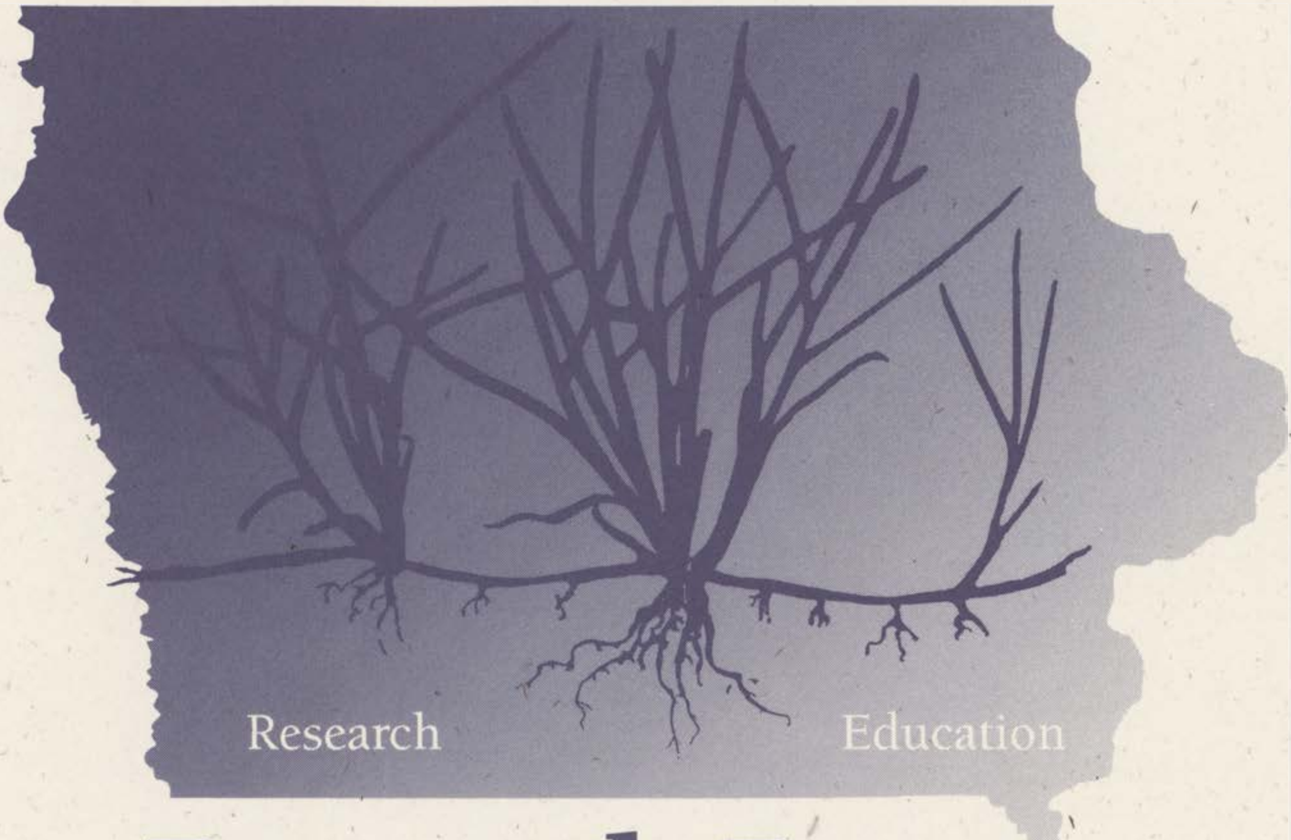
# 1998 Iowa Turfgrass




# Research Report

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

In Cooperation with the
Iowa Turfgrass Institute

IOWA STATE UNIVERSITY
University Extension
Ames, Iowa

FG-466 | July 1998

# Field Day Program - July 16, 1998

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

**9:15 a.m.** **CHOICE OF FIVE TOURS**

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

**Tour #1** **Lawn Care & Grounds --** Turfgrass varieties, fertilizers, plant growth regulators, herbicides, application demonstration.

**Tour #2** **Golf Course** -- Turfgrass varieties, sand green management, disease control, topdressing, SubAir demonstration, crumb rubber.

**Tour #3** **Sports Turf** -- Turfgrass varieties, SportGrass, Enkamat, pregermination and divot mix demonstration, crumb rubber.

**Tour #4** **Mowing Equipment** -- Safety, summer maintenance, and mowing equipment demonstration.

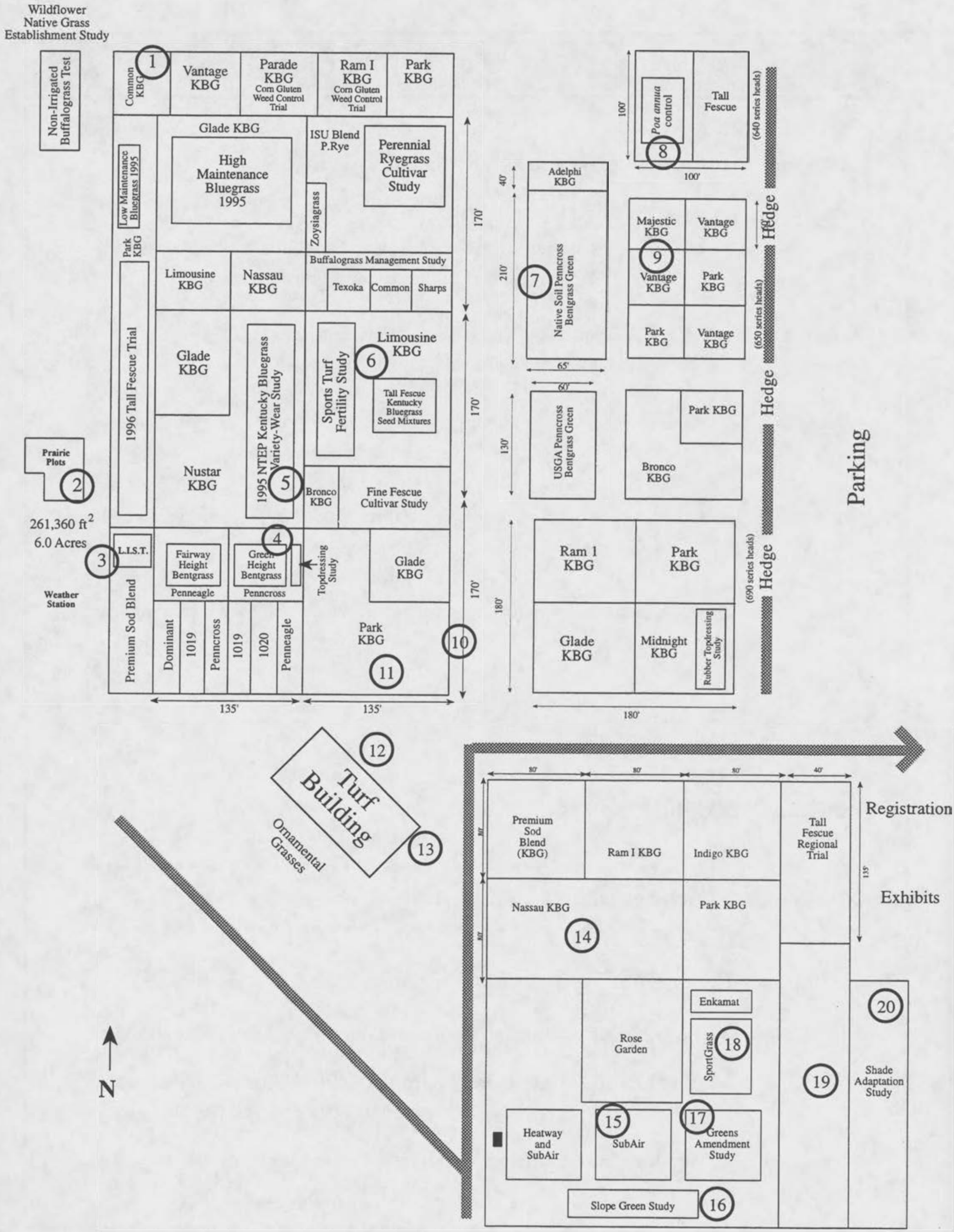
**Tour #5** **Tree Care** -- Selection, planting demonstration, and care of trees for Iowa's landscape.

