14	0.0	0.0	0.0
	+ Aliette Signature	2.0 oz				
11	Heritage 50 WG	0.4 oz	10	0.0	0.0	2.5
12	Heritage 50 WG	0.4 oz	14	0.0	0.0	4.5
13	Heritage 50 WG	0.7 oz	14	0.0	0.0	4.0
14	Banol 6 EC	2 fl oz	14	0.25	0.0	1.0
15	Banol 6 EC	1 fl oz	14	0.0	0.0	1.0
	+ Fore FF	6.4 fl oz				
16	Banol 6 EC	1 fl oz	14	0.0	0.0	5.0
	+ Heritage 50 WG	0.2 oz				
17	Subdue MAXX	0.5 oz	14	0.0	0.0	2.75
	+ Fore F	6.4 fl oz				
18	Subdue MAXX	0.4 fl oz	14	0.25	0.0	7.25
	+ Heritage 50 WG	0.2 fl oz				
19	Aliette Signature 80 WP	8 oz	14	0.0	0.25	0.0
20	S-8172	6 fl oz	14	0.0	0.0	1.0
21	S-8174	2 fl oz	14	0.75	0.25	0.5
	+ S-5223	4.5 oz (add 1 st)				
22	S-7248	20.5 oz	14	0.0	0.0	0.5
23	S-7248	41 oz	14	0.0	0.0	1.5
24	UCC-A1562 20 SC	1 fl oz	14	0.25	0.25	0.5
25	UCC-A1562 20 SC	4 fl oz	14	0.25	0.25	5.25
26	UCC-A1562 20 SC	8 fl oz	14	0.0	0.0	8.5
	Least Significant Difference ^a			0.38	0.34	7.14

^a $P = 0.05$. $n = 4$ replications

Evaluation of Fungicides for Control of Brown Patch in Creeping Bentgrass - 1998

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/1,000 ft². The experimental design was a randomized complete block with four replications. All plots measured 4 ft x 5 ft. All plots were bordered on opposite sides by 1-ft-wide strips of untreated turf in order to help create uniform disease pressure.

Fungicide applications began on May 22 (Bio-Trek treatments only). The remainder of the treatments received the first application on June 10. Subsequent applications were made on June 17, 19, and 24; and July 1, 8, 15, and 22.

Brown patch symptoms were first observed on June 29. Disease development on untreated check plots – expressed on a 0-5 scale (0=no disease, 1=1-5%, 2=5-10%, 3=10-25%, 4=25-50%, 5=>50%) – was light on June 29 and moderate on July 10 and 22. Most, but not all, fungicide treatments exhibited significantly (LSD, P=0.05) less disease than the untreated check.

Phytotoxicity (browning of tips of grass blades) on plots treated with AMV 300 became progressively worse during July, and was more severe at the higher rate of product.

Table 1. 1998 Brown Patch Trial - WOI creeping bentgrass greens, Veenker Memorial Golf Course, ISU.

Trt	Product	Rate/1,000 ft ²	Interval (days)	Mean disease rating ^a		
				June 29	July 10	July 22
1	-----	-----	--	1.75	3.25	2.50
2	Bio-Trek G	1.5 lb	late May	1.25	0.00	0.25
	Bio-Trek G	1.5 lb	4 wks later			
	Bio-Trek WP	6 oz	10 days later			
	Heritage	0.2 oz	21			
3	Bio-Trek G	1.5 lb	late May	0.25	0.25	0.00
	Bio-Trek G	1.5 lb	4 wks later			
	Bio-Trek WP	3.0 oz	10 days later			
	Heritage	0.2 oz	21 days			
4	3336 50 WP	4 oz	14	0.25	0.00	0.00
5	Spectro 90 WDG	8 oz	14	0.00	0.00	0.00
6	WAC 75	5 oz	14	0.25	0.00	0.00
7	WAC 76	5.3 oz	14	0.00	0.00	0.00
8	Thalonil 90 DF	3.5 oz	7	0.00	0.00	0.00
9	TRA-0232	3.5 oz	7	0.25	0.00	0.75
10	Thalonil 90 DF	3.5 oz	14	0.00	0.00	0.00
11	TRA-0232	3.5 oz	14	0.25	0.25	0.25
12	BAS 500 2.09 EC	0.42 fl oz	14	0.50	0.25	0.25
13	BAS 505 DF	0.21 oz	14	1.00	0.25	0.00
14	CGA 279202 50 WG	0.1 oz	14	0.25	0.25	0.50
15	CGA 279202 50 WG	0.15 oz	14	0.00	0.00	0.50
16	CGA 279202 50 WG + Banner MAXX	0.1 oz 1 fl oz	14	0.50	0.50	0.25
17	Chipco 26 GT 2 SC	4 fl oz	14	1.00	0.00	0.25
18	EXP 10830A 4.17 SC*	0.3 fl oz	14	0.50	1.75	0.50
19	EXP 10830A 4.17 SC*	0.6 fl oz	14	0.00	0.00	0.25

Trt	Product	Rate/1,000 ft ²	Interval (days)	Mean disease rating ^a		
				June 29	July 10	July 22
20	EXP 10830A 4.17 SC*	1 fl oz	14	0.00	0.00	0.00
21	Chipco Triton 1.67 SC (=80318)	1 fl oz	14	0.25	1.00	0.25
22	Chipco Triton 1.67 SC	1 fl oz	21	0.75	0.00	0.75
23	Heritage 50 WG	0.2 oz	14	0.50	0.00	0.00
24	Heritage 50 WG	0.2 oz	14	0.00	0.00	0.00
	+Daconil Ultrex	3.8 oz				
25	Heritage 50 WG	0.4 oz	28	0.25	0.50	1.50
	ALTERNATE WITH					
	Daconil Ultrex	3.8 oz	14			
26	Eagle 50 WP	0.6 oz	14	0.25	0.00	0.00
	+ Fore 75 DG	6 oz				
27	ZeroTol	0.5 fl oz/80 ft ²	7	0.50	1.00	3.00
28	ProStar 50 WP	3 oz	14	0.75	1.0	0.50
29	ProStar 70 WP	2.25 oz	14	0.50	0.00	0.50
30	ProStar 70 WP	1.5 oz	14	0.25	0.00	0.00
	+ Heritage 50 WG	0.2 oz				
31	S-8172	4 fl oz	14	0.00	1.50	1.00
32	S-8172	8 fl oz	14	0.00	0.50	0.00
33	S-8206	3.2 fl oz	14	0.75	0.50	0.50
34	S-8206	6.4 fl oz	14	0.00	0.00	0.00
35	AMV 300	1 fl oz	14	0.75	0.25	3.25
36	AMV 300	2 fl oz	14	0.25	0.00	0.00
37	UCC-A1562 20 SC	1 fl oz	14	1.50	1.50	0.50
38	UCC-A1562 20 SC	4 fl oz	14	0.50	1.00	1.50
39	UCC-A1562 20 SC	8 fl oz	14	0.25	0.25	0.25
	Least Significant Difference ^b			1.02	0.98	0.93

^aRating Scale: 0 = no disease; 1 = 1-5%; 2 = 5-10%; 3 = 10-25%; 4 = 25-50%; and 5 = >50% of plot diseased.

^bP = 0.05. n = 4 replications.

Creeping Bentgrass Establishment and Management on Sand Greens

Michael B. Faust and Nick E. Christians

INTRODUCTION

This creeping bentgrass establishment trial was initiated on 1 Sept. 1996 at the Iowa State University Horticulture Research Station. Data from the 1998 growing season are discussed in this report. The study was conducted to observe the development of creeping bentgrass from seed grown in a sand-based golf course green and to study the effects of liquid and granular fertilizer applications on the quality of mature bentgrass.

The objectives of the study were i) to compare the effects of five different combinations of organic-based fertilizer products and a control on the establishment of creeping bentgrass (*Agrostis palustris* Huds. cv. Crenshaw), and ii) to compare the effects of two different application frequency schedules on the quality of mature creeping bentgrass.

MATERIALS AND METHODS

The research was conducted on a 100% sand-based golf green. The rooting material contained 10% calcium carbonate (CaCO_3) and had a pH of 8.2. Physical analysis of the sand particles showed the rooting medium to be within the standards set by the United States Golf Association (USGA) for golf course green construction. The research, with a 900 ft² area, was conducted as a split-plot design with six treatments as main plots and two application frequency schedules as subplots. The study included three replications. Each experimental plot (36 total) had an area of 25 ft².

The main plots of the research consisted of five liquid fertilizer products and a granular fertilizer material (Tables 1, 2, and 3). Four of the liquid treatments, excluding the control, were general use organic soil conditioners designed to stimulate microbial activity and to provide overall improved soil fertility. The organic liquid treatments were mixed in solution with NH_4NO_3 and KNO_3 to supply adequate nitrogen and potassium requirements of the plant. The control treatment contained only the inorganic nitrogen (NH_4NO_3) and potassium (KNO_3) sources. All of the liquid treatments contained the same rate of nitrogen and potassium, and they were applied to the turf using a CO_2 tank and hand-held spray boom. Granular treatments were applied with a hand-held shaker to match the N and K rates of the liquid products.

The first application to experimental plots in the spring of 1998 occurred on 21 May. The application frequency schedule established in 1997, where half of the experimental plots received one application every two weeks and the other half of the plots received two applications per week, was continued in 1998. Plots treated once every two weeks received 0.25 lb N and 0.125 lb K/1000 ft²/application. Plots treated two times per week received 0.0625 lb N and 0.0313 lb K/1000 ft²/application. All plots received 0.5 lb N and 0.25 lb K/1000 ft²/month regardless of application frequency schedule or treatment differences.

Clipping tissue samples were collected three times during the 1998 season. Individual collection dates were 17 and 31 August, and 14 September. Clippings were taken 3 to 4 days following the fourth and eighth 0.0625 lb N/1000 ft² treatment application when all plots had received identical N and K rates. The clippings were dried at 68 °C for 48 h, dry-ashed, diluted with acid, and analyzed for nutrient content by inductively coupled argon plasma spectrometry (ICAP). Plant tissue nitrogen content was determined using the total Kjeldahl nitrogen procedure (TKN).

One root sample was taken during the 1998 growing season on 1 October. Five one-inch diameter cores were removed from random locations on each plot at a depth of 15 cm. The roots were washed from the sand media using a screening technique. The extracted root material was dried at 68 °C for 48 h. An oven-dry root mass was taken and the samples were placed into a muffle furnace for 12 h at a temperature of 500 °C. A second root weight was taken following the ashing procedure. The actual dry root mass of plants grown on each experimental plot was determined by subtracting the dry-ashed root mass from the oven-dry root mass.

Visual quality data, rating density and color of each plot was taken four times in 1998. The data was collected 17 and 31 August, and 8 and 14 September. Quality was rated on a 1 to 9 scale; where 1 = poor quality and 9 = highest quality.

RESULTS AND DISCUSSION

Results from clipping analysis are shown in Tables 1 and 2. The tables have been divided into macronutrient (Table 1) and micronutrient (Table 2) concentrations of turfgrass tissue.

Differences in plant shoot tissue concentration due to treatment effects were shown for the elements nitrogen (N), phosphorus (P), magnesium (Mg), copper (Cu), and molybdenum (Mo) (Tables 1 and 2). Compared to the five liquid treatments, the granular treatment provided the highest tissue N, P, and Mg concentrations. Plants grown in control plots had the lowest tissue N levels. Phosphorus shoot tissue concentration of plants grown using the granular treatment was on average 36% higher than plants supplied with the liquid treatments. Tissue P concentrations were probably higher because the granular product contained 3% P_2O_5 (12-3-9 formulation). Phosphorus was not supplied to plots receiving the liquid treatments throughout the 1998 growing season. Plants fertilized by the liquid treatments had significantly more Cu in the shoot tissue as compared to those plants grown using the granular material. Plants grown using the control and granular treatments had significantly lower Mo tissue levels as compared to the other liquid treatments. The high organic matter content of the granular product may have complexed Cu and Mo reducing the ability of the plant to absorb these elements.

Application frequency of treatments (2 vs. 8 applications/month) caused differences in shoot tissue concentration for the elements: nitrogen (N), copper (Cu), and molybdenum (Mo) (Tables 1 and 2). Nitrogen shoot tissue concentration was 3% higher for plants grown in plots receiving 8 applications/month compared to those plants receiving 2 applications/month. Shoot tissue concentrations were 6% and 8% higher for Cu and Mo, respectively, in plots receiving 8 applications/month compared to the plots which received 2 applications/month. However, plants grown in plots receiving 2 applications/month had an average 8% higher shoot tissue Mn concentration compared to plants grown in plots that received 8 applications/month.

Mean visual quality data taken throughout 1998 showed differences among fertilizer treatments (Table 3). The granular product (treatment 6) had significantly higher visual quality ratings compared to the liquid treatments. The better visual quality could be explained by the shoot tissue nutrient concentration data which showed the highest N levels in plants treated with the granular feather meal product. Plots receiving 8 applications per month had a higher visual quality rating than plots receiving 2 applications/month.

No differences were shown between treatments or application frequency schedules for root development of grass plants (Table 3). These findings are similar to rooting data taken in 1997.

Table 1. Mean macronutrient tissue concentration and analysis of variance.

Treatment	Macronutrients ²					
	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Sulfur (S)
	% of dry tissue					
22% humic acid	3.39	0.26	1.83	0.74	0.28	0.25
6-0-0 w/ organic acids	3.45	0.26	1.87	0.72	0.27	0.25
15% humic acid	3.44	0.26	1.87	0.70	0.26	0.25
5-3-2 w/ molasses	3.36	0.26	1.89	0.70	0.26	0.26
Control	3.23	0.25	1.85	0.74	0.27	0.25
12-3-9 ground feather meal	3.47	0.40	1.87	0.77	0.30	0.25
LSD _(0.05) ^y	0.14	0.02	NS	NS	0.02	NS
Application Frequency						
2 apps/month	3.34	0.28	1.85	0.74	0.28	0.25
8 apps/month	3.43	0.28	1.87	0.71	0.27	0.25
LSD _(0.05) ^y	0.08	NS	NS	NS	NS	NS
Anova^x						
Prob > F						
Treatment	0.0146	0.0001	0.5884	0.2256	0.0038	0.2515
Application frequency	0.0303	0.1851	0.3652	0.1965	0.2247	0.1076
Trt*Application frequency	0.0053	0.6029	0.2056	0.4941	0.7280	0.3067

²Data shown are the mean of three tissue collection dates during the 1998 growing season. Individual collection dates were 17 and 31 August, and 14 September.

^yMean separation within columns by Fisher's least significant difference test.

^xSignificant differences occur at the $P \leq 0.05$ level

Table 2. Mean micronutrient tissue concentration and analysis of variance.

Treatment	Micronutrients ²						
	Boron (B)	Copper (Cu)	Iron (Fe)	Manganese (Mn)	Molybdenum (Mo)	Sodium (Na)	Zinc (Zn)
	mg·kg ⁻¹						
22% humic acid	5.37	8.80	213.17	158.17	2.93	64.08	61.49
6-0-0 w/ organic acids	5.52	9.33	205.44	148.37	2.78	60.56	61.47
15% humic acid	5.43	8.82	170.28	158.77	2.92	60.43	62.70
5-3-2 w/ molasses	5.44	8.89	171.33	163.56	2.86	59.66	64.21
Control	5.57	8.99	214.61	166.41	2.61	62.11	62.08
12-3-9 ground feather meal	5.38	6.98	230.89	158.95	2.39	70.07	64.16
LSD _(0.05) ^y	NS	0.87	NS	NS	0.31	NS	NS
Application Frequency							
2 apps/month	5.47	8.37	206.06	165.32	2.64	62.00	62.94
8 apps/month	5.44	8.90	195.85	152.76	2.86	63.63	62.43
LSD _(0.05) ^y	NS	0.50	NS	11.18	0.18	NS	NS
Anova^x Prob > F							
Treatment	0.8838	0.0002	0.2186	0.5175	0.0082	0.0751	0.7501
Application frequency	0.7977	0.0387	0.5379	0.0294	0.0198	0.4422	0.7220
Trt*Application frequency	0.8349	0.3775	0.8895	0.8790	0.1156	0.6871	0.9758

²Data shown are the mean of three tissue collection dates during the 1998 growing season. Individual collection dates were 17 and 31 August, and 14 September.

^yMean separation within columns by Fisher's least significant difference test.

^xSignificant differences occur at the $P \leq 0.05$ level.

Table 3. Visual quality, rooting data, and analysis of variance.