**11:30-12:00** **Exhibit Displays**

**12:00 noon** **Lunch Served in Exhibit Area**

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

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


Wildflower Native Grass Establishment Study
Non-Irrigated Buffalograss Test
Common KBG
Vantage KBG
Parade KBG Corn Gluten Weed Control Trial
Ram I KBG Corn Gluten Weed Control Trial
Park KBG
Glade KBG
High Maintenance Bluegrass 1995
ISU Blend P.Rye
Perennial Ryegrass Cultivar Study
Zoysiagrass
Low Maintenance Bluegrass 1995
Park KBG
Buffalograss Management Study
Texoka
Common
Sharps
Limousine KBG
Nassau KBG
1996 Tall Fescue Trial
Glade KBG
1995 NTEP Kentucky Bluegrass Variety-Wear Study
Sports Turf Fertility Study
Limousine KBG
Tall Fescue Kentucky Bluegrass Seed Mixtures
Nustar KBG
Bronco KBG
Fine Fescue Cultivar Study
Prairie Plots
261,360 ft²
6.0 Acres
L.I.S.T.
Fairway Height Bentgrass
Green Height Bentgrass
Topdressing Study
Glade KBG
Penneagle
Penncross
Weather Station
Premium Sod Blend
Dominant
1019
Penncross
1019
1020
Penneagle
Park KBG
170'
170'
170'
135'
135'
100'
Poa annua control
Tall Fescue
100'
(640 series heads)
40'
Adelphi KBG
210'
Native Soil Penncross Bentgrass Green
65'
60'
130'
USGA Penncross Bentgrass Green
Majestic KBG
Vantage KBG
Vantage KBG
Park KBG
Park KBG
Vantage KBG
(650 series heads)
Hedge
Hedge
Park KBG
Bronco KBG
Parking
180'
Ram 1 KBG
Park KBG
Glade KBG
Midnight KBG
Rubber Topdressing Study
(690 series heads)
Hedge
180'
Turf Building
Ornamental Grasses
N
80'
80'
80'
40'
Premium Sod Blend (KBG)
Ram I KBG
Indigo KBG
Tall Fescue Regional Trial
135'
Registration
Exhibits
Nassau KBG
Park KBG
Enkamat
Rose Garden
SportGrass
Shade Adaptation Study
Heatway and SubAir
SubAir
Greens Amendment Study
Slope Green Study
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

| Time | Lawn Care/Grounds Tour | Golf Course Tour | Sports Turf Tour | Mowing Equipment Tour | Tree Care Tour |
|---|---|---|---|---|---|
| 9:30 | #20 Shade trial | #8 Poa management | #19 Pre-germination | #13 Mower safety | Selection and care of shade and ornamental trees. This is a riding wagon tour with Dr. Jeff Iles, ISU Horticulture. Meet on the wagons by the registration tent at 9:30. |
| 9:45 | #14 Crabgrass control | #7 Disease control | #18 SportGrass | #12 Mower maintenance | |
| 10:00 | #13 Mower safety | #2 Prairie plants | #10 Crumb rubber | #11 Mower demonstrations | |
| 10:15 | #12 Mower maintenance | #3 Low input sustainable turf | #6 Primo/paint | | |
| 10:30 | #11 Mower demonstrations | #4 Bentgrass varieties | #5 Kentucky bluegrass - traffic | Visit plots on your own or join other tours. | |
| 10:45 | | #17 Bentgrass establishment | #13 Mower safety | | |
| 11:00 | #1 Summer phytotoxicity | #15 SubAir | #12 Mower maintenance | | |
| 11:15 | #9 PGR's | #16 Sloped green | #11 Mower demonstrations | | |

| Station # | Speaker | Topic |
|---|---|---|
| 1 | Dan Peterson, All American Turf Beauty | Demonstration of potential phytotoxicity from summer spray applications. |
| 2 | Kevin Jones, ISU Horticulture | Prairie plant demonstration. |
| 3 | Nick Christians, ISU Horticulture | Low input sustainable turf trial. |
| 4 | Nick Christians and Young Joo, ISU | Fairway and putting green height bentgrass variety trials. |
| 5 | Dave Minner, ISU Horticulture | NETP Kentucky bluegrass variety trial – traffic. |
| 6 | Mike Andresen, ISU Athletic Department | Demonstration of using Primo in field marking paint. |
| 7 | Mark Gleason, ISU Plant Pathology | Disease control studies – pythium, dollar spot, and wetting agents. |
| 8 | Nick Christians, ISU Horticulture | *Poa annua* management. |
| 9 | Mike Faust, ISU Horticulture | The effect of Primo on Kentucky bluegrass sod establishment. |
| 10 | Dave Minner, ISU Horticulture | Demonstration of rubber particles for vehicular and foot traffic areas. |
| 11 | Jim Dickson, ISU Horticulture | Mower demonstrations. |
| 12 | Big Bear | In-season mower maintenance. |
| 13 | Russ Gilkes, OSHA | Mower and power equipment safety. |
| 14 | Barb Bingaman and Melissa McDade | Pre- and postemergence control of crabgrass. |
| 15 | Jay Hudson, ISU Horticulture | SubAir demonstration. |
| 16 | Nick Christians, ISU Horticulture | Managing bentgrass stress on putting green slopes. |
| 17 | Mike Faust, ISU Horticulture | Creeping bentgrass establishment on sand greens. |
| 18 | Dave Minner, ISU Horticulture | Managing cool-season grasses as part of a SportGrass system. Stabilizing sand based athletic fields with Enkamat. |
| 19 | Mike Andresen, ISU Athletic Department | Pre-germination and divot mix demonstration. |
| 20 | Gary Peterson, ISU Extension | Shade adaptation study. |

# Introduction

*Nick E. Christians and David D. Minner*

The following research report is the 19th 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 second year that the entire report is available on the Internet. It can be accessed at:

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

The 1997 season was mild with sufficient rainfall during most of the summer. The fall was very dry.

Several new sand-based golf and athletic field research plots are under construction on the south end of the Turf Facility at the Horticulture Research Station. Various products and technologies associated with sand-based systems will be evaluated such as: SportGrass - a combination of natural grass and synthetic turf, Heatway - a water circulated soil heating system, SubAir - a subsurface forced air system, several organic and inorganic sand amendments, and a sloped area to study temperature and moisture stress on putting greens.

We would like to acknowledge Richard Moore, superintendent of the ISU Horticulture Research Station; Jim Dickson, manager of the turf research area; Barbara Bingaman, Postdoctoral researcher; Doug Campbell, research associate; Jeff Salmond, Mike Faust, and Melissa Weinhold, graduate students; and all others employed at the field research area in the past year for their efforts in building the turf program.

Special thanks to Lois Benning for her work in typing and helping to edit this publication.

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

---

Dr. Nick Christians
Phone: 515/294-0036
Fax: 515/294-0730
E-mail: nchris@iastate.edu

Dr. David Minner
Phone: 515/294-5726
Fax: 515/294-0730
E-mail: dminner@iastate.edu

# Table of Contents

**Weather data for the ISU Horticulture Research Station from January 1 to December 31, 1997.**

| January | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 27 | 15 | |
| 2 | 40 | 27 | |
| 3 | 46 | 33 | |
| 4 | 44 | 31 | |
| 5 | 45 | 26 | .18 |
| 6 | 26 | 8 | .04 |
| 7 | 23 | 6 | |
| 8 | 28 | 2 | |
| 9 | 39 | 16 | |
| 10 | 26 | 3 | |
| 11 | 3 | -7 | |
| 12 | 2 | -10 | |
| 13 | 4 | -12 | |
| 14 | 14 | -4 | |
| 15 | 17 | -6 | |
| 16 | 23 | 2 | |
| 17 | 4 | -5 | |
| 18 | 8 | -15 | |
| 19 | 17 | -6 | |
| 20 | 40 | 17 | .05 |
| 21 | 44 | 21 | |
| 22 | 47 | 32 | |
| 23 | 41 | 8 | |
| 24 | 24 | 6 | |
| 25 | 24 | 0 | |
| 26 | 1 | -8 | |
| 27 | 7 | -7 | |
| 28 | 7 | -9 | |
| 29 | 9 | -17 | |
| 30 | 24 | 2 | .03 |
| 31 | 33 | 2 | |

| February | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 45 | 32 | .04 |
| 2 | 39 | 32 | |
| 3 | 34 | 27 | |
| 4 | 33 | 26 | |
| 5 | 30 | 23 | |
| 6 | 28 | 19 | .01 |
| 7 | 22 | 18 | |
| 8 | 24 | 17 | |
| 9 | 28 | 12 | .08 |
| 10 | 28 | 13 | |
| 11 | 27 | 13 | |
| 12 | 24 | 16 | |
| 13 | 23 | -14 | .01 |
| 14 | 25 | -13 | |
| 15 | 28 | 6 | .01 |
| 16 | 24 | -11 | |
| 17 | 25 | 15 | .12 |
| 18 | 47 | 21 | |
| 19 | 53 | 35 | |
| 20 | 40 | 26 | |
| 21 | 44 | 32 | .05 |
| 22 | 35 | 25 | |
| 23 | 34 | 18 | |
| 24 | 33 | 11 | |
| 25 | 28 | 13 | |
| 26 | 42 | 15 | |
| 27 | 37 | 26 | .08 |
| 28 | 32 | 23 | .07 |

| March | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 41 | 26 | |
| 2 | 42 | 25 | .01 |
| 3 | 43 | 22 | |
| 4 | 40 | 29 | |
| 5 | 35 | 23 | |
| 6 | 33 | 14 | |
| 7 | 29 | 13 | |
| 8 | 58 | 18 | |
| 9 | 55 | 19 | |
| 10 | 47 | 31 | .36 |
| 11 | 59 | 30 | |
| 12 | 47 | 31 | |
| 13 | 47 | 30 | |
| 14 | 37 | 24 | .93 |
| 15 | 25 | 11 | |
| 16 | 25 | 9 | |
| 17 | 50 | 17 | .03 |
| 18 | 53 | 33 | |
| 19 | 41 | 29 | .02 |
| 20 | 52 | 30 | .03 |
| 21 | 60 | 31 | |
| 22 | 60 | 36 | |
| 23 | 54 | 30 | |
| 24 | 45 | 29 | |
| 25 | 38 | 32 | .32 |
| 26 | 46 | 28 | |
| 27 | 71 | 26 | |
| 28 | 74 | 44 | |
| 29 | 59 | 38 | |
| 30 | 53 | 37 | .03 |
| 31 | 56 | 29 | .01 |

| April | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 56 | 29 | 0.01 |
| 2 | 68 | 39 | |
| 3 | 59 | 45 | 0.01 |
| 4 | 61 | 41 | |
| 5 | 57 | 50 | 0.06 |
| 6 | 61 | 47 | 0.70 |
| 7 | 47 | 26 | |
| 8 | 42 | 20 | |
| 9 | 28 | 14 | |
| 10 | 40 | 15 | |
| 11 | 33 | 30 | 0.02 |
| 12 | 34 | 30 | 0.12 |
| 13 | 40 | 29 | 0.12 |
| 14 | 49 | 25 | |
| 15 | 55 | 23 | |
| 16 | 62 | 37 | |
| 17 | 47 | 27 | |
| 18 | 58 | 23 | |
| 19 | 70 | 36 | 0.01 |
| 20 | 69 | 33 | |
| 21 | 57 | 41 | 0.02 |
| 22 | 63 | 39 | 0.04 |
| 23 | 54 | 45 | |
| 24 | 60 | 40 | |
| 25 | 60 | 30 | |
| 26 | 65 | 30 | |
| 27 | 67 | 37 | |
| 28 | 67 | 45 | |
| 29 | 72 | 33 | |
| 30 | 73 | 47 | |