Treatment	Visual Quality ²					Root Mass (g) October 1
	Aug 17	Aug 31	Sept 8	Sept 14	Mean	
22% humic acid	6.5	6.8	6.7	7.5	6.9	0.56
6-0-0 w/ organic acids	7.3	6.5	6.7	6.8	6.8	0.56
15% humic acid	6.7	6.8	6.5	7.0	6.8	0.52
5-3-2 w/ molasses	6.7	7.2	7.2	6.8	7.1	0.58
Control	7.0	6.5	6.7	7.5	6.8	0.53
12-3-9 ground feather meal	7.5	7.7	7.7	7.8	7.7	0.63
LSD _(0.05) ^y	NS	0.8	0.6	0.5	0.4	NS
Application Frequency						
2 apps/month	6.7	6.6	6.5	7.0	6.7	0.56
8 apps/month	7.2	7.3	7.3	7.5	7.3	0.57
LSD _(0.05) ^y	0.4	0.4	0.3	0.3	0.3	NS
Anova^x Prob>F						
Treatment	0.0955	0.0425	0.0031	0.0029	0.0023	0.1325
Application frequency	0.0213	0.0031	0.0001	0.0031	0.0001	0.7084
Trt*Application frequency	0.2090	0.4362	0.0302	0.3320	0.1224	0.9255

²Visual quality (Color and Density) was rated on a 9 to 1 scale: 1=poor quality; 9=highest quality.

^yMean separation within columns by Fisher's least significant difference test.

^xSignificance occurs at the $P \leq 0.05$ level.

Corn Gluten Hydrolysate for Weed Control

Melissa C. McDade and Nick E. Christians

Corn gluten hydrolysate (CGH) is an effective natural preemergent control in growth chamber and greenhouse environments. Its performance in the field may be improved by using a carrier. Two carriers for CGH are being investigated in this study, humic acid (RL 37, Liquid Seaweed Foliar from International Ag Labs, Inc., Fairmont, MN) and a soybean oil (SprayTech Oil from Agro-K Corporation, Minneapolis, MN). CGH at rates of 0, 10, 20 and 40 lb/1000 ft², humic acid at rates of 0, 1, 2 and 4 gal/acre and oil at rates of 0, 0.5, 1 and 2 pts/acre were used, with each rate of CGH being applied with each rate of humic acid and oil for a total of 32 treatments. The treatments were randomized in each of three replications. Each individual plot measured 5'x 5'. This study took place at the ISU Horticulture Research Station north of Ames, Iowa in an area with a mature stand of Kentucky bluegrass. Treatments were sprayed onto the plots on 9 May. The study area was irrigated as needed to provide a good growing condition for the turf. Weed control was determined by collecting data on percent cover of crabgrass during the season. Visual quality was also assessed during the season using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, 1 = poorest quality. Analysis of data used the Statistical Analysis System version 6.12 (SAS Institute, 1989-1996).

There were 72% fewer crabgrass plants at the greatest rate of CGH (200 g·m⁻²) compared to the control (Table 1). Increasing CGH rates had a positive effect on turfgrass visual quality (Table 1). Humic acid and soybean oil had no effect on the number of crabgrass plants or on turfgrass quality.

CGH applied at a rate of 200 g·m⁻² provided 72% reduction of crabgrass in this study, similar to a 66% reduction found in the first year of another CGH field study at the 200 g·m⁻² rate (Bingaman and Christians, 1996). This reduction is also similar to that of corn gluten meal, which provided 86% control when applied to turf at the 200 g·m⁻² rate (Bingaman et al., 1998). Rates of 50 and 100 g CGH per m² did not control crabgrass in this study and varied in effectiveness in previous studies by Bingaman and Christians (1996, 1997, 1998).

Applying 200 g·m⁻² CGH provides 20 g N per m², since CGH is 10% N by weight. The CGH has a fertilizing effect, improving the visual quality of the turfgrass at higher rates. Other studies have reported this fertilizing effect in both CGH (Bingaman and Christians, 1996, 1997, 1998) and corn gluten meal (Bingaman et al., 1998; Christians, 1993).

If soybean oil or humic acid had a positive effect on the herbicidal activity of the CGH, we would have seen similar crabgrass counts or quality at different rates of CGH because of the addition of soybean oil or humic acid. Only the rate of CGH had an effect on crabgrass counts and quality, so the soybean oil and humic acid treatments had no effect, neither as interactions nor as single effects.

Table 1. Mean number of crabgrass (*Digitaria* spp.) plants at the end of the 1998 growing season (16 weeks). Mean turfgrass quality from the 1998 season, rated visually: 9 = highest quality, 6 = acceptable quality, 1 = lowest quality. Each rate of corn gluten hydrolysate was applied to 10 plots in each of three replications.

Corn gluten hydrolysate (g·m ⁻²)	Number of crabgrass plants (per 2.25 m ² plot)	Turfgrass visual quality
0	29	6.0
50	17	6.5
100	26	7.0
200	8	8.0
LSD _{0.05}	13	0.2

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1991 Corn Gluten Meal Crabgrass Control Study - Year 8

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

A study screening corn gluten meal (CGM) for efficacy as a natural product herbicide and fertilizer in turf has been continued on the same plot for since 1991. It is being conducted at the Iowa State University Research Station north of Ames, IA 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 3.6% a pH of 7.1, 4.5 ppm P, and 101 ppm K. Individual experimental plots are 5 x 5 ft and there are 5 treatments with 3 replications. The experimental design is a randomized complete block. Corn gluten meal is applied each year to the same plots at 0, 20, 40, 60, 80, 100, and 120 lbs/1000 ft² (Table 1). Because corn gluten meal is 10% N, these rates are equivalent to 0, 2, 4, 6, 8, and 10 lb N/1000 ft². In 1998, the CGM was applied in a single early spring preemergence application on April 21 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 monitored throughout the season for turf quality. Visual turf quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. Quality data were taken on April 22, May 13, May 18, May 27, June 10, June 16, July 9, July 15, July 29, August 18, and August 28 (Tables 1 and 2).

Weed control was measured by either counting the number of plants or estimating the percentage cover per individual plot. Crabgrass in the 1- to 3-leaf stage was found in the untreated turf on June 23. The crabgrass plants were large enough by July 15 to count the number per plot. Additional crabgrass count data were taken on July 29, August 18, and August 28 (Table 3). Crabgrass counts were converted to express percentage reductions in numbers as compared to the untreated controls (Table 4).

Dandelion and clover populations also were surveyed. The number of dandelions per plot was counted on July 15, July 29, August 18, and August 28 (Table 5). On these same dates, percentage clover cover data were taken. Clover cover was determined by estimating the area per plot covered by clover (Table 7). Dandelion count and percentage clover cover data were modified to express percentage reductions as compared to the untreated controls (Tables 6 and 8).

Data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference (LSD) means comparison tests were used to assess CGM effects on bluegrass quality and weed control.

Spring greenup was obvious by April 22. Bluegrass treated with CGM had better quality than untreated turf from May 13 through June 16 (Table 1 and 2). After June 16, the season was quite hot and dry and the treated and untreated bluegrass had similar quality.

Crabgrass populations were low in the untreated controls because the dandelion and clover infestations were large and well established creating intense competition for the emerging crabgrass. Treatment with CGM at all levels except 20 lb/1000 ft² resulted in much lower crabgrass populations (Table 3). Reductions in crabgrass populations were > 91% at 40 and 60 lb/1000 ft² (Table 4). There were more crabgrass plants in turf treated with CGM at 20 lb/1000 ft² than in untreated turf (Table 3). In 1997, there also were more crabgrass plants in turf treated with CGM at 20 lb/1000 ft² as compared with the untreated control (Table 9). Reductions in crabgrass counts were similar to 1997 at all CGM levels except 40 lb/1000 ft². Much better crabgrass control was achieved at 40 lb in 1998 as compared with 1997.

Corn gluten meal at all levels except 20 lb/1000 ft² significantly reduced dandelion counts as compared with the untreated control (Table 5). Mean reductions > 72% were achieved with CGM at 40 lb and higher (Table 6). Dandelion control in 1998 was similar to control in 1997 and previous years except at the 20 lb/1000 ft² level (Table 11).

On July 29 and August 18, there was significantly less clover cover in turf treated with CGM as compared with the untreated controls (Table 7). On August 28, all CGM levels except 20 lb/1000 ft² significantly reduced clover cover. Mean reductions in clover cover were > 84% as compared with the untreated controls in turf treated with CGM at all levels except 20 lb (Table 8). Clover control in 1998 was similar to that in previous years except at 20 lb/1000 ft². At this rate, the level of clover control was much lower in 1998 as compared to 1994 through 1997 (Table 10).

Table 1 Visual quality¹ of Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs CGM/ 1000 ft ²	lbs N/ 1000 ft ²	April 22	May 13	May 18	May 27	June 10	June 16
1	Untreated control	0	0	6.7	5.0	5.3	5.0	5.7	5.0
2	Corn gluten meal	20	2	6.3	5.7	6.3	6.3	6.3	6.3
3	Corn gluten meal	40	4	7.3	7.0	7.7	8.0	7.7	7.3
4	Corn gluten meal	60	6	8.3	8.7	8.7	8.0	8.7	8.3
5	Corn gluten meal	80	8	8.0	7.7	8.0	8.3	8.7	9.0
6	Corn gluten meal	100	10	8.3	8.3	8.3	8.0	9.0	8.7
7	Corn gluten meal	120	12	9.0	9.0	8.3	7.7	9.0	9.0
	LSD _{0.05}			1.1	1.4	0.8	1.4	0.6	0.6

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = least acceptable, and 1 = worst turf quality.

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

Table 2. Visual quality¹ of Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs CGM/ 1000 ft ²	July 9	July 15	July 29	August 5	August 18	August 28	Mean
1	Untreated control	0	6.0	6.0	6.0	6.0	6.0	6.0	5.4
2	Corn gluten meal	20	6.0	6.0	6.0	6.0	6.0	6.0	6.2
3	Corn gluten meal	40	6.0	6.0	6.0	6.0	6.0	6.0	7.5
4	Corn gluten meal	60	6.0	6.0	6.0	6.0	6.0	6.0	8.4
5	Corn gluten meal	80	6.0	6.0	6.0	6.0	6.0	6.0	8.3
6	Corn gluten meal	100	6.0	6.0	6.0	6.0	6.0	6.0	8.7
7	Corn gluten meal	120	6.0	6.0	6.0	6.0	6.0	6.0	8.7
	LSD _{0.05}		--	--	--	--	--	--	0.6

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = least acceptable, and 1 = worst turf quality.

-- = these data are not appropriate for means comparisons tests.

Table 3. Crabgrass count¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs CGM/ 1000 ft ²	July 15	July 29	August 18	August 28	Mean counts
1	Untreated Control	0	6.3	22.7	29.7	21.3	20.0
2	Corn gluten meal	20	5.3	38.3	41.3	36.7	30.4
3	Corn gluten meal	40	3.7	1.0	0.7	1.7	1.8
4	Corn gluten meal	60	0.3	1.0	3.7	1.7	1.7
5	Corn gluten meal	80	8.7	9.0	12.0	5.7	8.8
6	Corn gluten meal	100	4.0	4.3	3.0	2.0	3.3
7	Corn gluten meal	120	1.7	7.0	6.0	4.7	4.8
	LSD _{0.05}		NS	NS	NS	NS	NS

¹These values represent the number of crabgrass plants per plot.

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

Table 4. Percentage crabgrass count reductions¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

	Material	lbs CGM/ 1000 ft ²	July 15	July 29	August 18	August 28	Mean reduction
			%				
1	Untreated Control	0	0.0	0.0	0.0	0.0	0.0
2	Corn gluten meal	20	15.7	0.0	0.0	0.0	0.0
3	Corn gluten meal	40	42.1	95.6	97.8	92.2	91.3
4	Corn gluten meal	60	94.7	95.6	87.6	92.2	91.7
5	Corn gluten meal	80	0.0	60.3	59.6	73.4	55.8
6	Corn gluten meal	100	36.8	80.9	89.9	90.6	83.3
7	Corn gluten meal	120	73.7	69.1	79.8	78.1	75.8
	LSD _{0.05}		NS	NS	NS	NS	NS

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

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

Table 5. Dandelion count¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

Material	lbs CGM/ 1000 ft ²	July 15	July 29	August 18	August 28	Mean counts
1. Untreated control	0	25.0	25.7	47.7	48.7	36.8
2. Corn gluten meal	20	25.0	24.7	40.7	49.7	35.0
3. Corn gluten meal	40	9.0	4.7	15.3	12.0	10.3
4. Corn gluten meal	60	3.7	3.0	8.3	8.7	5.9
5. Corn gluten meal	80	3.7	1.3	3.3	4.7	3.3
6. Corn gluten meal	100	4.0	1.3	5.0	5.3	3.9
7. Corn gluten meal	120	0.3	0.7	1.3	2.7	1.3
LSD _{0.05}		13.6	11.0	15.2	29.6	13.7

¹These counts represent the number of dandelions per plot.**Table 6.** Percentage dandelion count reductions¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

Material	lbs CGM/ 1000 ft ²	July 15	July 29	August 18	August 28	Mean reduction
%						
1. Untreated control	0	0.0	0.0	0.0	0.0	0.0
2. Corn gluten meal	20	0.0	3.9	14.7	0.0	4.8
3. Corn gluten meal	40	64.0	81.8	67.8	75.3	72.1
4. Corn gluten meal	60	85.3	88.3	82.5	82.2	83.9
5. Corn gluten meal	80	85.3	94.8	93.0	90.4	91.2
6. Corn gluten meal	100	84.0	94.8	89.5	89.0	89.3
7. Corn gluten meal	120	98.7	97.4	97.2	94.5	96.6
LSD _{0.05}		54.5	43.0	31.9	60.8	37.3

¹These values represent the percentage reduction in dandelions per plot as compared with the untreated controls.**Table 7.** Percentage clover cover¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

Material	lbs CGM/ 1000 ft ²	July 15	July 29	August 18	August 28	Mean cover
1. Untreated control	0	34.7	43.3	43.3	53.3	43.7
2. Corn gluten meal	20	35.0	21.7	30.0	41.7	32.1
3. Corn gluten meal	40	10.7	8.3	3.3	5.3	6.9
4. Corn gluten meal	60	6.7	7.0	5.3	6.7	6.4
5. Corn gluten meal	80	3.3	2.0	3.7	3.7	3.2
6. Corn gluten meal	100	7.0	3.7	2.0	5.3	4.5
7. Corn gluten meal	120	6.7	5.3	3.7	2.3	4.5
LSD _{0.05}		NS	15.7	13.1	14.3	9.3

¹Percentage clover cover represents the area per plot covered by clover.**Table 8.** Percentage clover cover reductions¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

Material	lbs CGM/ 1000 ft ²	July 15	July 29	August 18	August 28	Mean reduction
%						
1. Untreated control	0	0.0	0.0	0.0	0.0	0.0
2. Corn gluten meal	20	0.0	50.0	30.8	21.9	26.5
3. Corn gluten meal	40	69.3	80.8	92.3	90.0	84.2
4. Corn gluten meal	60	80.8	83.8	87.7	87.5	85.3
5. Corn gluten meal	80	90.4	95.4	91.5	93.1	92.7
6. Corn gluten meal	100	79.8	91.5	95.4	90.0	89.7
7. Corn gluten meal	120	70.8	87.7	91.5	95.6	89.7
LSD _{0.05}		NS	36.2	30.2	26.9	21.2

¹These values represent the percentage reduction in clover cover per plot as compared with the untreated controls.

Table 9. Comparisons of the mean percentage crabgrass count reductions¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study for 1991 through 1998.

Material	lbs CGM/ 1000 ft ²	%							
		1991	1992	1993	1994	1995	1996	1997	1998
1 Untreated control	0	0	0	0	0	0	0	0	0
2 Corn gluten meal	20	58	85	91	70	36	15	0	0
3 Corn gluten meal	40	86	98	98	97	88	97	79	91
4 Corn gluten meal	60	97	98	93	98	93	85	82	92
5 Corn gluten meal	80	87	93	93	87	75	69	54	56
6 Corn gluten meal	100	79	94	95	86	75	87	79	83
7 Corn gluten meal	120	97	100	100	98	84	97	82	76
LSD _{0.05}		26	44	31	39	40	60	NS	NS

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

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

Table 10. Comparisons of the mean percentage clover cover reductions¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study for 1994 through 1998.

Material	lbs CGM/ 1000 ft ²	%				
		1994	1995	1996	1997	1998
1 Untreated control	0	0	0	0	0	0
2 Corn gluten meal	20	81	56	71	63	27
3 Corn gluten meal	40	90	64	82	87	84
4 Corn gluten meal	60	98	93	93	95	85
5 Corn gluten meal	80	100	76	90	95	93
6 Corn gluten meal	100	94	84	92	76	90
7 Corn gluten meal	120	90	93	93	93	90
LSD _{0.05}		NS	48	29	26	21

¹Percentage clover cover represent the area per plot covered by clover.

²These values represent the percentage reduction of clover cover per plot as compared with the untreated controls.

Table 11. Comparisons of the mean percentage dandelion count reductions¹ in Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study for 1994 through 1998.

Material	lbs CGM/ 1000 ft ²	%				
		1994	1995	1996	1997	1998
1 Untreated control	0	0	0	0	0	0
2 Corn gluten meal	20	71	49	33	24	5
3 Corn gluten meal	40	100	77	75	76	72
4 Corn gluten meal	60	100	89	79	84	83
5 Corn gluten meal	80	98	96	95	93	91
6 Corn gluten meal	100	100	98	96	88	89
7 Corn gluten meal	120	100	100	100	97	97
LSD _{0.05}		50	65	60	61	37

¹Dandelion counts represent the number of dandelions per plot.