| May | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 62 | 33 | 1.69 |
| 2 | 59 | 32 | |
| 3 | 51 | 43 | 0.52 |
| 4 | 60 | 43 | |
| 5 | 70 | 34 | |
| 6 | 74 | 48 | |
| 7 | 69 | 34 | |
| 8 | 59 | 52 | 0.36 |
| 9 | 65 | 47 | |
| 10 | 66 | 39 | |
| 11 | 73 | 32 | |
| 12 | 65 | 44 | |
| 13 | 63 | 37 | |
| 14 | 58 | 28 | |
| 15 | 60 | 40 | |
| 16 | 58 | 32 | |
| 17 | 82 | 32 | 0.05 |
| 18 | 86 | 43 | |
| 19 | 89 | 59 | |
| 20 | 62 | 43 | |
| 21 | 65 | 34 | |
| 22 | 70 | 38 | |
| 23 | 72 | 46 | |
| 24 | 78 | 50 | |
| 25 | 69 | 57 | 0.02 |
| 26 | 64 | 54 | |
| 27 | 56 | 43 | 0.70 |
| 28 | 56 | 46 | 0.09 |
| 29 | 53 | 47 | 0.25 |
| 30 | 62 | 49 | |
| 31 | 71 | 43 | |

| June | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 80 | 44 | |
| 2 | 82 | 46 | |
| 3 | 80 | 47 | |
| 4 | 80 | 59 | |
| 5 | 78 | 56 | |
| 6 | 74 | 54 | |
| 7 | 73 | 51 | 0.01 |
| 8 | 80 | 50 | |
| 9 | 74 | 55 | |
| 10 | 77 | 51 | |
| 11 | 81 | 52 | |
| 12 | 81 | 52 | |
| 13 | 79 | 62 | 0.17 |
| 14 | 86 | 58 | |
| 15 | 83 | 60 | |
| 16 | 88 | 66 | |
| 17 | 85 | 59 | |
| 18 | 85 | 53 | |
| 19 | 81 | 61 | |
| 20 | 91 | 62 | 0.04 |
| 21 | 90 | 68 | |
| 22 | 85 | 65 | 2.57 |
| 23 | 88 | 67 | |
| 24 | 88 | 68 | |
| 25 | 84 | 70 | 0.03 |
| 26 | 82 | 63 | 0.13 |
| 27 | 84 | 56 | |
| 28 | 84 | 61 | |
| 29 | 87 | 66 | 0.16 |
| 30 | 86 | 63 | 0.36 |

| July | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 85 | 64 | 0.01 |
| 2 | 87 | 70 | |
| 3 | 80 | 61 | |
| 4 | 72 | 57 | |
| 5 | 72 | 52 | |
| 6 | 77 | 49 | |
| 7 | 74 | 57 | 0.78 |
| 8 | 79 | 50 | 0.02 |
| 9 | 85 | 63 | 0.05 |
| 10 | 75 | 56 | |
| 11 | 78 | 58 | |
| 12 | 86 | 65 | 0.04 |
| 13 | 89 | 70 | 0.07 |
| 14 | 90 | 72 | 0.04 |
| 15 | 83 | 66 | |
| 16 | 91 | 61 | |
| 17 | 91 | 70 | |
| 18 | 91 | 71 | |
| 19 | 91 | 68 | |
| 20 | 93 | 72 | |
| 21 | 92 | 69 | 0.27 |
| 22 | 83 | 67 | 0.15 |
| 23 | 77 | 67 | |
| 24 | 80 | 66 | 1.66 |
| 25 | 85 | 68 | 1.72 |
| 26 | 94 | 75 | |
| 27 | 92 | 73 | |
| 28 | 88 | 71 | 0.56 |
| 29 | 82 | 64 | |
| 30 | 78 | 60 | |
| 31 | 76 | 56 | |

| August | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 78 | 54 | |
| 2 | 82 | 62 | 0.03 |
| 3 | 90 | 62 | |
| 4 | 91 | 66 | |
| 5 | 84 | 62 | |
| 6 | 75 | 53 | |
| 7 | 78 | 51 | |
| 8 | 81 | 59 | |
| 9 | 81 | 57 | |
| 10 | 80 | 57 | |
| 11 | 73 | 58 | |
| 12 | 64 | 57 | 0.71 |
| 13 | 70 | 63 | 0.12 |
| 14 | 75 | 57 | |
| 15 | 76 | 62 | |
| 16 | 86 | 61 | 0.22 |
| 17 | 87 | 63 | |
| 18 | 72 | 60 | |
| 19 | 71 | 58 | |
| 20 | 70 | 61 | 0.07 |
| 21 | 75 | 56 | 0.02 |
| 22 | 78 | 50 | |
| 23 | 77 | 50 | |
| 24 | 83 | 58 | |
| 25 | 74 | 64 | .07 |
| 26 | 72 | 62 | |
| 27 | 86 | 66 | 0.05 |
| 28 | 88 | 66 | |
| 29 | 86 | 70 | 0.03 |
| 30 | 90 | 73 | |
| 31 | 87 | 64 | |

| September | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 89 | 68 | 0.17 |
| 2 | 73 | 57 | |
| 3 | 70 | 51 | |
| 4 | 73 | 46 | |
| 5 | 82 | 54 | |
| 6 | 92 | 61 | |
| 7 | 84 | 65 | 0.67 |
| 8 | 75 | 65 | 0.01 |
| 9 | 75 | 53 | |
| 10 | 71 | 47 | |
| 11 | 75 | 52 | |
| 12 | 77 | 52 | 0.19 |
| 13 | 70 | 60 | 0.01 |
| 14 | 80 | 57 | |
| 15 | 84 | 62 | |
| 16 | 84 | 58 | 0.05 |
| 17 | 86 | 54 | |
| 18 | 87 | 63 | |
| 19 | 86 | 56 | |
| 20 | 66 | 43 | |
| 21 | 67 | 38 | 0.38 |
| 22 | 58 | 52 | 0.99 |
| 23 | 69 | 52 | |
| 24 | 75 | 46 | |
| 25 | 85 | 52 | |
| 26 | 83 | 50 | |
| 27 | 82 | 52 | |
| 28 | 81 | 54 | |
| 29 | 80 | 55 | |
| 30 | 79 | 50 | |