²These values represent the percentage reduction of dandelion count per plot as compared with the untreated controls.

1995 Corn Gluten Meal Rate Weed Control Study - Year 4

Barbara R. Bingaman, Melissa C. McDade, and Nick E. Christians

Corn gluten meal (CGM) is being screened for efficacy as a natural product herbicide in turf in this long-term study begun in 1995. It is being conducted at the Iowa State University Horticulture Research Station north of Ames, IA in established 'Ram 1' Kentucky bluegrass. The soil is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.8%, a pH of 7.1, 4 ppm P, and 96.5 ppm K. The initial broadleaf weed population exceeded 50% cover on most of the test area.

Individual experimental plots are 10 x 10 ft with 4 treatments and 3 replications. The experimental design is a randomized complete block. Each year corn gluten meal is applied at a yearly rate of 40 lb. CGM/1000 ft² (equivalent to 4 lb. N/1000 ft²) using 4 different regimes of single and split applications (Table 1). Four applications of 10 lb./1000 ft², split applications of 20 lb./1000 ft², an initial application of 30 lb. plus a sequential of 10 lb./1000 ft², and a single application of 40 lb./1000 ft² are included with an untreated control.

Initial applications for 1998 were made on April 21 before crabgrass germination. The second application of treatment 2 was made on June 3, the third on July 14, and the final on August 26. Sequential applications of treatments 3 and 4 were made on July 14.

The experimental plot was checked for phytotoxicity after each treatment. The study was monitored for visual quality throughout the season. Visual quality was measured using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality (Tables 1 and 2). Visual quality data were taken on April 22, May 13, May 18, May 27, June 10, June 18, June 30, July 9, July 15, July 24, July 29, August 11, August 18, and August 26.

Populations of annual grass and perennial broadleaf weed species were surveyed. Crabgrass populations were assessed by counting the number of plants per individual plot on July 9, July 24, July 29, August 11, August 18, and August 26 (Table 3). Clover infestations were estimated by determining the percentage of area in each individual plot covered by clover. These data were taken on July 29, August 11, August 18, and August 26 (Table 5). Dandelion populations were measured by counting the number of plants per plot on July 29, August 11, August 18, and August 26 (Table 7). Levels of crabgrass, clover, and dandelion control were expressed by converting the population data to reductions as compared with the untreated control (Table 4, 6, and 8).

Data were analyzed with the Statistical Analysis System (SAS, Version 6.12) and the Analysis of Variance (ANOVA) procedure. Means comparisons were made with Fisher's Least Significant Difference test (LSD).

There were no phytotoxic symptoms detected on the treated bluegrass. Visual turf quality was significantly better in bluegrass treated with CGM than in the untreated control on May 13, May 27, June 10, June 18, June 30, July 9, August 11, August 18, and August 26 (Table 1 and 2). Mean visual quality for the entire season was better for bluegrass treated with CGM than the untreated grass.

Crabgrass populations were lower in turf treated with CGM than in untreated turf but the counts were not statistically different (Table 3). Crabgrass numbers were low in the untreated controls. Broadleaf weed species were well established when the crabgrass was emerging especially in the untreated controls and the competition from the broadleaves and the mature turf probably prevented the establishment of large crabgrass populations within the untreated plots. Reductions in crabgrass populations were not significant for any of the CGM treatments on any of the collection dates but there were large numerical reductions achieved in treated bluegrass as compared with untreated turf (Table 4). Bluegrass treated with split applications of 20 lb. CGM reduced crabgrass counts by > 89% from July 9 through August 11.

In 1998, crabgrass control was much better overall than in 1995, 1996, and 1997 (Table 9). In contrast to 1996 and 1997, there was more crabgrass in the untreated controls than in treated grass in 1998. Split applications of 20 lb. CGM provided 86% crabgrass reductions in 1998 as compared to 45, 33, and 50% in 1995, 1996, and 1997, respectively.

There was significantly less clover in CGM treated turf than in the untreated controls on all data collection dates except August 18 (Table 5). All CGM rates significantly decreased clover populations and clover cover was lowest in turf treated with a single application of 40 lb. CGM. The mean clover cover in untreated turf was 40.4% as

compared to 10.7, 11.4, 14.7, and 3.0% cover in turf receiving treatments 2, 3, 4, and 5, respectively. The single application of 40 lb. CGM provided $\geq 89\%$ reductions in clover cover throughout the season as compared to the untreated control (Table 6).

Clover control was better in 1998 than 1996 and 1997 in turf treated with CGM four times at 10 lb. (Table 10). Clover control in 1998 with split applications of 20 lb. was slightly less than in 1997 and similar to 1996. Control provided by CGM at 30 lb. followed by 10 lb. was much lower in 1998 as compared with 1996 and 1997. A single application at 40 lb. provided similar clover cover reductions in 1998 as in 1996 and slightly lower than 1997.

Dandelion cover was significantly less in all CGM treated turf as compared to the untreated control on all data collection days except August 26 (Table 7). Percentage reductions in dandelion cover were similar for all CGM treatments (Table 8).

In 1998, dandelion control was higher than in 1996 and 1997 when CGM was applied four times at 10 lb. and in a single application at 40 lb. (Table 11). Dandelion reductions were similar in 1996, 1997, and 1998 for CGM at 20 lb. split applications. Percentage reductions were much higher in 1998 as compared with 1996 and 1997 for CGM applied at 30 lb. followed by 10 lb.

Table 1. Visual quality¹ of Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study (April 22 - June 30).

Material	Rate (lb. product /1000 ft ²)	April 22	May 13	May 18	May 27	June 10	June 18	June 30
1. Untreated control	0	6.3	6.0	6.3	5.3	5.0	6.0	6.0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	8.7	8.7	7.0	7.0	6.7	7.3	7.0
3. Corn gluten meal	20 fb 20	7.7	8.7	8.7	7.7	7.0	7.0	7.3
4. Corn gluten meal	30 fb 10	8.0	9.0	7.7	8.7	8.3	8.3	8.3
5. Corn gluten meal	40	7.0	8.7	8.7	8.3	9.0	8.7	9.0
LSD _{0.05}		NS	0.8	1.4	0.8	0.6	0.9	0.7

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality.

All treatments were at an annual rate of 4 lb.s N/1000 ft². Initial applications were made on April 21. Second application of trt 2 was made on June 3, the third on July 14, and the final on August 26. Sequential applications of trt 3 & 4 were made on July 14. NS = means are not significantly different at the 0.05 level

Table 2. Visual quality¹ of Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study (July 9 - August 26).

Material	Rate (lb. product /1000 ft ²)	July 9	July 15	July 24	July 29	Aug 11	Aug 18	Aug 26	Mean
1. Untreated control	0	6.0	6.0	6.0	6.0	6.0	6.7	6.0	6.0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	7.0	8.0	8.0	8.0	7.3	8.3	8.0	7.6
3. Corn gluten meal	20 fb 20	7.3	7.3	7.3	7.7	7.0	8.3	9.0	7.7
4. Corn gluten meal	30 fb 10	8.0	7.7	7.7	8.3	7.3	8.3	8.3	8.1
5. Corn gluten meal	40	8.3	8.3	8.3	7.0	7.0	8.3	7.3	8.1
LSD _{0.05}		0.7	1.6	NS	1.2	0.7	1.1	0.6	0.5

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst turf quality.

NS = means are not significantly different at the 0.05 level

Table 3. Crabgrass counts per plot¹ in Kentucky bluegrass treated with corn gluten meal (CGM) in the 1995 Corn Gluten Meal Rate Weed Control Study.

Material	Rate (lb. product /1000 ft ²)	July 9	July 24	July 29	August 11	August 18	August 26	Mean
1. Untreated control	NA	8.7	13.3	16.7	18.3	23.3	31.7	18.7
2. Corn gluten meal	10 fb 10 fb 10 fb 10	3.3	9.0	6.7	11.7	11.7	23.3	10.9
3. Corn gluten meal	20 fb 20	0.3	0.7	1.7	2.0	3.7	7.0	2.6
4. Corn gluten meal	30 fb 10	1.0	2.3	2.0	7.0	5.3	7.3	4.2
5. Corn gluten meal	40	5.0	8.3	6.7	10.0	6.7	16.7	8.9
LSD _{0.05}		NS	NS	NS	NS	NS	NS	NS

¹These values represent the number of crabgrass plants per plot.

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

Table 4. Crabgrass count reductions¹ in Kentucky bluegrass treated with corn gluten meal (CGM) in the 1995 Corn Gluten Meal Rate Weed Control Study.

Material	Rate (lb. product /1000 ft ²)	July 9	July 24	July 29	August 11	August 18	August 26	Mean
		%						
1. Untreated control	NA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	61.7	32.3	60.1	36.2	50.0	26.4	41.5
3. Corn gluten meal	20 fb 20	96.2	95.0	90.0	89.1	84.3	77.9	86.3
4. Corn gluten meal	30 fb 10	88.5	82.5	88.0	61.7	77.1	76.9	77.7
5. Corn gluten meal	40	42.5	37.3	60.1	45.4	71.4	47.4	52.5
LSD _{0.05}		NS	NS	NS	NS	NS	NS	NS

¹These values represent the percentage reduction in crabgrass plants per plot as compared with the untreated controls.All treatments were at an annual rate of 4 lb.s N/1000 ft². Initial applications were made on April 21. Second application of trt 2 was made on June 3, the third on July 14, and the final on August 26. Sequential applications of trt 3 & 4 were made on July 14. NS = means are not significantly different at the 0.05 level.**Table 5.** Percentage clover cover per plot¹ in Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

Material	Rate (lb. product/1000 ft ²)	July 29	August 11	August 18	August 26	Mean
		%				
1. Untreated control	NA	40.0	41.7	31.7	48.3	40.4
2. Corn gluten meal	10 fb 10 fb 10 fb 10	10.7	8.3	7.0	16.7	10.7
3. Corn gluten meal	20 fb 20	10.0	12.0	6.7	17.0	11.4
4. Corn gluten meal	30 fb 10	11.7	16.0	14.3	16.7	14.7
5. Corn gluten meal	40	1.7	1.7	3.3	5.3	3.0
LSD _{0.05}		20.5	16.5	NS	21.4	19.6

¹These data represent the area per plot covered by clover.

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

Table 6. Percentage clover cover reductions¹ in Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

Material	Rate (lb. product/1000 ft ²)	July 29	August 11	August 18	August 26	Mean
%						
1. Untreated control	NA	0.0	0.0	0.0	0.0	0.0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	73.3	80.0	77.9	65.5	73.6
3. Corn gluten meal	20 fb 20	75.0	71.2	79.0	64.8	71.7
4. Corn gluten meal	30 fb 10	70.8	61.6	54.8	65.5	63.7
5. Corn gluten meal	40	95.8	96.0	89.5	89.0	92.6
LSD _{0.05}		51.3	39.6	NS	44.4	48.5

¹These values represent the percentage reductions in clover cover per plot as compared with the untreated control.

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

Table 7. Percentage dandelion cover¹ in Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

Material	Rate (lb. product/1000 ft ²)	July 29	August 11	August 18	August 26	Mean
%						
1. Untreated control	NA	25.0	20.0	15.0	28.3	22.1
2. Corn gluten meal	10 fb 10 fb 10 fb 10	8.3	5.0	5.0	11.7	7.5
3. Corn gluten meal	20 fb 20	10.0	6.7	6.7	13.3	9.2
4. Corn gluten meal	30 fb 10	6.7	6.0	4.3	10.0	6.8
5. Corn gluten meal	40	10.0	6.7	5.7	11.7	8.5
LSD _{0.05}		7.1	6.6	4.6	NS	4.7

¹These figures represent the area per plot covered by dandelions.All treatments were at an annual rate of 4 lb.s N/1000 ft². Initial applications were made on April 21. Second application of trt 2 was made on June 3, the third on July 14, and the final on August 26. Sequential applications of trt 3 & 4 were made on July 14.

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

Table 8. Percentage reductions in dandelion cover¹ in Kentucky bluegrass treated with corn gluten meal in the 1995 Corn Gluten Meal Rate Weed Control Study.

Material	Rate (lb. product/1000 ft ²)	July 29	August 11	August 18	August 26	Mean
%						
1. Untreated control	NA	0.0	0.0	0.0	0.0	0.0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	66.7	75.0	66.7	58.8	66.1
3. Corn gluten meal	20 fb 20	60.0	66.7	55.6	52.9	58.5
4. Corn gluten meal	30 fb 10	73.3	70.0	71.1	64.7	69.5
5. Corn gluten meal	40	60.0	66.7	62.2	58.8	61.5
LSD _{0.05}		28.3	33.1	31.0	NS	21.2

¹These figures represent the percentage reductions in dandelion cover per plot as compared to the untreated control.All treatments were at an annual rate of 4 lb.s N/1000 ft². Initial applications were made on April 21. Second application of trt 2 was made on June 3, the third on July 14, and the final on August 26. Sequential applications of trt 3 & 4 were made on July 14.

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

Table 9. Crabgrass counts per plot¹ and percentage crabgrass reductions² in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study for 1995 through 1998.

Material	Rate (lb. product /1000 ft ²)	1995		1996		1997		1998	
		Percentage crabgrass reduction ²	— % —	Crabgrass counts ¹	Percentage crabgrass reduction ²	Crabgrass counts ¹	Percentage crabgrass reduction ²	Crabgrass counts ¹	Percentage crabgrass reduction ²
1. Untreated control	NA	0		4	0	36	0	19	0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	28		7	0	19	48	11	42
3. Corn gluten meal	20 fb 20	45		3	33	18	50	3	86
4. Corn gluten meal	30 fb 10	44		1	67	14	61	4	78
5. Corn gluten meal	40	54		5	0	37	0	9	53
LSD _{0.05}		NS		NS	NS	NS	NS	NS	NS

¹Crabgrass counts represent the number of crabgrass plants per plot.²These values represent the percentage reduction in plants per plot as compared with the untreated controls.

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

Table 10. Percentage clover cover per plot¹ and percentage clover cover reductions² in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study for 1996 through 1998.

Material	Rate (lb. product /1000 ft ²)	1996		1997		1998	
		Mean clover cover ¹	Percentage clover reduction ²	Mean clover cover ¹	Percentage clover reduction ²	Mean clover cover ¹	Percentage clover reduction ²
			— % —		— % —		— % —
1. Untreated control	NA	20	0	40	0	40	0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	11	45	14	65	11	74
3. Corn gluten meal	20 fb 20	6	69	7	82	11	72
4. Corn gluten meal	30 fb 10	3	90	7	92	15	64
5. Corn gluten meal	40	2	92	3	83	3	93
LSD _{0.05}		NS	NS	22	58	20	49

¹These values represent the area per plot covered by clover.²These values represent the percentage reductions in clover cover per plot as compared with the untreated control.

NS = means are not significantly different at the 0.05 level

Table 11. Percentage dandelion cover per plot¹ and percentage dandelion cover reductions² in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study for 1996 through 1998.

Material	Rate (lb. product /1000 ft ²)	1996		1997		1998	
		Mean dandelion cover ¹	Percentage dandelion reduction ² %	Mean dandelion cover ¹	Percentage dandelion reduction ² %	Mean dandelion cover ¹	Percentage dandelion reduction ² %
1. Untreated control	NA	23	0	17	0	22	0
2. Corn gluten meal	10 fb 10 fb 10 fb 10	12	48	8	50	8	66
3. Corn gluten meal	20 fb 20	12	50	7	60	9	59
4. Corn gluten meal	30 fb 10	17	28	12	28	7	69
5. Corn gluten meal	40	12	50	7	58	9	62
LSD _{0.05}		NS	NS	NS	NS	5	21

¹Percentage dandelion cover data represent the area per plot covered by dandelions.

²These values represent the percentage reductions in dandelion cover per plot as compared with the untreated control.

NS = means are not significantly different at the 0.05 level

1999 Select® Liquid Ice Melter Study

David D. Minner and Barbara R. Bingaman

Objective

To determine if a liquid ice melt material may be suitable to remove ice from golf course putting greens. Ice formation on putting greens in Iowa is a common occurrence. Freezing rain and melted snow followed by re-freezing can lead to an ice layer forming on the green nearly 2 inches thick. Some superintendents have tried to physically remove the ice layer from the green. Various commercial ice melt materials are available for non-turfgrass use.

Materials and Methods

A commercial liquid ice melting product, Select®, was screened for toxicity on creeping bentgrass during the winter months of 1999. Select®, a mixture of potassium acetate and water, was applied at various rates to creeping bentgrass plugs.

Plugs were cut from an established 'Crenshaw' creeping bentgrass area at the Iowa State University Horticulture Research Station north of Ames, IA in January. They were potted in sand medium and maintained outside from February until mid-March.

Two separate tests were run. In Test I, Select® was applied at 0, 2, 3, 4, 5, 6, and 7 gal/1000 ft² on three dates (Table 1). In Test II, the deicer was applied at 0, 6, 9, 12, 15, 18, and 21 gal/1000 ft² in one application. The deicer was diluted in water to a volume of 20 ml for ease of application using a hand sprayer. Three replications were conducted for each test.