| October | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 75 | 44 | |
| 2 | 90 | 56 | |
| 3 | 89 | 68 | |
| 4 | 93 | 64 | |
| 5 | 83 | 47 | 0.11 |
| 6 | 91 | 60 | 0.07 |
| 7 | 90 | 60 | 0.14 |
| 8 | 85 | 68 | |
| 9 | 72 | 65 | 0.90 |
| 10 | 67 | 44 | |
| 11 | 72 | 39 | 0.18 |
| 12 | 80 | 60 | |
| 13 | 71 | 58 | 1.98 |
| 14 | 59 | 43 | |
| 15 | 63 | 44 | |
| 16 | 65 | 43 | |
| 17 | 68 | 48 | |
| 18 | 67 | 42 | |
| 19 | 68 | 50 | |
| 20 | 64 | 49 | |
| 21 | 61 | 39 | |
| 22 | 56 | 37 | |
| 23 | 49 | 23 | |
| 24 | 60 | 45 | |
| 25 | 54 | 49 | 0.06 |
| 26 | 49 | 44 | 0.01 |
| 27 | 44 | 32 | 0.20 |
| 28 | 44 | 13 | |
| 29 | 55 | 35 | |
| 30 | 60 | 36 | |
| 31 | 62 | 49 | |

| November | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 62 | 44 | |
| 2 | 55 | 48 | |
| 3 | 51 | 38 | .04 |
| 4 | 42 | 38 | .03 |
| 5 | 44 | 39 | .01 |
| 6 | 47 | 42 | .02 |
| 7 | 51 | 46 | |
| 8 | 53 | 46 | |
| 9 | 56 | 48 | |
| 10 | 50 | 42 | .15 |
| 11 | 43 | 23 | |
| 12 | 45 | 17 | |
| 13 | 45 | 18 | |
| 14 | 40 | 37 | |
| 15 | 39 | 31 | .02 |
| 16 | 36 | 17 | |
| 17 | 32 | 14 | |
| 18 | 51 | 26 | |
| 19 | 40 | 23 | |
| 20 | 48 | 16 | |
| 21 | 55 | 29 | |
| 22 | 40 | 23 | |
| 23 | 37 | 22 | |
| 24 | 42 | 20 | |
| 25 | 44 | 16 | |
| 26 | 62 | 32 | |
| 27 | 52 | 29 | |
| 28 | 57 | 35 | |
| 29 | 51 | 34 | |
| 30 | 44 | 35 | .96 |

| December | High (F°) | Low (F°) | Precipitation (inches) |
|---|---|---|---|
| 1 | 42 | 33 | |
| 2 | 39 | 37 | |
| 3 | 42 | 38 | .06 |
| 4 | 38 | 30 | .01 |
| 5 | 33 | 19 | |
| 6 | 24 | 13 | |
| 7 | 28 | 23 | |
| 8 | 27 | 24 | |
| 9 | 31 | 24 | |
| 10 | 33 | 26 | .01 |
| 11 | 34 | 28 | |
| 12 | 31 | 25 | |
| 13 | 27 | 12 | |
| 14 | 38 | 19 | .07 |
| 15 | 42 | 13 | |
| 16 | 48 | 31 | |
| 17 | 42 | 27 | |
| 18 | 44 | 16 | |
| 19 | 52 | 30 | |
| 20 | 44 | 32 | |
| 21 | 36 | 19 | |
| 22 | 32 | 18 | |
| 23 | 34 | 30 | .07 |
| 24 | 33 | 27 | |
| 25 | 31 | 25 | |
| 26 | 34 | 24 | |
| 27 | 39 | 24 | .01 |
| 28 | 32 | 11 | |
| 29 | 34 | 24 | |
| 30 | 31 | 19 | |
| 31 | 34 | 17 | .01 |

# Results of Regional Kentucky Bluegrass Cultivar Trials

*Nick E. Christians, David D. Minner, and James R. Dickson*

The National Turfgrass Evaluation Program (NTEP) has sponsored several regional Kentucky bluegrass cultivar trials conducted at most of the northern agricultural experiment stations. The current tests at Iowa State University include a high-maintenance trial with 103 cultivars, a second high-maintenance trial with the same cultivars that is subjected to compaction treatments, and a low-maintenance study with 21 cultivars. The high-maintenance trials receive 4 lb. N/1000 $ft^2$/yr, and are irrigated as needed. The low maintenance trial is not irrigated and receives 1 lb. N/1000 $ft^2$/yr. All three trials are mowed at two inches. The objective of the high-maintenance study is to investigate cultivar performance under a cultural regime similar to that used on irrigated home lawns in Iowa. The objective of the low-maintenance study is to observe the cultivar response under conditions similar to those found in non-irrigated lawns that receive a standard lawn care program. The objective of the traffic study is determine what cultivars perform better on intense traffic areas such as sports fields. Traffic treatments will begin in 1998. A non-traffic recovery period will immediately follow each traffic period. Traffic will be applied using a differential slip-type traffic simulator (Brouwer model). One pass over the entire plot area will be made every Monday, Wednesday, and Friday during the traffic period with the traffic simulator.

The values listed under each month in Tables 1, 2, and 3 are the averages of visual quality ratings made on three replicated plots for the three studies. Visual quality was based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Yearly means of monthly data were taken and are listed in the last column. The first cultivar received the highest average rating for the entire 1997 season. The cultivars are listed in descending order of average quality.

Data for genetic color (Gcol), spring greenup (Grn), leaf texture (Leaf), and leaf spot (Lspot) also are included for the high-maintenance, irrigated trial. Genetic color (Gcol), spring greenup (Grn), and leaf texture (Leaf) ratings are listed for the low-maintenance trial. Genetic color (Gcol), spring greenup (Grn), leaf texture (Leaf), spring density (Sden), summer density (Suden), fall density (Fden), and percentage spring ground cover (% cov) data are listed for the high-maintenance, irrigated traffic trial.

The 1997 season began with high rainfall and cool temperatures and ended cool and dry.