Treatments for Test I were applied on February 17, February 22, and March 1. Deicer was applied for Test II on February 22. On March 22, the bentgrass plugs were placed in the greenhouse and evaluated for greenup.

Percent green cover and visual quality data were taken beginning on March 24. Percent green cover was estimated as the area per pot covered by green bentgrass. Visual quality was assessed using a 9 to 1 scale with 9 = best and 1 = worst quality. Additional data were taken on March 29, April 1, April 4, April 9, and April 12.

Table 1. Application rates and timing for treatments in the 1999 Select® Liquid Ice Melter Study.

Trt	Material	Application rate (gal product/1000 ft ²)	Number of Applications
1	Untreated control	0.0	NA
2	Select®	2.0	3
3	Select®	3.0	3
4	Select®	4.0	3
5	Select®	5.0	3
6	Select®	6.0	3
7	Select®	7.0	3
8	Select®	6.0	1
9	Select®	9.0	1
10	Select®	12.0	1
11	Select®	15.0	1
12	Select®	18.0	1
13	Select®	21.0	1

Table 2. Visual quality of creeping bentgrass treated in the 1999 Select® Liquid Ice Melter Study.

Trt	Material	Application rate (gal product/ 1000 ft ²)	Number of Applications	March 24	March 29	April 1	April 5	April 9	April 12	Mean
1	Untreated control	0.0	NA	8.0	9.0	9.0	9.0	9.0	9.0	8.3
2	Select®	2.0	3	7.7	9.0	8.0	8.0	8.0	8.0	8.6
3	Select®	3.0	3	6.7	8.0	7.7	7.7	7.7	7.7	7.7
4	Select®	4.0	3	5.7	7.3	7.3	7.3	7.3	7.3	7.3
5	Select®	5.0	3	4.7	7.5 ²	7.5 ²	7.5 ²	5.3	5.3	5.9
6	Select®	6.0	3	5.3	7.5 ²	6.3	6.3	7.0	7.0	5.8
7	Select®	7.0	3	6.0 ³	5.0 ³	7.0 ³	7.0 ³	7.0 ³	7.0 ³	2.9
8	Select®	6.0	1	8.0	9.0	8.0	8.0	8.0	8.0	8.7
9	Select®	9.0	1	7.0	8.3	7.7	7.7	7.7	7.7	8.3
10	Select®	12.0	1	5.3	7.3	7.0	7.0	7.0	7.0	7.0
11	Select®	15.0	1	3.0 ²	6.5 ²	6.0	6.0	6.0	6.0	5.4
12	Select®	18.0	1	6.0 ²	6.0 ²	6.5 ²	6.5 ²	6.5 ²	4.7	5.3
13	Select®	21.0	1	6.0 ³	6.0 ³	6.0 ³	6.0 ³	3.5 ²	3.5 ²	2.7
LSD _{0.05}				2.2	2.3	2.2	2.4	2.4	NS	2.8

¹Visual quality was assessed using a 9 to 1 scale with 9 = best, 6 = lowest acceptable, and 1 = worst quality.

²This value represents only two replications - there was no bentgrass in the third replication.

³This value represents only one replications - there was no bentgrass in the other two replications.

Table 3. Percentage green cover of creeping bentgrass treated in the 1999 Select® Liquid Ice Melter Study.

Trt	Material	Application rate (gal product/ 1000 ft ²)	Number of Applications	March 24	March 29	April 1	April 5	April 9	April 12	Mean
1	Untreated control	0.0	NA	66.7	100.0	100.0	100.0	100.0	100.0	94.4
2	Select®	2.0	3	46.7	78.3	80.0	86.7	86.7	86.7	77.5
3	Select®	3.0	3	7.0	15.0	15.0	18.3	23.3	28.3	17.8
4	Select®	4.0	3	2.7	11.7	11.7	15.0	20.0	23.3	14.1
5	Select®	5.0	3	4.7	5.7	5.7	11.7	12.0	13.7	8.9
6	Select®	6.0	3	2.7	5.0	5.3	7.0	6.7	8.3	5.8
7	Select®	7.0	3	0.7	1.7	1.7	1.7	1.7	1.7	1.5
8	Select®	6.0	1	28.3	60.0	68.3	76.7	78.3	83.3	65.8
9	Select®	9.0	1	16.7	40.0	45.0	56.7	61.7	65.0	47.5
10	Select®	12.0	1	11.7	18.3	18.3	25.0	25.0	20.0	19.7
11	Select®	15.0	1	1.3	2.0	4.0	5.7	5.3	7.0	4.2
12	Select®	18.0	1	4.0	8.3	10.0	13.3	13.3	25.0	12.3
13	Select®	21.0	1	0.3	0.0	0.3	0.0	0.7	0.7	0.3
LSD _{0.05}				11.5	16.3	17.6	18.1	18.5	20.2	15.1

¹These values represent the percentage of area per plot covered by green bentgrass.

Results

These results are preliminary and the products mentioned in this report should not be used at this time for removing ice from golf course turf.

Phytotoxicity caused by Select® was rate dependent. A single application of Select® at 6 gal/1000 sq. ft. resulted in some initial phytotoxicity, but turf recovered to an acceptable level within 1.5 months. At 9 to 12 gal/1000 sq. ft., injury was greater and recovery slower. Lower application rates applied more frequently reduced injury compared to single applications applied at an equal rate. Since golf course putting greens are highly scrutinized, this product should be investigated at rates lower than 2.0 gal/1000 sq. ft.

Stabilizing Sand-based Athletic Fields With Enkamat

David D. Minner and Jay S. Hudson

Objective: The objectives of the study are to determine the proper placement depth for Enkamat and to evaluate it as a stabilization material for sand-based systems.

Sand-based systems are widely used for sports fields to reduce compaction and promote rapid drainage. Sand is an excellent media for drainage of the rootzone, but it can result in an unstable surface, especially when the grass has worn away. New technologies are being developed to stabilize sand-based fields. Fibrillated polypropylene fibers woven into a synthetic black backing (SportGrass™), fibrillated fibers (TurfGrids®), and interlocking mesh elements (Netlon, Ltd.) are a few of the products available for stabilizing sand-based athletic fields. Reinforcement material can be grouped into two categories: those that form a horizontal layer at or near the turf surface and those that are comprised of individual discrete units that are mixed into the rootzone layer (Baker, 1997).

Enkamat consists of a bulky mat made from nylon threads which are fused together where they cross. The thickness of this three-dimensional mat ranges from 11/16- to 7/8-inch and has an open construction leaving 90% of its volume to be filled with sand or soil (Baker, 1997). Enkamat has been used in combination with other geotextile material (polyester covers, TurfArmor®, and plywood) to protect the grass surface when special events are held on stadium fields.

Demonstration plots have shown that if Enkamat is exposed to the surface during field wear, there is a potential for tripping with cleated shoes. We are interested in how deep Enkamat needs to be placed to prevent exposure to the surface and if there is any benefit from field stabilization with Enkamat.

Methods:

A 50 ft. by 50 ft. sand-based pad, six inches deep, was constructed in the fall of 1997 for evaluation of Enkamat at the Horticulture Research Station, Ames, Iowa. The sand-based system was placed over a 4-inch gravel blanket with a network of 4-inch drain pipes. The sand rootzone is described below and no other physical amendments were added. The study area is automatically watered and is part of our new sand-based sports turf research facility. Table 1 shows the treatments that were installed to evaluate Enkamat as a reinforcement material for sand based athletic fields.

Table 1. Treatments used to compare the reinforcement capability of Enkamat on sand-based athletic fields.

Trt	Synthetic	Depth of synthetic below sod (sod contains 0.75 inches of soil)	Comments
1	Sand	—	Standard for the industry
2	Enkamat	0 (0.75 inches)	
3	Enkamat	1 (1.75 inches)	

The experimental design is a randomized complete block with three treatments and three replications. Individual treatment plots are 13 ft. by 16 ft. The large size of the plots will allow for study of an additional factor by subdividing each treatment plot. Potential split plot treatments could include typical field management factors such as topdressing or drill seeding. Enkamat will be placed at two different depths to ensure that it will not become exposed during intense traffic. We will determine if Enkamat provides any advantage for turf growth, even when placed deep enough in the soil profile to avoid surface exposure. Enkamat will be placed at two depths, even with the surface of the sand base or one inch below the surface of the sand base. In treatment #2, the top of the Enkamat is even with the top of the sand surface. When sodded, the top of the Enkamat is then covered by 0.75 inch of soil. In treatment #3, the top of the Enkamat is placed one inch below the surface of the sand. When sodded, the top of the Enkamat is then covered by 1.75 inches of soil. The study area was sodded on 7 November 1997 with 'Midnight' Kentucky bluegrass containing 0.75 inch of a Nicollet fine loam soil. Sod laid on sand based fields is the current standard for the industry. In northern climates, sand-based fields are seldom established from seed. Enkamat reinforced fields will need to show an improvement over the conventionally accepted sand fields that are sodded. Turf will be mowed, watered, and fertilized to simulate a high maintenance sand-based sports field. Turf will be mowed, without catching clippings, at a 1.5-inch height three times per week. Water will be applied

through an automatic watering system at the first sign of wilt. Approximately 1.5 inches of water will be applied each week from May through September. Nitrogen will be applied at 1 lb N/1000 sq. ft./growing month. Phosphorous, potassium, calcium, magnesium, and micronutrients will be applied based on soil testing.

The study was evaluated for turf appearance, surface hardness, and traction from July through October. Turf appearance was evaluated by determining turf quality and percent turf cover. Surface hardness was measured with a 2.25-kg hammer attached to the Bruel and Kjaer 2515 Vibration Analyzer. The hammer was dropped from a height of 18 inches. Also, surface hardness was measured with a 0.5-kg Clegg impact hammer. Traction was conducted with a torque wrench apparatus attached to a cleated plate that was developed by Canaway and Bell, 1986. One hundred pounds was the load bearing weight of the torque device and the weight was dropped from a height of 2 inches. Traction was assessed as the amount of torque (N·m) required to tear the underlying sod. Traction data represent the average of two individual measurements per plot. From mid-August through October, traffic was applied every Monday, Wednesday, and Friday with a model T224 Brouwer roller that has been converted into a riding traffic simulator. Both of the two-foot-wide rollers on the traffic simulator are fitted with 5/8-inch football cleats on 2-inch centers. The rollers are attached by chain and sprocket to supply a differential-slip-type of traffic that produces a tearing action of the grass surface. During 1998, all Enkamat treatments received a total of 133 passes of simulated traffic. Soil moisture content was performed by randomly sampling soil cores from the study area on each of the four different dates. The soil moisture content was 10.69%, 17.21%, 10.57%, and 17.30% respectively for the four dates. The entire study area will receive both hollow and solid coring in 1999 to determine if Enkamat disrupts this routine management practice.

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 treatments effects on surface hardness (Tables 1 and 2), traction (Table 3), and turf appearance (Table 4).

1998 Results:

On 9 September 1998 Enkamat placed 1 inch below the sod resulted in a significantly harder surface than Enkamat placed immediately below the sod or the control without Enkamat when measured with the 0.5kg hammer (Table 1). This effect was observed in both the traffic and no traffic areas. Also, on 9 September 1998 the control treatment without Enkamat was significantly different between the traffic treated areas and no traffic treated areas when measured with the 2.25kg hammer (Table 2).

Enkamat treatments had no effect on surface traction, turf quality, and percent turf cover under conditions of no traffic or intense traffic. On 29 October 1998 turf injury resulted in a quality of 3 with 30 percent turf cover for the control and 35 percent turf cover for the treatments with Enkamat (Table 4). This level of loss resulted in approximately a 10 N·m decline in traction (Table 3). Traction was significantly less for the traffic treated areas compared to the non-trafficked turf.

Enkamat treatments did not affect traction in the traffic treated areas. Even though the turf was significantly worn, 30-35 percent turf cover, the sod layer was not "broken through" and the cleats of the traction measurement device did not contact the Enkamat. The traction device impacts a rotational force in a plane horizontal to the surface. It appears that this device does not simulate the forces necessary to cause breakthrough of the surface as observed when a player makes a foot-plant or sharp turn. There is currently no device available that measures field stability or the ability of a player to break through the sod surface. A visual but quantitative scale also needs to be developed to rapidly assess surface stability conditions.

Research will continue before a final report is prepared.

Literature Cited

- Baker, S.W. 1997. The reinforcement of turfgrass areas using plastics and other synthetic materials: a review. *International Turfgrass Society Research Journal*, 8:3-13.
- Canaway, P.M. and M.J. Bell. 1986. Technical note: An apparatus for measuring traction and friction on natural and artificial playing surfaces. *J. Sports Turf Res. Inst.* 62:211-214.

Enkamat Study Plot Plan

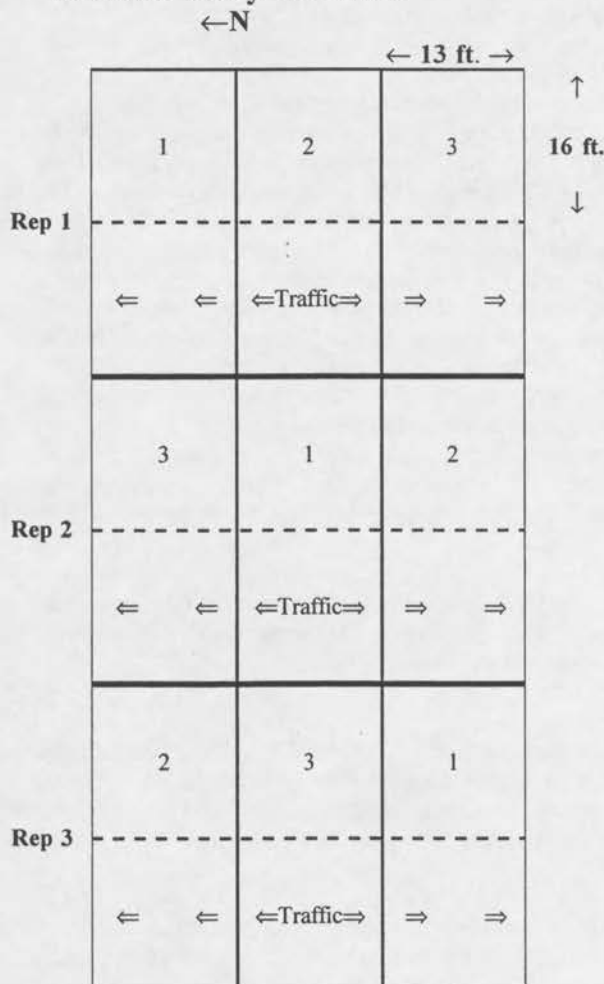
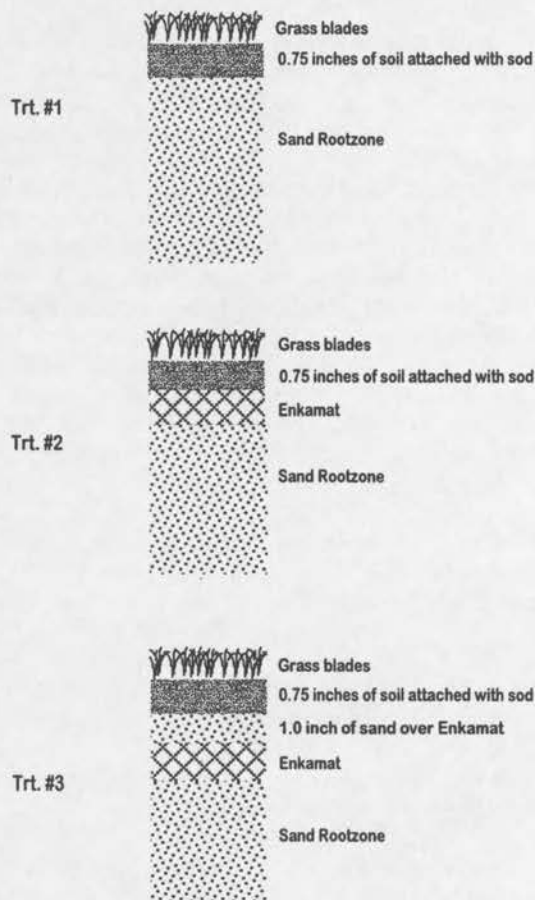


Figure 1. Treatments to evaluate the placement depth of Enkamat.



Objective: To determine required depth of placement for Enkamat.

Treatments:

1. No Enkamat
2. Enkamat 0" below surface of sand.
3. Enkamat 1" below surface of sand.

Installation procedure:

1. Treatment 1--No Enkamat installed. Existing surface is considered top of sand.
2. Treatment 2--Loosen top one-half inch of surface with stiff rake. Press Enkamat into sand and roll surface so that top of Enkamat is even with top of final sand surface.
3. Treatment 3--Remove the top one inch of sand. Loosen top one-half inch of surface with stiff rake. Press Enkamat into sand and roll surface. Replace one inch of sand on top of Enkamat.
4. Roll entire surface area for all treatments.
5. Individual plots are 16' by 13'. Overall plot size is 48' by 39'.
6. All treatments were sodded with 'Midnight' Kentucky bluegrass containing 0.75 inches of soil attached to the grass mat.