**Table 1.** The 1997 ratings for the 1995 high-maintenance, irrigated Kentucky bluegrass trial.

| | | | | | | Turf Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultivar | Gcol | Grn | Leaf | Lspot | May | June | July | Aug | Sept | Oct | Mean |
| 1 | ZPS-2572 | 6.0 | 6.0 | 5.3 | 7.0 | 5.7 | 6.7 | 7.3 | 6.7 | 8.0 | 7.7 | 7.0 |
| 2 | Absolute (MED-1497) | 5.7 | 6.0 | 4.7 | 7.0 | 6.0 | 7.3 | 7.7 | 6.3 | 7.3 | 7.0 | 6.9 |
| 3 | Award | 6.0 | 5.7 | 5.0 | 6.0 | 6.0 | 6.3 | 7.3 | 6.3 | 7.7 | 7.7 | 6.9 |
| 4 | PST-B2-42 | 4.7 | 7.0 | 5.3 | 5.7 | 6.7 | 7.0 | 6.3 | 6.3 | 7.3 | 7.3 | 6.8 |
| 5 | NJ 1190 | 3.7 | 7.0 | 5.7 | 6.7 | 5.3 | 6.3 | 6.7 | 7.3 | 7.3 | 7.3 | 6.7 |
| 6 | Unique | 4.3 | 6.7 | 4.3 | 5.0 | 7.0 | 6.3 | 6.3 | 6.3 | 7.0 | 7.0 | 6.7 |
| 7 | Arcadia (J-1936) | 5.3 | 5.7 | 5.3 | 6.7 | 6.0 | 6.3 | 7.0 | 6.0 | 7.3 | 7.0 | 6.6 |
| 8 | Blacksburg | 5.0 | 6.0 | 5.3 | 7.0 | 6.0 | 6.3 | 6.7 | 6.3 | 7.3 | 7.0 | 6.6 |
| 9 | J-1576 | 6.0 | 5.7 | 5.3 | 6.0 | 6.0 | 6.0 | 6.7 | 6.0 | 7.7 | 7.3 | 6.6 |
| 10 | Midnight | 5.3 | 6.7 | 5.0 | 6.3 | 6.0 | 6.3 | 7.0 | 6.3 | 7.0 | 7.0 | 6.6 |
| 11 | Quantum Leap (J-1567) | 5.7 | 5.0 | 5.0 | 7.0 | 5.3 | 6.7 | 6.3 | 6.7 | 7.3 | 7.0 | 6.6 |
| 12 | ZPS-2183 | 5.0 | 6.7 | 4.7 | 8.0 | 6.3 | 7.0 | 6.0 | 6.7 | 6.7 | 7.0 | 6.6 |
| 13 | BAR VB 3115B | 4.0 | 6.0 | 4.3 | 6.0 | 5.7 | 6.7 | 6.3 | 6.7 | 6.7 | 7.0 | 6.5 |

| | Cultivar | Gcol | Grn | Leaf | Lspot | Turf Quality May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | Baron | 5.0 | 6.0 | 5.0 | 6.0 | 5.3 | 6.7 | 6.3 | 6.7 | 7.0 | 7.0 | 6.5 |
| 15 | Bartitia | 4.0 | 5.0 | 4.7 | 7.0 | 5.3 | 6.7 | 6.7 | 6.3 | 7.0 | 7.0 | 6.5 |
| 16 | Caliber | 4.3 | 6.7 | 5.7 | 5.3 | 6.3 | 6.3 | 6.3 | 6.7 | 6.7 | 6.7 | 6.5 |
| 17 | Coventry | 5.0 | 7.7 | 4.3 | 5.3 | 6.0 | 6.3 | 5.3 | 6.3 | 7.7 | 7.3 | 6.5 |
| 18 | BA 81-058 | 5.0 | 7.0 | 5.3 | 5.3 | 5.3 | 6.0 | 6.3 | 6.3 | 7.3 | 7.3 | 6.4 |
| 19 | BA 81-270 | 4.0 | 7.3 | 4.0 | 5.7 | 6.0 | 6.0 | 5.7 | 6.3 | 7.3 | 7.0 | 6.4 |
| 20 | BAR VB 233 | 4.3 | 6.0 | 5.3 | 6.3 | 6.3 | 7.0 | 6.3 | 5.7 | 6.3 | 7.0 | 6.4 |
| 21 | Challenger | 5.0 | 6.3 | 5.0 | 6.7 | 5.3 | 6.3 | 6.7 | 6.3 | 6.7 | 7.0 | 6.4 |
| 22 | Explorer (Pick-3561) | 5.0 | 5.7 | 4.7 | 5.7 | 5.7 | 6.3 | 6.0 | 6.7 | 7.0 | 7.0 | 6.4 |
| 23 | PST-BO-141 | 4.7 | 6.7 | 5.3 | 5.7 | 6.7 | 7.0 | 5.3 | 6.0 | 6.7 | 6.7 | 6.4 |
| 24 | Total Eclipse (Tcr-1738) | 5.7 | 5.3 | 5.0 | 6.7 | 5.3 | 6.3 | 6.7 | 6.0 | 7.0 | 7.0 | 6.4 |
| 25 | Limousine | 4.0 | 4.3 | 5.3 | 6.7 | 4.7 | 6.7 | 7.0 | 5.3 | 7.0 | 7.0 | 6.3 |
| 26 | NJ-54 | 4.7 | 7.0 | 5.0 | 5.3 | 5.7 | 5.7 | 6.7 | 6.7 | 6.3 | 7.0 | 6.3 |
| 27 | Pick 8 | 5.0 | 6.0 | 5.0 | 6.7 | 6.0 | 6.0 | 5.7 | 6.3 | 7.0 | 6.7 | 6.3 |
| 28 | Platini | 4.7 | 6.0 | 5.0 | 6.0 | 5.3 | 6.3 | 6.7 | 6.3 | 6.7 | 6.7 | 6.3 |