Table 1. Surface hardness measured with the 0.5kg hammer (g_{max})

Treatment	7-24-98	8-25-98	9-29-98	10-29-98	Mean
NO TRAFFIC					
Control - no Enkamat	80.3	84.0	74.7	59.3	74.6
Enkamat - 0 inch below	77.3	76.0	73.7	61.7	72.2
Enkamat - 1 inch below	81.0	80.0	86.3	60.7	77.0
TRAFFIC					
Control - no Enkamat	88.0	90.0	87.3	62.3	81.9
Enkamat - 0 inch below	86.0	82.0	83.7	64.7	79.1
Enkamat - 1 inch below	86.7	85.0	98.3	64.7	83.7
LSD _(0.05) =	ns	ns	8.9	ns	5.3

NS = not significant at $P \leq 0.05$.**Table 2.** Surface hardness measured with the 2.25kg hammer (g_{max})

Treatment	7-24-98	8-25-98	9-29-98	10-29-98	Mean
NO TRAFFIC					
Control - no Enkamat	53.7	53.0	54.3	51.7	53.2
Enkamat - 0 inch below	55.7	55.7	58.3	52.3	55.5
Enkamat - 1 inch below	53.0	52.3	64.0	54.0	55.8
TRAFFIC					
Control - no Enkamat	55.0	57.3	67.0	51.3	57.7
Enkamat - 0 inch below	57.0	57.7	63.7	50.7	57.3
Enkamat - 1 inch below	54.0	53.0	73.0	50.0	57.5
LSD _(0.05)	ns	3.8	10.3	ns	ns

NS = not significant at $P \leq 0.05$.

Table 3. Traction measurements (N·m)

Treatment	7-24-98	8-25-98	9-29-98	10-29-98	Mean
NO TRAFFIC					
Control - no Enkamat	52.3	46.7	48.6	49.9	49.4
Enkamat - 0 inch below	52.8	48.1	48.3	49.8	49.8
Enkamat - 1 inch below	50.4	46.6	52.5	49.7	49.8
TRAFFIC					
Control - no Enkamat	50.6	49.8	49.4	39.3	47.3
Enkamat - 0 inch below	54.6	50.6	48.2	38.4	47.9
Enkamat - 1 inch below	51.6	48.3	49.7	38.3	47.0
LSD _(0.05)	ns	ns	ns	2.2	ns

NS = not significant at $P \leq 0.05$.**Table 4.** Percent turf cover (% cov) and turf quality (Q), 10 = best and 1 = worst.

Treatment	7-24-98		8-25-98		9-29-98		10-29-98		Mean	
	Q	% cov	Q	% cov	Q	% cov	Q	% cov	Q	% cov
• No Traffic										
Control – no Enkamat	8	100	9	100	10	100	10	100	9	100
Enkamat – 0 inch below	8	100	9	100	10	100	10	100	9	100
Enkamat – 1 inch below	8	100	9	100	10	100	10	100	9	100
• Traffic										
Control – no Enkamat	8	100	9	100	6	55	3	30	7.7	71
Enkamat – 0 inch below	8	100	9	100	6	50	3	35	7.7	71
Enkamat – 1 inch below	7	100	9	100	6	55	3	35	7.7	72
LSD _(0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

NS = not significant at $P \leq 0.05$.

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

David D. Minner and Jay S. Hudson

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 known for their durability and infrequent need for maintenance. SportGrass® is the first product that combines the playability of natural grass with some of the more durable characteristics of synthetic turf.

The SportGrass® system is a synthetically reinforced layer of grass that is grown on a sand-based rootzone. The system consists of natural grass growing in a synthetic matrix containing fibrillated fibers (polypropylene blades) attached to a backing. Within the layer of sand are polypropylene grass blades tufted into a woven backing (www.sportgrass.com). 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 horizontally and vertically stabilized by the combination of the polypropylene blades and the backing material. Grass can be established by seeding or sprigging. Specialized methods have been developed to produce, harvest, and install large-roll 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 (www.sportgrass.com).

The SportGrass® synthetic material is typically produced in 15 ft by 100 ft rolls. The synthetic turf material is laid on top of the sand-based root zone. During installation, the seams of the synthetic material are temporarily held to the rootzone with metal sod staples. Sand that matches the root zone is then topdressed and brushed into the 3/4-inch 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. SportGrass® sod is grown over a plastic sheet to impede root penetration. The sod is then sliced into appropriate sizes in the sod field (usually 42 inches by 40 feet). A large roll harvester is used to roll up the sod. SportGrass® has been used on football, baseball, and soccer fields and golf courses.

Most natural grass systems tend to become elevated above the surface where the grass was first established. Over time the accumulation of thatch and the process of topdressing can add as much as 0.5 to 2.0 inches of material above the original soil line where the grass was first started. Stabilizing materials that were once near the surface can be lowered in the profile as organic and mineral material accumulates above the synthetic stabilizer. We are interested in finding out if this "burying" of the stabilizer material reduces their effectiveness. We also want to know if current management practices can be used to prevent accumulation of thatch above the synthetic stabilizer. Stabilizers also tend to reduce surface resilience and increase surface hardness (as measured by Gmax). Two separate studies were established in the fall of 1996 to evaluate mat management above the surface of the stabilizers and to evaluate field hardness.

Methods:

Study # 1 - Mat Management

The 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 and above the synthetically reinforced zone. Most grass systems tend to increase in elevation as topdressing, thatch, and mat accumulate above the original surface where the grass was first established. Moderate accumulation of thatch may improve surface characteristics by increasing cushion and biomass cover. Eight treatments including two non-SportGrass® controls were used to evaluate mat management in the SportGrass® System (Table 1a). The six SportGrass® treatments consisted of catching clippings, returning clippings, verticutting, solid coring, Primo plant growth regulator, and verticutting after thatch accumulation. Verticutting was applied on 4 May 1998 and was aerified on both 4 May and 25 August 1998. Primo treatments were applied on 23 May, 27 June, and 29 July 1998. Verticutting was applied by making two passes over the plot in opposite directions using a Bluebird vertical mower. The verticut depth was set so that it just touched the top of the synthetic grass blades. The thatch litter was hand raked and removed from the surface. Hollow tine coring with 5/8-inch tines was attempted on a border area containing

SportGrass®. The GA30 Cushman aerifier with 5/8-inch hollow tines did not adequately penetrate the synthetic backing of the SportGrass® material. Pointed 3/8-inch solid tines easily penetrated the backing and were used in the study. Holes were punched on 2-inch centers at a rate of 36 holes/sq ft. Heavier coring equipment such as the Cushman GA60 have successfully hollow cored through the SportGrass® backing using 3/4-inch tines.

Study #2 - Grass Species

The objective was to evaluate how grass species, seeding rates, and traffic intensity influence the performance of the natural grass and synthetic turf combination. (Tables 2a and 2b). Synthetically stabilizing sand surfaces typically increases surface hardness. In some situations synthetic stabilizers have been perceived as making fields too hard. When cleat penetration and traction are reduced the field appears slippery. Fields dominated by a thick stand of perennial ryegrass have been described as being more slippery than other types of grass. This study evaluates the performance of a SportGrass® system with respect to hardness and footing.

Studies were evaluated for turf appearance, surface hardness, and traction measurements from May through October 1998. Turf appearance was evaluated by determining turf quality, turf color, and percent cover on 4 May and 16 October 1998. On five different dates, surface hardness was measured with a 2.25-kg hammer attached to the Bruel and Kjaer 2515 Vibration Analyzer. The hammer was dropped from a height of 18 inches. Also, surface hardness was measured with a 0.5-kg Clegg impact hammer. Traction was conducted with a torque wrench apparatus attached to a cleated plate that was developed by Canaway and Bell, 1986. One hundred pounds was the load bearing weight of the torque device and the weight was dropped from a height of 2 inches. Traction was assessed as the amount of torque (N·m) required to tear the underlying sod. Traction data represent the average of three individual measurements per plot. From mid-August through October, traffic was applied every Monday, Wednesday, and Friday with a model T224 Brouwer Roller that has been converted into a riding traffic simulator. Both of the two-foot-wide rollers on the traffic simulator are fitted with 5/8-inch football cleats on 2-inch centers. The rollers are attached by chain and sprocket to supply a differential-slip-type of traffic that produces a tearing action of the grass surface. During 1998, all SportGrass® treatments received a total of 133 passes of simulated traffic. Soil moisture content was performed by randomly sampling soil cores from each study area on data collection dates.

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 treatments effects on surface hardness (Tables 3 and 4) and traction (Table 3).

1997 Results:

Study # 1 Mat Management

Information is preliminary at this time since treatments just started in 1997 and thatch may take two or more years to accumulate. However, there was a clear and significant difference in surface hardness associated with solid tine coring on 12 November 1997, 54 days after treatment (Table 3a). Solid tine coring of SportGrass® reduced surface hardness by approximately 18g (77g for solid tine vs. approximately 95g for non-cored SportGrass® treatments). The solid tined SportGrass® plots had a surface hardness that was similar to the seeded or sodded non-SportGrass® controls (Table 3a). The sodded control had a significantly higher Gmax than the seeded control.

With respect to surface hardness of SportGrass®, the preliminary results in this study indicate that solid tine coring can be used to effectively manage surface hardness.

Traction was not affected by the treatments at this time. There was no difference in traction between SportGrass® treatment and non-SportGrass® treatments.

Study # 2 Grass Species

Seeding rate did not affect surface hardness, although there was a slight trend showing reduced hardness with higher seeding rates (Table 4). Perennial ryegrass alone or mixed with Kentucky bluegrass significantly reduced surface hardness compared to Kentucky bluegrass used alone.

1998 Results:

Study # 1 Mat Management

Solid tine coring produced a reduction in surface hardness in both 1997 and 1998 (Tables 5 and 7). In contrast verticutting produced an increase in surface hardness in both years (Table 5). Primo had no effect on surface hardness but did produce turf with better color and quality (Table 10a).

Study # 2 Grass Species

Traffic treatment was more detrimental to perennial ryegrass than Kentucky bluegrass. On 16 October 1998, following approximately two months of simulated traffic, perennial ryegrass had 60% turf cover while Kentucky bluegrass had 97% turf cover (Table 10b). The ryegrass was showing severe cleat marks every two inches and exposed soil while the Kentucky bluegrass had only a few cleat marks and no exposed soil.

Research will continue for two more years before a final report is prepared, however, early indications are that typical turfgrass management practices can be used to regulate surface hardness on SportGrass® fields. Additional research will include soil physical characteristics and root sampling above and below the synthetic layer.

Literature Cited

Canaway, P.M. and M.J. Bell. 1986. Technical note: An apparatus for measuring traction and friction on natural and artificial playing surfaces. J. Sports Turf Res. Inst. 62:211-214.

Table 1a. 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 1b. Plot layout for mat management study.

extra plot	extra plot	6	2	4
3	5	2	5	1
4	6	1	3	6
1	3	2	5	4
7	8	7	8	7
GRASS SPECIES STUDY AREA				
North «				

Rep 1	Rep 2	Rep 3
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Table 2a. Species layout for grass species study.

Trt	Grass species (whole plot trt)	Seeding rate lb/1000 ft ²	Traffic Intensity (Split plot)	
			Low	High
1.	Kentucky bluegrass ¹	2	yes	
2.	Kentucky bluegrass	2		yes
3.	Kentucky bluegrass	4	yes	
4.	Kentucky bluegrass	4		yes
5.	Perennial ryegrass ²	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

¹ 'Limousine' Kentucky bluegrass

² 'Pinnacle' Perennial ryegrass

Table 2b. Plot plan of treatment arrangements for the grass species study.

MAT MANAGEMENT STUDY AREA								
North «								
REP 1						REP 2		
1	2	3	4	5	6	7	8	9
1 (1a)	3 (2a)	5 (3a)	7 (4a)	9 (5a)	11 (6a)	1 (1a)	7 (4a)	9 (5a)
10	11	12	13	14	15	16	17	18
2 (1b)	4 (2b)	6 (3b)	8 (4b)	10 (5b)	12 (6b)	2 (1b)	8 (4b)	10 (5b)
REP 3								
19	20	21	22	23	24	25	26	27
7 (4a)	5 (3a)	11 (6a)	3 (2a)	1 (1a)	9 (5a)	5 (3a)	11 (6a)	3 (2a)
28	29	30	31	32	33	34	35	36
8 (4b)	6 (3b)	12 (6b)	4 (2b)	2 (1b)	10 (5b)	6 (3b)	12 (6b)	4 (2b)

Table 3a. Surface hardness and traction measurements for the mat management study on 12 November 1997. Three traction measurements were taken within each plot and averaged.

Treatments	Surface hardness (g_{max}) 2.25-kg hammer	Traction (N·m)
1. Catch clippings	94.4	65.2
2. Return clippings	95.3	68.5
3. Verticut (prevent thatch)	94.3	67.3
4. Solid tine aerify	77.6	67.5
5. PGR (Primo)	93.5	67.0
6. Verticut (after thatch accumulates)	97.3	67.0
7. Control seeded	73.3	63.6
8. Control sodded	83.5	63.1
LSD _(0.05)	10.0	NS

NS = not significant at $P \leq 0.05$.**Table 3b.** Percent soil moisture and organic matter (by weight).

Treatment	Rep	Sample description	% soil moisture	% organic matter
extra plot		fibers in sample	3.4	0.7
8	3	fibers in sample	3.1	0.7
7	1	seeded KB	3.3	0.5
7	2	seeded KB	4.4	0.7
7	3	seeded KB	3.0	0.7

Table 4. Surface hardness measurements taken on 12 November 1997 on the grass species study. The a and b parts of the individual plots were combined as an overall plot and surface hardness was performed.

Treatments	Seeding rate lb/1000 sq.ft.	Surface hardness (g_{max})
1. Kentucky bluegrass ¹	2	92.8
2. Kentucky bluegrass	4	88.2
3. Perennial ryegrass ²	7	81.0
4. Perennial ryegrass	14	76.1
5. KB ¹ + PR ²	2 + 7	78.5
6. KB + PR	4 + 14	77.4
7. KB Control seeded	4	73.3
8. KB Control sodded	--	83.5
LSD _(0.05)		6.1

¹ 'Limousine' Kentucky bluegrass² 'Pinnacle' perennial ryegrass**Table 5a.** Surface hardness and traction measurements for the mat management study on 4 May 1998. Three traction measurements were taken within each plot and averaged.

Treatments	Surface hardness (g_{max}) 2.25-kg hammer	Surface hardness (g_{max}) .5-kg hammer	Traction (N·m)
1. Catch clippings	75.3	56.7	68.0
2. Return clippings	73.0	60.1	66.5
3. Verticut (prevent thatch)	75.7	63.4	71.0
4. Solid tine aerify	69.1	64.3	71.3
5. PGR (Primo)	70.7	61.2	70.5
6. Verticut (after thatch accumulates)	73.9	63.2	69.8
7. Control seeded	56.9	64.8	69.7
8. Control sodded	53.2	55.3	68.0

Table 5b. Surface hardness measurements for the mat management study on 4 May 1998 after specific management practices were performed.

Treatments	Surface hardness (g_{max}) 2.25-kg hammer	Surface hardness (g_{max}) .5-kg hammer
3. Verticut (prevent thatch)	94.3	108.8
4. Solid tine aerify	70.4	58.1

Table 6. Surface hardness and traction measurements taken on 4 May 1998 on the grass species study. The a and b parts of the individual plots were combined as an overall plot and surface hardness was performed. Traction is the average of three measurements.

Treatments	Surface hardness (g_{max}) 2.25-kg hammer	Surface hardness (g_{max}) .5-kg hammer	Traction (N·m)
1. Kentucky bluegrass ¹	63.1	49.0	69.2
2. Kentucky bluegrass	63.6	57.7	65.8
3. Perennial ryegrass ²	63.6	60.4	66.0
4. Perennial ryegrass	64.2	61.3	66.8
5. KB ¹ + PR ²	62.7	61.6	66.5
6. KB + PR	63.8	65.8	65.7

¹ 'Limousine' Kentucky bluegrass² 'Pinnacle' perennial ryegrass

NOTE: On 4 May 1998 all plots for mat management and grass species studies were rated for turf quality, color, and % cover.

Quality	All plots = 9 (9 = best quality)
Color	All plots = 9 (9 = best color)
% Cover	All plots = 99% (99% = best cover)

Table 7a. Surface hardness measurements(g_{max}) for the mat management study on four different dates in 1998 using a 2.25 kg hammer.

Treatments	July 24	August 25	September 29	October 29
2. Return clippings	98.7	95.0	104.4	109.0
3. Verticut (prevent thatch)	99.5	95.7	101.6	113.1
4. Solid tine aerify	94.8	89.6	94.8	101.9
5. PGR (Primo)	97.7	92.1	99.7	107.8
7. Control seeded	86.7	84.3	90.7	90.3
8. Control sodded	81.2	72.8	78.7	75.6

Table 7b. Surface hardness measurements for the mat management study on four different dates in 1998 using a .5 kg hammer.

Treatments	July 24	August 25	September 29	October 29
2. Return clippings	107.5	106.2	98.1	115.3
3. Verticut (prevent thatch)	118.2	107.9	98.9	124.9
4. Solid tine aerify	115.5	100.7	100.5	116.1
5. PGR (Primo)	107.8	101.8	97.3	111.9
7. Control seeded	129.7	102.8	96.1	113.5
8. Control sodded	114.7	103.9	94.2	98.5

Table 7c. Traction measurements(N·m) for the mat management study on four different dates in 1998. Three traction measurements were taken within each plot and averaged

Treatments	July 24	August 25	September 29	October 29
2. Return clippings	73.0	66.3	61.7	59.8
3. Verticut (prevent thatch)	71.7	71.0	63.3	61.8
4. Solid tine aerify	75.0	68.3	61.0	57.2
5. PGR (Primo)	74.7	70.0	64.0	62.3
7. Control seeded	66.5	69.3	66.3	56.2
8. Control sodded	62.8	67.8	62.0	57.0

Table 7d. Surface hardness and traction measurements for the mat management study on 25 August 1998 after specific management practices were performed.

Treatments	Surface hardness (g_{max}) 2.25-kg hammer	Surface hardness (g_{max}) .5-kg hammer	Traction (N·m)
4. Solid tine aerify	66.2	84.0	65.3

Table 8a. Surface hardness measurements(g_{max}) for the grass species study on four different dates in 1998 using a 2.25 kg hammer. The a and b parts of the individual plots were combined as an overall plot and surface hardness was performed.

Treatments	July 24	August 25	September 29	October 29
1. Kentucky bluegrass ¹	96.6	91.0	97.0	103.8
2. Kentucky bluegrass	99.7	89.3	96.9	104.5
3. Perennial ryegrass ²	86.2	81.8	85.5	90.6
4. Perennial ryegrass	83.0	78.7	85.0	89.1
5. KB ¹ + PR ²	83.7	77.1	85.0	90.8
6. KB + PR	81.7	81.1	86.5	91.1

¹ 'Limousine' Kentucky bluegrass² 'Pinnacle' perennial ryegrass

Table 8b. Surface hardness measurements for the grass species study on four different dates in 1998 using a .5 kg hammer. The a and b parts of the individual plots were combined as an overall plot and surface hardness was performed.

Treatments	July 24	August 25	September 29	October 29
1. Kentucky bluegrass ¹	110.5	107.4	92.3	104.9
2. Kentucky bluegrass	109.3	101.8	82.0	106.7
3. Perennial ryegrass ²	115.1	115.7	95.3	120.5
4. Perennial ryegrass	116.5	112.8	95.4	109.1
5. KB ¹ + PR ²	112.7	116.7	92.7	112.9
6. KB + PR	114.4	113.8	96.3	120.7

¹ 'Limousine' Kentucky bluegrass² 'Pinnacle' perennial ryegrass**Table 8c.** Traction measurements(N·m) for the grass species study on four different dates in 1998. The a and b parts of the individual plots were combined as an overall plot and surface hardness was performed. Traction is the average of three measurements.

Treatments	July 24	August 25	September 29	October 29
1. Kentucky bluegrass ¹	70.7	61.0	68.3	58.5
2. Kentucky bluegrass	75.7	63.0	60.7	65.5
3. Perennial ryegrass ²	64.7	56.3	55.8	51.0
4. Perennial ryegrass	65.7	56.8	52.0	47.2
5. KB ¹ + PR ²	58.8	54.2	52.7	53.0
6. KB + PR	60.2	55.3	53.3	51.2

¹ 'Limousine' Kentucky bluegrass² 'Pinnacle' perennial ryegrass**Table 9.** Percent soil moisture (by weight) taken for mat management and grass species study on four different dates.

	7/24/98	8/25/98	9/29/98	10/29/98
Mat Management	4.68	6.98	6.47	8.35
Grass Species	5.91	7.51	8.14	9.81

Table 10a. Ratings of turf quality, color, and % cover for the mat management study on 16 October 1998.

Treatments	Turf Quality (9 = best)	Turf Color (9 = best)	% Turf Cover
1. Catch clippings	6.3	6.3	97.0
2. Return clippings	6.3	6.3	97.7
3. Verticut (prevent thatch)	6.7	7.0	99.0
4. Solid tine aerify	6.3	6.7	99.0
5. PGR (Primo)	8.0	8.0	99.0
6. Verticut (after thatch accumulates)	6.7	6.3	99.0
7. Control seeded	5.3	6.0	86.7
8. Control sodded	5.0	6.0	82.5

Table 10b. Ratings of turf quality and % cover for the grass species study on 16 October 1998.

Treatments	Turf Quality (9 = best)	% Turf Cover
1. Kentucky bluegrass ¹	7.0	97.7
2. Kentucky bluegrass	7.0	97.7
3. Perennial ryegrass ²	4.0	60.0
4. Perennial ryegrass	4.0	61.7
5. KB ¹ + PR ²	4.0	65.0
6. KB + PR	4.0	65.0

¹ 'Limousine' Kentucky bluegrass² 'Pinnacle' perennial ryegrass

Managing Bentgrass Stress on Putting Green Slopes -1998 Report

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Iowa Golf Course Superintendents Association, Golf Course Superintendents Association of America*

Turf management practices are usually applied uniformly across a putting green. Research greens are usually perfectly flat and uniform. However the actual greens are not flat and problem areas are not uniform. A meaningful interpretation of research results depends on how close the research situation is to the real world. A sloped research green (SRG) was constructed at the Horticulture Research Center, Ames, IA, in July 1997 to evaluate bentgrass management under difficult and variable growing conditions. Construction of the green was funded by Iowa State University, the Iowa Golf Course Superintendents Association, and the Golf Course Superintendents Association of America. The objective of this project was to evaluate organic and inorganic amendments applied as topdressing.

The SRG was erected to simulate the undulating topography that occurs on many putting greens - as opposed to a typical flat research green (Figure 1). A 12-inch sand rootzone containing no amendments, organic or inorganic, was positioned over a 4-inch gravel blanket with 4-inch drain lines. The subgrade, gravel blanket, and sand rootzone all follow the same contour. The SRG has four distinct microenvironments that will be simultaneously evaluated for nine different treatments. The microenvironments are: 1) cool slope - this 7.0% slope faces north and should be cooler in the summer but also colder in the winter, 2) knoll - the crown of the green is expected to have the most potential for scalping and dry spot injury in the summer, 3) hot slope - this 6.6% slope faces south and is expected to generate high surface temperatures, and 4) swale - the low portion of the green is expected to have excessively wet conditions. To our knowledge, this type of sloped green project has never been used for putting green research.

The sand for rootzone construction has a pH of 8.2 and is calcareous. The green was seeded with Crenshaw creeping bentgrass in September 1997. The sloped green matured and filled in during the summer of 1998. By August there was 100 percent turf cover and approximately 0.5 cm of thatch. The experimental area measures 100 ft by 40 ft. The main experiment contains five topdressing treatments in a complete randomized block design. Each treatment unit (plot) measures 40 ft by 6 ft. The long and narrow plots are situated so that each treatment covers all four distinct microenvironments on the green. The five topdressing treatments are listed in Table 1. Axis, Profile, Zeolite, and Zeopro are inorganic amendments that will be compared with the organic amendment Dakota Peat. Axis is a diatomaceous earth, Profile is a porous ceramic clay, Zeolite is a aluminosilicate mineral, and Zeopro is a nutrient loaded zeolite. In another experiment, Bio-Flex-A-Clay was used as topdressing at three different rates 5 lb/1000 ft², 10 lb/1000 ft², 20 lb/1000 ft². Bio-Flex-A-Clay is a polymer coated sand with a kelp material incorporated. All of the products claim to improve cation exchange, and nutrient and water holding capacity.

On 25 September 1998 the green was severely verticut. A 0.5 cm depth of topdressing material was immediately applied for each treatment following verticutting. The green was maintained at a 0.25-inch cutting height and covered during the winter with a Covermaster cover for winter protection. Moderate-to-severe winter desiccation damage was observed when the protective cover was removed in April. Most of the injury occurred on the knoll and south facing slope near the knoll of the green. The entire green was reseeded with 2.0 lbs. Of 'Crenshaw' creeping bentgrass in May. There were no apparent differences among treatments based on winter injury. An additional 1.5 cm of topdressing is targeted for the entire 1999 growing season. Topdressing will be applied in light and frequent applications (Table 2).

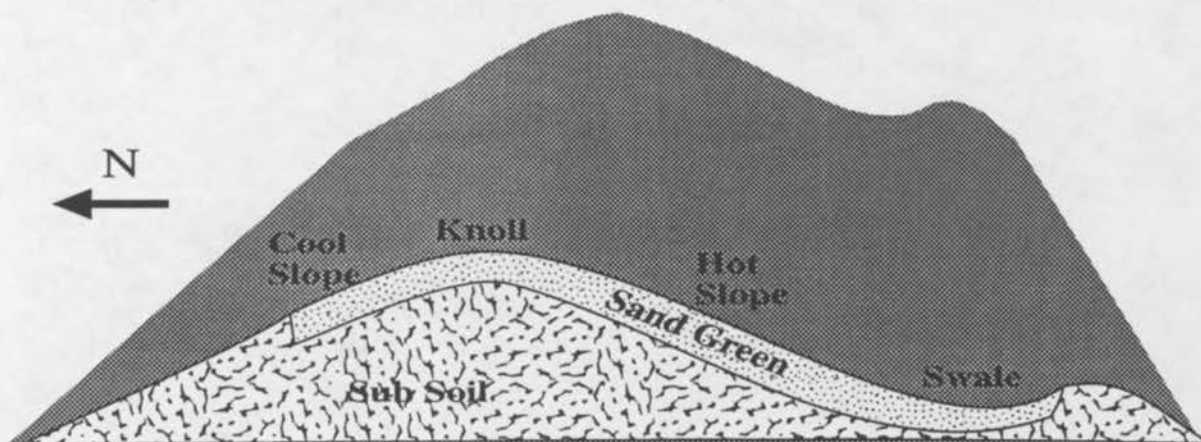
Routine traffic, fertilizer and mowing will be applied. Dry condition will be simulated by restricting irrigation on a temporary basis from July through August. Turfgrass survival and loss will be related to the treatments and micro climate areas.

Table 1. Organic and inorganic amendments applied to the sloped putting green as topdressing treatments.

Topdressing Treatment		Calcareous Sand	Inorganic Amendment	Organic Amendment
		% by volume		
1	sand + Dakota peat (control)	90	-	10
2	sand + Axis	80	20	-
3	sand + Profile	80	20	-
4	sand + Zeolite	80	20	-
5	sand + Zeopro	80	20	-

Table 2. Amount and date of topdressing application.

Topdressing Treatment		Topdressing depth (cm)								
		<u>9-25-98</u>	<u>5-14-99</u>	<u>6-2-99</u>	<u>6-11-99</u>	<u>6-25-99</u>	<u>7-9-99</u>	<u>7-23-99</u>	<u>8-6-99</u>	<u>8-20-99</u>
1	sand + Dakota peat (control)	0.5	0.2	0.2	Target topdressing depth of 0.2 cm for each treatment and date.					
2	sand + Axis	0.5	0.2	0.2						
3	sand + Profile	0.5	0.2	0.2						
4	sand + Zeolite	0.5	0.2	0.2						
5	sand + Zeopro	0.5	0.2	0.2						

Fig 1. Sloped Research

Effects of Inorganic Soil Amendments on Sand-based Media

Deying Li, Young K. Joo, Nick E. Christians, and David D. Minner

ABSTRACT

Inorganic soil amendments have been suggested for use in turf to alleviate soil compaction, to increase the water retention and hydraulic conductivity, and to improve many other soil physical properties. No single soil conditioner can have all those properties. They, therefore, should be used in a site- and case-specific way. This study was to determine the effects of four different inorganic soil amendment materials Bio-ceramic, Profile, Axis, and Bio-Flex-A-Clay on the soil hydraulic parameters of a sand-based media. The inorganic materials were added to a USGA sand-based green at 15% v/v during construction in 1996. The study was conducted during the 1997 and 1998 seasons. A laboratory study using a peat amendment and a pure sand control was also conducted in the spring of 1999. Data collected on the field areas included saturated hydraulic conductivity (K_{sat}), water retention, water release curves, bulk density, and total porosity on both undisturbed and recompacted samples collected from the treated plots one and two years after establishment. The Profile treatment had significantly higher cation exchange capacity (CEC) than the control in both years. Bio-ceramic had a higher CEC and Bio-Flex-A-Clay had lower CEC than the control in 1997. Profile increased the K_{sat} significantly in the recompacted and undisturbed samples in 1998. Axis increased water retention in both recompacted and undisturbed samples. K_{sat} of all treated plots was reduced by 75% in November of 1998. The K_{sat} values in the spring of 1999 increased from the low levels of 1998 by 19.2% (Bio-Flex-A-Clay), 43.5% (control), 58.6% (Bio-ceramic), 72.1% (Profile) and 81.7% (Axis). The changes of K_{sat} over the winter may have been induced by freezing and thawing that occurred over the winter. This hypothesis was further tested in the laboratory in a freeze-and-thaw study conducted in 1999. The bulk density of sand mixed with Bio-Flex-A-Clay, peat, Axis and Profile was decreased by 10.7%, 7.2%, 2.5% and 2.2% respectively following a freeze-and-thaw cycle. The decrease of bulk density in the control and in sand treated with Bio-ceramic was negligible.

Table 1. Soil test results for the inorganic soil modification study¹ (Sand-based green 1998)

Treatments	CEC	PH	SS	Na	OM	NIT	P	K	Mg	Ca
Control	8.3	8.3	0.08	19.7	0.5	1.3	3.0	25	80	1486
Bio-ceramic	8.1	8.3	0.08	18.0	0.5	2.3	4.0	25	78	1454
Profile	8.9	8.2	0.08	19.7	0.5	1.3	4.3	49	114	1534
Axis	8.1	8.3	0.08	18.3	0.4	1.3	4.7	25	73	1478
Bio-Flex-A-Clay	7.8	8.2	0.11	17.7	0.6	1.7	3.0	22	79	1414
LSD _{0.05}	0.6	NS	NS	NS	NS	NS	NS	4	12	NS
	S	Zn	Mn	Cu	Fe	B	AK	AMg	ACa	ANa
Control	1.0	0.8	2.8	0.6	6.57	0.3	0.8	8.1	90.1	1.0
Bio-ceramic	1.0	0.9	2.8	0.9	6.57	0.3	0.8	8.0	90.2	1.0
Profile	1.0	0.7	2.5	0.6	7.87	0.3	1.4	10.8	86.9	0.9
Axis	1.0	0.7	2.5	0.7	7.23	0.3	0.8	7.5	90.8	1.0
Bio-Flex-A-Clay	1.7	0.9	2.9	0.7	6.13	0.3	0.7	8.3	90.0	1.0
LSD _{0.05}	0.5	NS	0.3	NS	NS	NS	0.2	0.7	0.8	NS

¹NS= Not significant at 0.05 level

CEC= Cation Exchange Capacity (meg/100g)

SS= Soluble salts (mmhos/cm)

Na= Sodium (ppm)

OM= Organic matter (%)

NIT= Nitrite N (ppm)

AK= Actual Potassium (% base saturation)

AMg= Actual Magnesium (% base saturation)

ACa= Actual Calcium (% base saturation)

ANa= Actual Sodium (% base saturation)