| 29 | PST-BO-165 | 4.0 | 7.3 | 4.3 | 4.7 | 6.3 | 5.3 | 6.0 | 6.0 | 7.0 | 7.0 | 6.3 |
| 30 | Seabring (BA 79-260) | 5.7 | 6.0 | 5.3 | 5.7 | 5.7 | 6.0 | 6.0 | 6.0 | 6.7 | 7.3 | 6.3 |
| 33 | Sodnet | 5.7 | 6.0 | 5.7 | 5.7 | 5.3 | 6.3 | 6.0 | 6.0 | 7.0 | 7.0 | 6.3 |
| 32 | SRX 2205 | 4.7 | 5.3 | 5.3 | 7.3 | 5.0 | 6.0 | 6.3 | 6.7 | 7.0 | 6.7 | 6.3 |
| 33 | A88-744 | 5.7 | 6.7 | 4.3 | 5.3 | 6.3 | 6.0 | 6.0 | 6.0 | 6.3 | 6.7 | 6.2 |
| 34 | America | 4.0 | 7.0 | 6.0 | 5.3 | 6.3 | 6.0 | 5.7 | 6.3 | 6.3 | 6.3 | 6.2 |
| 35 | BA 73-373 | 4.7 | 5.7 | 4.3 | 5.3 | 5.7 | 6.0 | 6.0 | 6.7 | 6.3 | 6.3 | 6.2 |
| 36 | BAR VB 6820 | 4.7 | 4.3 | 5.7 | 7.7 | 4.3 | 6.7 | 6.0 | 6.0 | 7.0 | 7.0 | 6.2 |
| 37 | H86-690 | 6.0 | 6.3 | 4.7 | 5.0 | 5.7 | 5.7 | 6.3 | 6.3 | 6.3 | 6.7 | 6.2 |
| 38 | LKB-95 | 4.0 | 5.7 | 5.3 | 6.0 | 5.7 | 6.0 | 6.3 | 6.0 | 6.7 | 6.7 | 6.2 |
| 39 | NJ-GD | 5.3 | 7.0 | 5.0 | 4.3 | 5.0 | 5.3 | 5.7 | 6.7 | 7.0 | 7.3 | 6.2 |
| 40 | PST-A7-245A | 4.0 | 6.7 | 4.7 | 5.7 | 6.0 | 5.7 | 5.7 | 6.7 | 6.7 | 6.7 | 6.2 |
| 41 | Shamrock | 5.3 | 7.0 | 5.0 | 5.3 | 6.0 | 6.0 | 5.7 | 6.0 | 6.7 | 7.0 | 6.2 |
| 42 | Wildwood | 5.3 | 5.3 | 6.0 | 7.3 | 5.7 | 6.0 | 6.0 | 6.0 | 6.7 | 6.7 | 6.2 |
| 43 | ZPS-309 | 5.0 | 5.3 | 5.0 | 7.0 | 5.3 | 6.7 | 6.0 | 6.0 | 6.3 | 7.0 | 6.2 |
| 44 | Abbey | 4.3 | 5.7 | 4.7 | 5.3 | 5.3 | 6.0 | 6.0 | 6.0 | 6.7 | 6.7 | 6.1 |
| 45 | BA 81-113 | 5.3 | 5.0 | 5.3 | 4.3 | 5.3 | 5.3 | 6.0 | 6.3 | 6.3 | 7.0 | 6.1 |
| 46 | BAR VB 5649 | 5.0 | 6.0 | 4.3 | 6.0 | 6.0 | 5.7 | 6.0 | 6.3 | 6.3 | 6.3 | 6.1 |
| 47 | Bluechip (MED-1991) | 4.3 | 5.7 | 5.7 | 6.3 | 5.7 | 6.3 | 6.0 | 5.7 | 6.3 | 6.3 | 6.1 |
| 48 | Cardiff | 5.0 | 5.7 | 5.7 | 6.3 | 5.3 | 6.0 | 6.0 | 6.0 | 6.7 | 6.7 | 6.1 |
| 49 | Goldrush (BA 87-102) | 5.0 | 4.3 | 5.3 | 5.3 | 5.3 | 6.3 | 6.3 | 5.7 | 6.3 | 6.3 | 6.1 |
| 50 | Jefferson | 4.7 | 5.7 | 5.0 | 4.0 | 6.0 | 5.3 | 6.0 | 6.0 | 6.7 | 6.7 | 6.1 |
| 51 | Livingston | 4.7 | 6.0 | 4.7 | 5.0 | 5.7 | 5.7 | 6.0 | 5.7 | 6.7 | 7.0 | 6.1 |
| 52 | MED-1580 | 4.7 | 6.0 | 5.0 | 6.7 | 5.3 | 6.3 | 6.3 | 6.0 | 6.3 | 6.3 | 6.1 |
| 53 | Nimbus | 4.0 | 5.3 | 5.0 | 6.3 | 6.0 | 6.0 | 5.7 | 6.0 | 6.3 | 6.3 | 6.1 |
| 54 | Nuglade | 5.7 | 6.3 | 5.0 | 6.7 | 4.7 | 6.3 | 6.3 | 5.7 | 6.7 | 6.7 | 6.1 |
| 55 | Nustar | 4.3 | 5.7 | 5.3 | 6.3 | 6.0 | 5.7 | 6.0 | 6.0 | 6.3 | 6.7 | 6.1 |
| 56 | Raven | 4.7 | 5.3 | 5.0 | 6.0 | 5.3 | 6.0 | 6.3 | 6.0 | 6.3 | 6.3 | 6.1 |
| 57 | SR 2000 | 5.7 | 6.7 | 4.7 | 6.3 | 5.7 | 5.7 | 5.7 | 6.0 | 6.7 | 6.7 | 6.1 |
| 58 | Blackstone (PST-638) | 6.0 | 6.3 | 5.0 | 7.0 | 5.0 | 6.0 | 6.0 | 6.0 | 6.3 | 6.7 | 6.0 |
| 59 | Chicago (J-2582) | 5.0 | 6.0 | 5.3 | 5.3 | 5.0 | 5.3 | 6.0 | 6.0 | 7.0 | 6.7 | 6.0 |
| 60 | Classic | 5.0 | 6.0 | 5.0 | 4.0 | 5.3 | 5.7 | 5.3 | 5.7 | 7.0 | 7.0 | 6.0 |