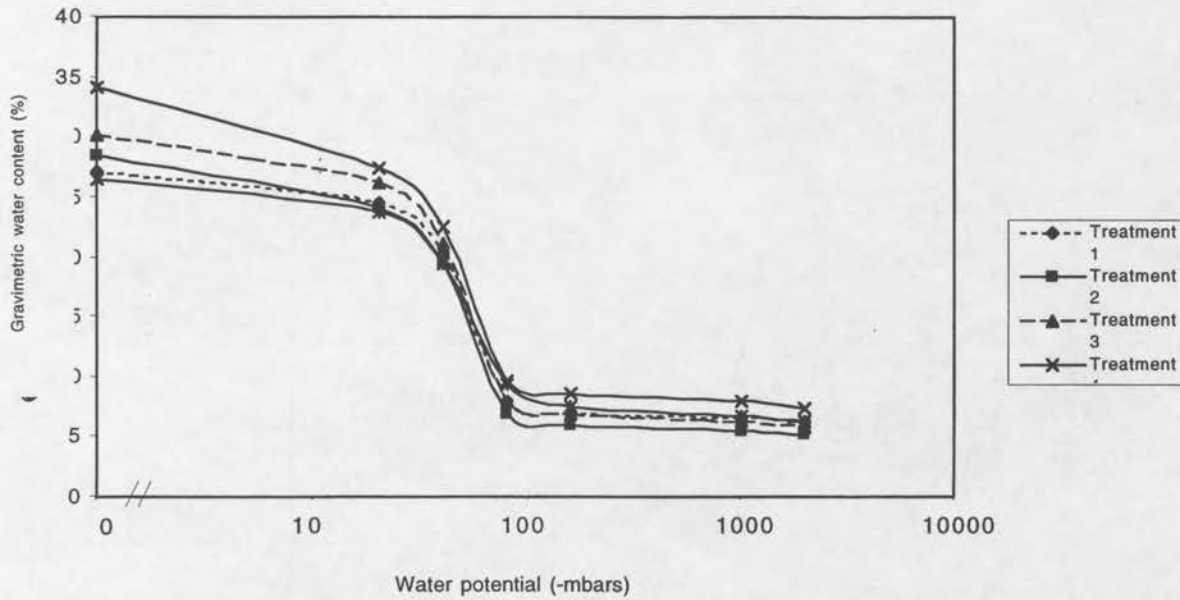


Figure 1. Water release curve of different soil amendment treatments

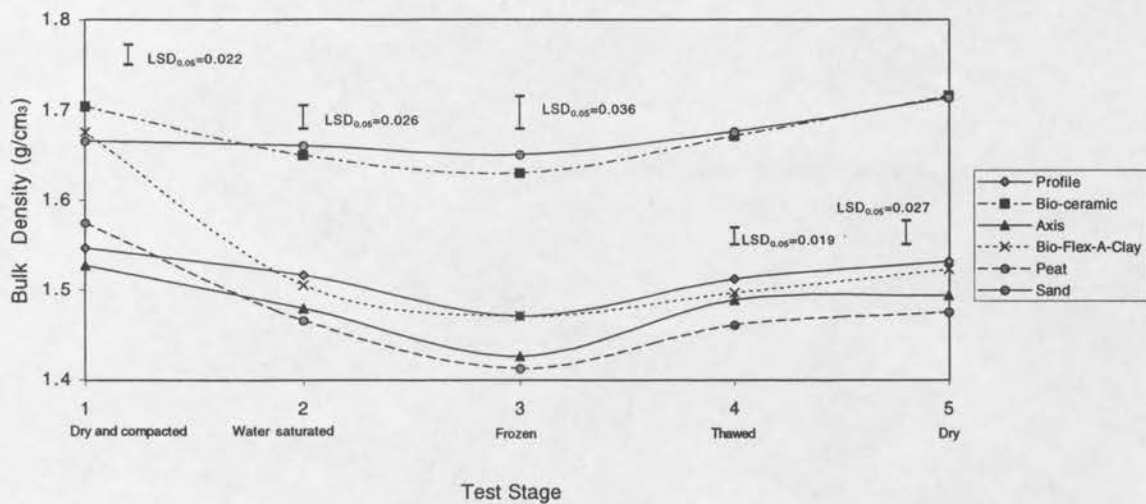


Figure 2. Freeze and thaw characteristics of soil conditioners

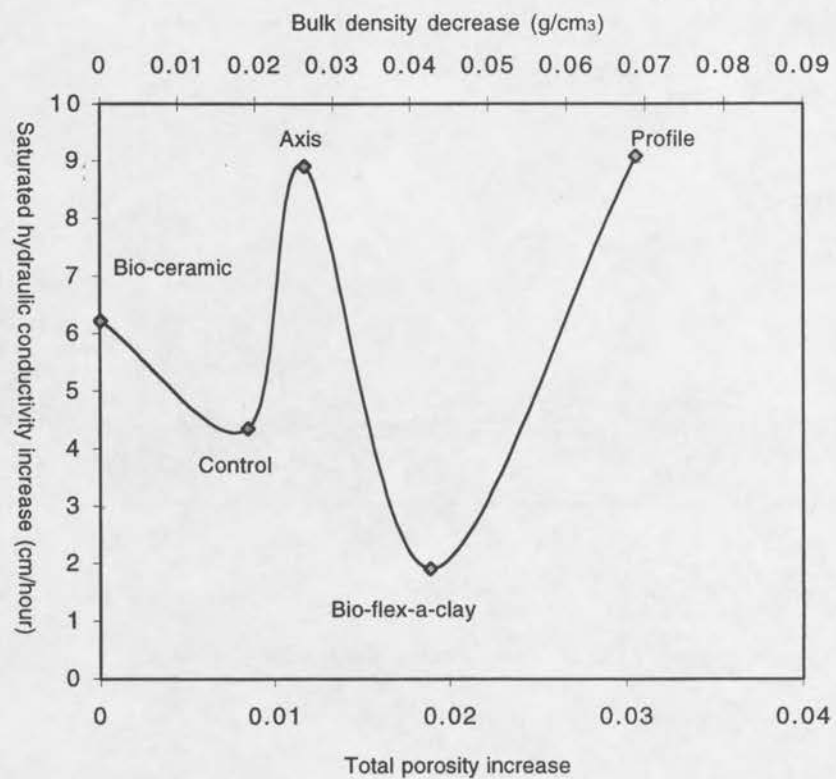


Figure 3. Saturated hydraulic conductivity increases vs porosity and bulk density changes

Modifying Athletic Field Soils with Calcined Clay and Tillage

David D. Minner and Jeffrey J. Salmond

The objective of this study was to evaluate calcined clay in a tilling renovation process and its effects on turfgrass growth.

A study was initiated in November 1997, at an Ames High School football practice field in Ames, Iowa, to evaluate calcined clay (Turface[®] MVP) in a tilled renovation procedure. The study was conducted on a separate irrigated practice field (different from the calcined clay topdressing study). The 15,750 sq. ft. experimental plot area was arranged between the hash marks and the goal lines. Each individual plot measured 15 ft. by 50 ft., and was centered on every yard line marker (goal line, 5, 10, 15, 20, etc.) (Table 1) such that 7.5 ft. was on one side of the yard line and 7.5 ft. was on the other side of the same yard line. Treatments consisted of calcined clay at 1 ton/1000 sq. ft., calcined clay at 2 tons/1000 sq. ft., and an untreated control (Table 2). Treatments were completely randomized and replicated seven times. Each replication was 45 ft. by 50 ft. with three treatments. Treatments were topdressed at their respective rate and tilled into the top 4 inches of soil with a Rotadairon (Bryan Wood, Commercial Turf & Tractor). The Rotadairon is used to level a playing surface and prepares the seed bed while burying roots, rocks, clods, clumps, or grass. The untreated control contained no amendment and was tilled.

The total plot area was seeded in May 1998 with a bluegrass blend containing 'Nubblue', 'Limousine', and 'Touchdown'. The field is used primarily for fall football practice (September through November) and spring soccer (April and May). Football in the fall of 1998 and soccer in the spring of 1999 resulted in substantial wear in the center of the field. Because of the two different sports, the wear pattern has not been consistent. Football wear was concentrated around each 5-yard line where the ball was placed to restart a practice set. Soccer wears out the center circle and the penalty and goalie areas. In the worn areas, the grass has been completely removed and bare soil is exposed. A visible response from treatments, based on traffic, was not apparent in the fall of 1998 or spring of 1999. In the summer of 1998, when the grass was establishing, there was a noticeable difference in the green color of both the turfgrass and the crabgrass weeds. The highest rate of Turface had the lightest green color followed by the low rate of Turface. The non-Turface control plot had a normal, dark green appearance. After applying 1.0 lb N/1000 sq. ft. to the entire study area in August, the Turface plots produced an acceptable green color that was similar to the control plots. There was no difference in turf color among treatments during the spring of 1999.

The inconsistent wear patterns on the research area made it difficult to determine if there were true treatment differences, even though there were seven reps and very large plots. The field was cored on 3-inch centers with 0.75-inch hollow tines on 9 June 1999. Cores were dragged within each plot and the area was drill seeded in three directions with a drill seeder.

It is too early in this research project to determine if tilling Turface into a field will help maintain better grass under intense traffic. However, we have observed that the Turface-treated plots dry quicker and make a better playing surface when the soil is exposed on worn areas. The Turface-treaded areas also are easier to penetrate when the field playing conditions are normally hard and dry.

Table 1. Experimental plot layout of calcined clay tilled renovation. Treatments were applied on November 13, 1997.

	[Center of field]	Plot #	
Goal Line	3	1	Plot size is 50 x 15 ft
	1	2	REP 1
	2	3	
	1	4	Plots are centered between hash marks
	3	5	REP 2
	2	6	
	3	7	Each 5-yard line is the center of the plot
	1	8	REP 3
	2	9	
	1	10	
50-yd Line	2	11	REP 4
	3	12	
	1	13	
	2	14	REP 5
	3	15	
	1	16	
	3	17	REP 6
	2	18	
	3	19	
	2	20	REP 7
Goal Line	1	21	

Table 2. Treatment listing and respective rates.

	Treatment	Rate (tons/1000 ft ²)
1	Turf	1
2	Turf	2
3	Untreated control*	NA

Turf applied to plots with topdresser and then tilled with Rotadairon to 4-inch depth.

*Untreated control received no amendment but was tilled with the Rotadairon.

Athletic Field Turfgrass Response to Calcined Clay Topdressing

David D. Minner and Jeffrey J. Salmond

Inorganic amendments have been used to amend soils that are compacted by excessive traffic. Our objective was to evaluate Turface as a topdressing material and its effects on turfgrass growth. The study is being conducted on a local high school football/soccer practice field. Topdressing with Turface is being compared to a topdressing with a local mason sand.

A study was initiated in August 1996 to evaluate calcined clay (Turface® MVP) as a topdressing material. The study was conducted on an irrigated practice field containing native clay loam soil. The 9000 sq.ft. experimental plot area was arranged between the hash marks and 20-yard lines. Each individual plot measured 15 ft. by 50 ft. for a total of 12 plots. Treatments consisted of two topdressing materials, Turface or sand, with six replications. Six plots were topdressed with Turface (4500 total sq.ft.) and six plots were topdressed with sand (4500 total sq.ft.). Plots were core aerified with 3/4-inch tines at a 4-inch depth, materials (calcined clay or sand) topdressed, core aerified again, seeded with a Gridiron blend of three Kentucky bluegrass cultivars and two perennial ryegrass cultivars, and fertilized (Table 1). The sand was topdressed at the same depths as the Turface. Plots were arranged every 5 yards. Core plugs were left on the surface and the plugs and topdressing were mixed on the surface by separately dragging each plot.

The topdressing treatments and renovation schedule are presented in Table 1. To date, the Surface-treated plots contain a rate of 2142 lbs/ 1000 sq.ft. or 1606 lbs per plot area. One-quarter inch of topdressed calcined clay on the individual plots is equivalent to a rate of 714 lbs/ 1000 sq.ft. The experimental plot layout is presented in Table 2.

The study area receives fall football and spring soccer. So far there have been no distinct differences in turf quality or percent turf cover that can be attributed to the treatments. In the worn areas of the study and where soil is exposed, the Turface maintains a drier surface and improves playing conditions. The study will be continued through 1999.

Table 1. Renovation schedule for Turface and sand topdressing treatments.

Sept. 1, 1996	Turf 1/4 in. (714 lbs/1000 sq. ft.) Sand 1/4 in.	core aerify	seed	fertilize
Nov. 1, 1996	Turf 1/4 in. (714 lbs/1000 sq. ft.) Sand 1/4 in.	core aerify	seed	fertilize
June 1, 1997	Turf 1/8 in. (357 lbs/1000 sq. ft.) Sand 1/8 in.	core aerify	seed	fertilize
Sept. 1, 1998	Turf 1/8 in. (357 lbs/1000 sq. ft.) Sand 1/8 in.	core aerify	seed	fertilize

Table 2. Experimental plot layout for topdressed calcined clay and sand between the hash marks and 20-yard lines on a practice football field.

The diagram shows a football field with yard lines labeled 20, 30, 40, 50, 40, 30, and 20 from left to right. A horizontal line across the middle is labeled "Center of field". Vertical dashed lines represent yard lines. The field is divided into two halves by the center line. The top half is labeled "Turf" and the bottom half is labeled "sand".

The Effect of Tarp Color on Turfgrass Growth

David D. Minner, Vince Patterozzi, Jeffrey J. Salmond, Jay S. Hudson, and Paul Stevens

Many of our research ideas come from inventive grounds managers in the turfgrass industry. This project is a good example. Vince Patterozzi, Head Grounds Manager Baltimore Ravens, noticed that there was a difference in turf appearance when he used different color rain tarps. After two years of hearing this comment, Vince put it to me like this, "There is something going on with tarp color, you figure it out". He arranged with M Putterman & Company Inc. (800-621-0146) to send us several different samples of tarp colors. The study below is what developed from a very astute observation. Thanks Vince.

Objective: To determine if tarp color has any effect on turf growth and color.

Method:

The Putterman Rain Buster Athletic Field tarps used in this study were designed to keep rain or snow off of the field. The tarps are made from 6-ounce polyethylene or 10-ounce vinyl. These tarps are generally placed on the field temporarily and then removed when the rain event ends. Fields are generally covered for only a few hours, but in some cases a tarp may be left on the field for three days or longer. Three different studies have been conducted since the spring of 1998 on a mature stand of 'Midnight' Kentucky bluegrass. Five-foot by five-foot tarps of each tarp color were pinned to the ground in a randomized block design with 3 replications. Tarps were placed on April 9 and removed on April 24 in study A. Tarps were placed on 3 November 1998 and removed on 23 March 1999 in study B. Tarps were placed on 23 March and removed 20 April 1999 in study C. Turf color was rated on a scale of 1-10, 10 = darkest green and 1 = no green color, white/brown, and 6 = lowest acceptable color. Turf growth was rated on a scale of 1-10, 10 = most growth and 1 = no growth.

Results:

The data has not been statistically analyzed but the magnitude of the differences and consistency among replications has been compelling. Studies A and C were similar because they were covered just during spring green-up. Study B was covered during the entire winter and then uncovered just before any green-up or growth occurred. In all studies, tarp color had a dramatic effect on turf color. Yellow, orange, red, and white tarps produced the best turf color with ratings ranging between 6.5 and 10. When compared to the control, turf color was generally enhanced by tarp colors yellow, orange, red, and white. Tarp colors light blue, blue, and purple produced some yellowing that made them inferior to yellow, orange, red, and white. Tarp colors gray, light-green, dark-green, and black produce the most decrease in turf color and they were considered unacceptable. A Covermaster grow tarp and Enkamat were also included in the study even though they are not moisture prevention tarps. Both Covermaster and Enkamat improved turf color compared to the non-covered control plots.

It is clear that tarp color has an affect on turf performance. More investigation will be needed to evaluate duration of tarp cover, season of tarp cover, heat load under tarps, and potential for diseases, and light penetration.

Table 1. Turf color and growth as affected by tarp color.

	Study A	Study B				Study C	
	covered for 16 days in April	Covered for 140 consecutive days November to March				Covered for 29 consecutive days in March and April	
	4-28-98	12-4-98		3-23-99		4-20-99	
	Turf color	Turf color	Turf growth	Turf color	Turf growth	Turf color	Turf growth
Orange	7.5	9.5	7.0	9.0	8.5	8.5	10.0
Red	6.5	8.3	8.7	9.7	9.0	8.7	8.7
Yellow	8.0	8.7	8.3	9.0	7.7	9.0	9.7
White	9.0	8.0	6.7	6.0	5.0	10	5.7
Light blue	5.0	5.0	5.5	6.0	5.0	6.0	6.0
Blue	5.5	6.5	6.5	7.0	7.5	6.0	7.5
Purple	5.0	5.7	6.7	5.0	6.7	4.0	8.0
Gray	2.0	4.0	4.5	4.0	5.5	2.5	7.7
Light green	3.0	3.7	6.7	4.0	6.7	3.7	8.0
Dark green	1.0	2.7	6.0	1.0	7.0	1.0	8.7
Black/white	1.0	3.0	8.0	1.0	6.0	1.0	7.0
White/black				1.0	6.0	8.0	1.0
Covermaster		7.0	5.0	5.0	5.0	10.0	3.0
Enkamat		9.7	9.0	5.0	4.0	10.0	5.0
Control no tarp	7.5	6.0	3.3	1.0	4.0	6.3	1.0

Calcium Applications to Turf on Sand-based Media

Rodney A. St. John and Nick E. Christians

Introduction:

There are two common ways to test for soil nutrients, the SLAN Method (Sufficiency Level of Available Nutrients) and the BCSR method (Basic Cation Saturation Ratio).

The SLAN method measures the amount of nutrients in the soil and makes recommendations based on studies done for that particular soil type and crop. Therefore, using the SLAN method for determining the fertilizer requirements for turfgrasses can be problematic, since soil testing facilities usually make recommendations based upon agricultural row crops.

The BCSR method consists of measuring the relative quantities of cations on the cation exchange sites and comparing their ratios. It is believed that optimal plant growth can be achieved by having Calcium on 60-65% of the cation exchange sites with ratios for the other cations being; Mg^{+2} 10-20%, K^{+} 5-10%, NH_4^{+} 5% and H^{+} 5-20%. When test results for a soil are outside the ranges for a cation, fertilizer treatments are recommended to correct any deficiencies and to bring the ratios back in line.

The majority of sand used in construction of greens and athletic fields is termed calcareous, because of the high quantity of calcium carbonate contained in the sand. Moreover, this sand usually, has a high pH around 8.2-8.3 and a low cation exchange capacity around 1.2 meq/100g. It is not unusual for calcium content to be low on cation exchange sites, resulting in recommendations for adding calcium. Calcium is recommended to be added even though the soil media is calcareous and contains a large amount of calcium in the soil.

Objectives:

To discover if adding calcium to calcareous soils that have a low calcium ratio will increase the amount of calcium taken up by the turfgrass plant, and more importantly if this increased calcium is beneficial to the grass plant.

Materials and Methods:

During the fall of 1998, a preliminary greenhouse study was conducted looking at five different calcium treatments (no calcium added, gypsum, lime, calcium nitrate, and calcium chelate) applied to Kentucky bluegrass and creeping bentgrass grown on calcareous sand and silica sand.

Results:

During the 12-week test period some visual response trends among the different treatments were noticed, but the data is still being analyzed to determine if the treatments were significant or not. Preliminary data are listed in Tables 1 and 2.

Table 1. Calcium concentration in dry tissue (ppm) for the two different grasses.

	Bentgrass	Bluegrass
No Calcium	7522	4282
Gypsum	10257	4951
Lime	9882	4680
Calcium Nitrate	9478	4745
Calcium Chelate	11309	5788

Table 2. Calcium concentration in dry tissue (ppm) for the two different soil types.

	Calcareous Sand	Silica Sand
No Calcium	7664	4140
Gypsum	8675	6532
Lime	7523	7038
Calcium Nitrate	7159	7064
Calcium Chelate	8317	8781

Effect of Organic and Mineral Mulches on Soil Properties and Growth of Fairview Flame® Red Maple Trees

Jeffery K. Iles and Michael S. Dosmann

Abstract. Five mineral mulches (crushed red brick, pea gravel, lava rock, carmel rock, and river rock) and three organic mulches (finely screened pine bark, pine wood chips, and shredded hardwood bark) were evaluated over two years to determine their influence on soil temperature, moisture, and pH, and to quantify their effect on growth of Fairview Flame® red maple (*Acer rubrum* L.). Mulch treatments (2.3-m² (25-ft²) plots of eight mulches applied as separate treatments and a non-mulched control) were randomly applied to trees in five blocks. Organic mulches were placed directly on bare ground, while mineral mulches were underlaid with a woven polypropylene fabric. Soil temperatures were highest and soil moisture percentages lowest under the mineral mulches and non-mulched control. Soil pH readings were highest under shredded bark and wood chips, and lowest in the non-mulched control. Despite these differences in root zone environments, there were no significant differences in tree height. Trees growing in river rock, crushed brick, pea gravel, and carmel rock, however, had larger stem calipers than those growing in shredded-bark plots. Crushed brick, pea gravel, and carmel rock treatments also resulted in greater leaf dry mass than shredded-bark. Leaf dry mass also was greater for trees in crushed brick and pea gravel than screened pine. Our results indicate mineral mulches used in this study do not create growth-limiting soil environments.

Benefits of using wood and bark by-products as horticultural mulch over the root zones of landscape plants are well-established (Gleason and Iles 1998; Green and Watson 1989; Greenly and Rakow 1995; Skroch et al. 1992; Watson 1988), however, several actual or perceived problems associated with organic mulches such as, unacceptable appearance (Rakow 1992), creation of a temporary soil nitrogen deficiency (Ashworth and Harrison 1983), potential fire hazard (Hickman and Perry 1996), and rapid decomposition (Rakow 1992) have led to increased usage of mineral or rock mulches. But concerns that materials like rock, gravel, and crushed brick may promote potentially injurious high temperatures both above and below the mulch layer, alkalization of the soil, and mechanical injury to the stems of plants, have caused many landscape and tree-care professionals to reexamine their rationale for using mineral mulches as suitable ground-covering materials around woody and herbaceous plants. This experiment was designed to evaluate and compare the effects of five mineral and three organic mulches on 1) several soil properties, and 2) growth of Fairview Flame® red maple (*Acer rubrum* L.).

MATERIALS AND METHODS

Ninety bare-root, 1.6- to 2.0-cm (0.6- to 0.8-in-caliper), 1.2- to 1.5-m (4- to 5-ft-tall), branched Fairview Flame® red maple trees were planted in a Nicollet fine sandy loam soil at the Iowa State University Horticulture Research Station, Gilbert, Iowa (USDA hardiness zone 5a; lat. 42°3'N), on April 22, 1996. The experimental design was a randomized complete block with nine treatments, five blocks (replications), with treatments repeated twice in each replication. Trees were spaced 2.0 m (6.5 ft) apart in north-south oriented rows with 3.0 m (10 ft) between rows. Trees were hand watered once on the day of planting to facilitate establishment. Treatments consisted of 2.3-m² (25-ft²) plots of eight mulches: a 5.0-cm (2-in) layer of 1.9-cm (0.75-in) diameter **crushed red brick**, 0.9-cm (0.4-in) diameter **pea gravel**, 1.3-cm (0.5-in) diameter **lava rock**, and 2.5-cm (1.0-in) diameter **carmel rock** (chert); a 7.5-cm (3.0-in) layer of 3.8-cm (1.5-in) diameter **river rock**; a 10.0-cm (4.0-in) layer of 4.0- to 6.0-cm (1.6- to 2.4-in) long **finely screened pine bark**, 2.0- to 3.0-cm (0.8- to 1.2-in) diameter **pine wood chips**, and 4.0- to 5.5-cm (1.6- to 2.2-in) long **shredded hardwood bark** (mostly oak); and a non-mulched control maintained as bare ground. Organic mulches were placed directly on bare ground, while mineral mulches were underlaid with a woven polypropylene fabric (DeWitt Landscape Pro 5). Weeds and other unwanted vegetation within and between treatment plots, and along the east and west borders of the plots (15-cm wide) were controlled with glyphosate (1% v/v). Plots were not fertilized.

Soil moisture was recorded weekly during the growing season (June-August) in 1996 and 1997 with a Theta Probe (meter type HH1, sensor type ML1; Delta-T Devices Ltd., Cambridge, United Kingdom) soil moisture sensor at 6 cm (2.4 in) below the soil surface. Soil temperature also was determined weekly using a portable Barnant 115 thermocouple thermometer (model 600 2810; Barrington, Ill.) at 10 cm (4.0 in) below the soil surface. Both soil moisture and soil temperature readings were taken on the south side of the tree, approximately 0.6 m (2.0 ft) from the trunk.

Stem diameter at 15 cm (6 in) above the soil surface and tree height from soil surface to the highest point in the crown were measured on September 19 and 20, 1997, respectively. Leaves were harvested from each tree on October 4 and 5, 1997, dried at 67°C (153°F) for five days, and weighed. Randomly chosen soil samples (one from each treatment in each replication) taken at the soil surface immediately below the mulch treatment, were retrieved on December 1, 1997 and again on June 17, 1998 to determine pH. All data were subjected to analysis of variance and means separated by least significant difference ($P \leq 0.05$).

RESULTS AND DISCUSSION

Effects on soil temperature and moisture. In 1997 (data from 1996 are not presented because unseasonably cool, wet conditions caused a lack of statistical significance), highest soil temperatures were recorded in the non-mulched control plots, followed by pea gravel, crushed brick, and carmel rock treatments (Table 1). Plots covered by organic mulch treatments had significantly lower soil temperatures (mean = 23.4°C/74.1°F) than plots treated with mineral mulches (mean = 25.9°C/78.6°F). Loosely packed organic mulches insulate soils by intercepting and absorbing solar radiation instead of conducting heat energy downward (Waggoner et al. 1960; Montague et al. 1998).

Soil moisture content was highest under the three organic mulches and pea gravel, however, the shredded-bark and pea gravel treatments were not different from lava rock or crushed brick (Table 1). Lowest moisture percentages were recorded in the non-mulched control. Soil moisture under mulch is increased through minimizing soil surface evaporation (Himelick and Watson 1990). In our study, organic mulches that meshed together, and fine-textured mineral mulches like pea gravel, presented a greater barrier to evaporation than coarser mulch materials or bare soil.

Effects on soil chemistry. Previous researchers report organic mulches cause no change in soil pH (Greenly and Rakow 1995; Watson and Kupkowski 1991) or reduce pH of the underlying soil (Billeaud and Zajicek 1989; Hild and Morgan 1993; Himelick and Watson 1990). Mulch-induced pH reduction results from the addition or retention of organic matter, with organic acids produced from decomposition of plant-derived materials accumulating or leaching into the soil (Himelick and Watson 1990). At the completion of our study (1997), soil pH was lowest in the non-mulched control plots and highest under shredded-bark and wood chip mulches (Table 1). Elevated pH under these mulches could have resulted from the leaching of basic cations (NH_4^+) from decomposing organic matter (Tisdale et al. 1993). If so, we would expect the increase in pH from ammonification to be temporary, however, because pH will decrease as ammonia is oxidized to nitrate by nitrifying bacteria in the soil. In 1998, soil pH readings again were highest under wood chip and shredded-bark mulches. Lowest pH measurements were recorded in the lava rock treatment and in the un-mulched control. While some mineral mulches could contribute to undesirably high soil pH, mineral mulches used in this study did not.

Effects on tree growth. Temperature, moisture, and chemical differences in root-zone environments brought about by the various mulch treatments did not translate into differences in tree height, however, trees growing in pea gravel, crushed brick, carmel, and river rock had larger stem calipers than those growing in shredded-bark plots (Table 2). Stem calipers of trees in the three organic mulch treatments, lava rock, and in the non-mulched control were not different.

Crushed brick, pea gravel, and carmel rock treatments resulted in greater leaf dry mass than shredded-bark plots. Leaf dry mass also was greater for trees in crushed brick and pea gravel than for trees mulched with screened pine. Dry mass of trees in the three organic mulch treatments, river rock, lava rock, and in the control were not different.

Differences in tree growth are most likely linked to temperature differences in the soil environment. Although we did not measure soil temperatures in April and May, based on summer readings it is logical to assume soil temperatures under organic mulches would be cooler and possibly more growth limiting (at least for the shredded-bark and screened pine mulches) than warmer, growth-enhancing temperatures under the mineral mulches (particularly pea gravel, crushed brick, and carmel rock). Holloway (1992) reported similar results in Alaska, where five woody plant species grew best in stone mulch treatments. Elevated pH also might have contributed to poorer growth for trees in the shredded-bark treatments.

CONCLUSION

Our results indicate mineral mulches used in this study do not create growth-limiting soil environments. In fact, the capacity of crushed brick and pea gravel to conduct heat to soils below, particularly in early spring, may be responsible for the observed advantage in leaf dry mass for trees growing in these materials over those growing in soils kept relatively cool by insulating organic mulches such as shredded-bark and screened pine. Mineral mulches used in this study also proved to be relatively inert, causing equal or smaller increases in pH than shredded-bark or wood chips.

These results, however, should not be interpreted as an indictment of organic mulches. Because soils at the ISU Horticulture Research Station are fertile and well-drained, the organic matter and nutrient contributions made by organic mulches may be of less consequence than if the study had been conducted on poor soils. Moreover, had conditions been drier and warmer during the years of the study (1996-97), or if the experiment had been conducted in a warmer climate, organic mulches may have outperformed many of the mineral mulches. Finally, because stem caliper and leaf dry mass measurements of trees growing in wood chips and any of the mineral mulches were not statistically different, blanket statements and generalizations regarding the performance of woody plants mulched with organic or mineral (rock) materials are unwise.

The nursery and landscape industry is fortunate to have a wide variety of mulch materials to choose from, and each has its place in the landscape. But in the final analysis, cost and maintenance considerations dictate which mulch materials will be used.

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Table 1. Effect of eight mulch treatments and a non-mulched control on soil temperature, percentage (%) soil moisture, and soil pH.

Treatment	Temperature ^z (°C)	Moisture ^y (%)	pH ^x	
			1997	1998
Control	29.3 ^w a ^v	19 ^u d	6.03 ^t d	5.86 ^s d
Pea gravel	27.6 b	31 ab	6.44 b	6.14 bc
Crushed brick	26.2 c	30 bc	6.29 bc	6.04 cd
Carmel	26.2 c	29 c	6.29 bc	6.06 cd
River rock	25.2 d	29 c	6.47 b	6.33 b
Lava rock	24.5 d	30 bc	6.21 cd	5.82 d
Shredded-bark	23.6 e	31 ab	6.82 a	6.81 a
Wood chip	23.3 e	32 a	6.81 a	6.37 b
Screened pine	23.2 e	32 a	6.13 cd	6.14 bc

^zSoil temperature measured at 10 cm (4 in) depth, between 2:00 and 4:00 p.m., CST.^ySoil moisture measured at 6 cm (2.4 in) depth, between 2:00 and 4:00 p.m., CST.^xSoil samples for pH measurements collected at 0- to 10-cm (0- to 4-in) depth.^wData shown are means of 12 dates x 5 replications (n=60) in 1997.^vMean separation within columns by LSD, $P \leq 0.05$.^uData shown are means of 12 dates x 5 replications (n=60) in 1997.^tData shown are means of 5 observations. Soil samples collected on December 1, 1997 for pH determination.^sData shown are means of 5 observations. Soil samples collected on June 17, 1998 for pH determination.**Table 2.** Effect of eight mulch treatments and a non-mulched control on stem caliper, height, and leaf dry mass of *Acer rubrum* Fairview Flame®.

Treatment	Height ^z (cm)	Stem caliper ^y (cm)	Leaf dry mass ^x (g)
Lava rock	222 ^w a ^v	4.1 ^u ab	441 ^t abc
Wood chip	222 a	4.1 ab	423 abc
Pea gravel	220 a	4.2 a	467 a
Crushed brick	219 a	4.2 a	478 a
Control	219 a	4.1 ab	419 abc
Carmel	218 a	4.2 a	463 ab
River rock	214 a	4.2 a	449 abc
Screened pine	214 a	4.0 ab	398 bc
Shredded-bark	210 a	3.9 b	383 c

^zHeight measured from ground level to highest shoot apex on September 20, 1997.^yStem caliper measured 15 cm (6 in) above ground level on September 19, 1997.^xLeaves harvested October 4 and 5, 1997.^wData shown are means of 10 observations.^vMean separation within columns by LSD, $P \leq 0.05$.^uData shown are means of 10 observations. Each observation is the average of measurements taken at (1) the widest point on the stem, and (2) rotated 90° clockwise from the first measurement.^tData shown are means of 10 observations.

Prairie Demonstration

David D. Minner and Paul Stevens

Iowa has two broad regions for potential natural vegetation. Bluestem prairies are found in the north half of Iowa while oak-hickory forests dominate the southern half of the state. Throughout the entire state there are pockets of land that support a mixture of both prairie and forest. The term "bluestem prairie" can be somewhat misleading since there is a wide variety of forbes and grasses that make up Iowa's prairie plant community. There are usually less than 10 different grasses found in most prairies, while there may be 30 to 50 different forbes or wild flowers. This demonstration area was initiated to show the diversity of plants suitable for prairie restoration in Iowa. Furthermore, many turf managers are finding that the prairie can provide an appealing and low maintenance alternative for some turf areas.

Individual species of prairie plants are growing in labeled plots for easy identification. The plants were started in the greenhouse and then field transplanted as plugs in the spring of 1997.

Table 1. Prairie plant identification plots.
Individual plots are 10 ft by 2 ft.

Sideoats grama		Tall boneset	Wild bergamont
Sand love grass		Mountain mint	Meadow blazing star
Little bluestem		Purple prairie cone flw.	Prairie smoke
Western wheatgrass		Boneset	New England aster
Bottle brush		Long headed cone flw.	Lance leaf coreopsis
Tall dropseed		White prairie cone flw.	Slender mountain mint
		Purple prairie clover	Black eyed Susan
			Sweet black eyed Susan
Canada wild rye		False dragon head	Prairie alumroot
Indian grass		Foxglove bear tongue	Yellow cone flower
Big blue stem			
Fowl mana grass			
Blue joint grass			
Prairie cord grass			

North



Introducing

Iowa State University Personnel Affiliated with the Turfgrass Research Program

Barbara Bingaman, Ph.D.	Postdoctoral Research Associate, Horticulture Dept.
Doug Campbell	Research Associate, Horticulture Department
Nick Christians, Ph.D.	Professor, Turfgrass Science Research and Teaching Horticulture Dept.
Jim Dickson	Former Superintendent, Turfgrass Research Station Horticulture Dept.
Mike Faust	Graduate Student, M.S. (Christians - Graduated Dec. 1998)
Mark Gleason, Ph.D.	Professor, Extension Plant Pathologist, Plant Pathology Dept.
Mark Helgeson	Field Technician, Horticulture Dept.
Clinton Hodges, Ph.D.	Professor, Turfgrass Science Research and Teaching Horticulture Dept.
Mark Howieson	Graduate Student, M.S. (Christians)
Jay Hudson	Graduate Student, M.S. (Minner)
Jeff Iles, Ph.D.	Associate Professor, Extension, Nursery Crops/Ornamentals Horticulture Dept.
Young K. Joo, Ph.D.	Visiting Scientist from Korea
Deying Li	Graduate Student, Ph.D. (Christians and Minner)
Melissa McDade	Graduate Student, M.S. (Christians)
David Minner, Ph.D.	Associate Professor, Turfgrass Science Research and Extension Horticulture Dept.
Richard Moore	Superintendent, Horticulture Research Station
Josh Olson	Field Technician, Horticulture Dept.
Gary Peterson	Commercial Horticulture Specialist
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Joe Stoeffler	Field Technician, Horticulture Dept.

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