| | Cultivar | Gcol | Grn | Leaf | Lspot | Turf Quality May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | Haga | 4.0 | 7.0 | 5.3 | 4.7 | 6.3 | 6.0 | 5.3 | 5.3 | 6.3 | 6.7 | 6.0 |
| 62 | Odyssey (J-1561) | 6.0 | 5.7 | 5.0 | 6.0 | 4.7 | 5.3 | 6.3 | 6.0 | 6.7 | 7.0 | 6.0 |
| 63 | Ascot | 5.3 | 5.0 | 5.0 | 7.0 | 4.7 | 6.0 | 6.3 | 5.3 | 6.3 | 6.7 | 5.9 |
| 64 | BA 75-490 | 5.0 | 6.0 | 5.0 | 4.3 | 5.0 | 5.0 | 5.7 | 6.3 | 6.7 | 7.0 | 5.9 |
| 65 | Baronie | 4.0 | 7.3 | 5.7 | 3.7 | 6.0 | 5.7 | 5.0 | 5.7 | 6.7 | 6.7 | 5.9 |
| 66 | Marquis | 5.0 | 6.0 | 4.7 | 5.3 | 5.3 | 6.0 | 6.0 | 5.7 | 6.3 | 6.3 | 5.9 |
| 67 | PST-B3-180 | 4.3 | 6.7 | 5.0 | 5.3 | 5.7 | 6.0 | 5.7 | 6.0 | 6.0 | 6.0 | 5.9 |
| 68 | Rambo (J-2579) | 4.0 | 5.7 | 5.3 | 6.3 | 5.0 | 6.7 | 5.7 | 6.0 | 6.0 | 6.3 | 5.9 |
| 69 | BA 81-220 | 4.7 | 4.7 | 4.7 | 5.7 | 5.3 | 5.0 | 6.0 | 5.7 | 6.3 | 6.3 | 5.8 |
| 70 | BA 81-227 | 4.3 | 6.3 | 4.3 | 6.0 | 5.3 | 5.3 | 5.3 | 5.7 | 6.7 | 6.7 | 5.8 |
| 71 | Glade | 5.0 | 5.7 | 5.7 | 6.0 | 5.0 | 5.3 | 6.0 | 5.7 | 6.3 | 6.3 | 5.8 |
| 72 | HV 130 | 4.0 | 4.7 | 5.0 | 5.7 | 5.0 | 5.0 | 6.0 | 6.3 | 6.3 | 6.3 | 5.8 |
| 73 | Kenblue | 4.0 | 5.0 | 5.3 | 4.0 | 5.3 | 5.0 | 6.0 | 6.0 | 6.0 | 6.3 | 5.8 |
| 74 | Princeton 105 | 5.7 | 6.0 | 5.7 | 6.7 | 5.3 | 6.0 | 5.0 | 5.3 | 6.7 | 6.7 | 5.8 |
| 75 | PST-A7-60 | 5.3 | 4.0 | 6.7 | 7.3 | 4.3 | 5.0 | 6.0 | 6.3 | 6.3 | 6.7 | 5.8 |
| 76 | Allure | 4.7 | 6.7 | 4.0 | 6.0 | 5.7 | 5.7 | 5.0 | 5.0 | 6.3 | 6.7 | 5.7 |
| 77 | Conni | 3.7 | 5.0 | 4.7 | 6.3 | 5.3 | 6.0 | 6.0 | 5.3 | 5.7 | 6.0 | 5.7 |
| 78 | Eclipse | 5.3 | 5.7 | 5.0 | 5.0 | 5.0 | 5.7 | 5.3 | 5.7 | 6.3 | 6.3 | 5.7 |
| 79 | SR 2100 | 5.0 | 6.0 | 4.7 | 5.3 | 5.7 | 5.3 | 5.3 | 5.3 | 6.0 | 6.3 | 5.7 |
| 80 | BA 70-060 | 5.0 | 5.3 | 4.7 | 6.0 | 5.3 | 5.7 | 5.3 | 5.3 | 6.0 | 6.0 | 5.6 |
| 81 | BA 76-197 | 3.7 | 5.3 | 4.3 | 3.3 | 4.7 | 4.7 | 5.7 | 5.7 | 6.3 | 6.3 | 5.6 |
| 82 | Chateau | 4.3 | 6.7 | 3.7 | 5.7 | 5.3 | 5.0 | 5.0 | 5.7 | 6.3 | 6.3 | 5.6 |
| 83 | J-1555 | 5.0 | 6.3 | 5.3 | 5.7 | 5.0 | 5.0 | 5.7 | 5.7 | 6.0 | 6.3 | 5.6 |
| 84 | Misty (BA 76-372) | 4.3 | 5.7 | 5.0 | 6.0 | 4.3 | 5.3 | 5.7 | 5.7 | 6.3 | 6.3 | 5.6 |
| 85 | Rugby II (MED-18) | 5.0 | 6.0 | 4.7 | 6.7 | 5.0 | 5.3 | 6.0 | 5.7 | 6.0 | 5.7 | 5.6 |
| 86 | Sidekick | 4.3 | 7.0 | 4.7 | 4.7 | 5.0 | 5.7 | 5.0 | 5.7 | 6.0 | 6.0 | 5.6 |
| 87 | VB 16015 | 6.3 | 5.3 | 5.3 | 6.7 | 4.3 | 5.3 | 5.3 | 5.0 | 6.7 | 6.7 | 5.6 |
| 88 | BA 77-702 | 4.3 | 5.7 | 4.7 | 6.0 | 4.7 | 5.7 | 5.7 | 5.0 | 6.0 | 6.0 | 5.5 |
| 89 | Dragon (ZPS-429) | 5.0 | 6.7 | 5.0 | 5.7 | 5.0 | 5.3 | 5.3 | 5.0 | 6.0 | 6.3 | 5.5 |
| 90 | Pick 855 | 4.7 | 5.7 | 4.7 | 5.3 | 4.7 | 5.3 | 5.0 | 5.7 | 6.0 | 6.3 | 5.5 |
| 91 | PST-P46 | 5.7 | 5.0 | 5.7 | 6.3 | 4.7 | 5.3 | 5.3 | 5.7 | 6.0 | 6.0 | 5.5 |
| 92 | SR 2109 | 4.7 | 5.7 | 5.3 | 6.7 | 4.0 | 5.3 | 5.7 | 5.7 | 6.0 | 6.3 | 5.5 |
| 93 | BA 75-163 | 5.7 | 6.7 | 5.0 | 5.0 | 4.7 | 4.7 | 5.3 | 5.0 | 6.3 | 6.3 | 5.4 |
| 94 | Fortuna | 5.0 | 5.0 | 5.0 | 6.3 | 4.3 | 5.7 | 5.7 | 5.3 | 5.7 | 6.0 | 5.4 |
| 95 | HV 242 | 4.3 | 5.0 | 5.3 | 6.0 | 5.0 | 5.3 | 5.7 | 4.7 | 6.0 | 6.0 | 5.4 |
| 96 | Lipoa | 5.7 | 5.0 | 6.3 | 6.0 | 4.0 | 5.3 | 5.7 | 5.7 | 6.0 | 6.0 | 5.4 |
| 97 | Pepaya (DP 37-192) | 4.7 | 4.0 | 5.0 | 6.3 | 4.0 | 5.3 | 5.7 | 6.0 | 5.7 | 5.7 | 5.4 |
| 98 | BA 75-173 | 5.0 | 5.3 | 4.3 | 4.0 | 4.7 | 4.3 | 5.3 | 5.0 | 6.0 | 6.0 | 5.2 |
| 99 | Baruzo | 5.7 | 5.0 | 5.7 | 4.7 | 4.7 | 5.0 | 4.7 | 4.7 | 6.0 | 6.3 | 5.2 |
| 100 | Moonlight (PST-A418) | 6.0 | 7.0 | 4.0 | 6.3 | 4.0 | 5.3 | 5.3 | 5.0 | 5.7 | 6.0 | 5.2 |
| 101 | Champagne (LTP-621) | 5.3 | 6.3 | 5.0 | 5.0 | 5.0 | 4.7 | 4.7 | 4.7 | 5.7 | 5.7 | 5.1 |
| 102 | LTP-620 | 5.0 | 6.7 | 5.0 | 5.7 | 4.0 | 5.3 | 5.0 | 4.7 | 5.7 | 5.7 | 5.1 |
| 103 | Compact | 4.0 | 5.3 | 5.7 | 4.0 | 4.3 | 5.0 | 5.0 | 5.0 | 5.0 | 5.3 | 4.9 |
| | $LSD_{(0.05)}$ | 1.0 | 1.7 | 1.5 | 1.5 | 2.3 | 2.0 | 1.8 | 2.8 | 2.7 | 2.6 | 1.6 |

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

**Table 2.** The 1997 ratings for the 1995 low-maintenance, non-irrigated Kentucky bluegrass trial.

| | Cultivar | Gcol | Grn | Leaf | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BAR VB 3115B | 6.3 | 7.0 | 7.0 | 5.7 | 6.3 | 6.3 | 6.7 | 7.3 | 6.3 | 6.4 |
| 2 | Eagleton | 6.3 | 6.0 | 6.0 | 5.7 | 5.7 | 6.3 | 6.3 | 7.3 | 6.7 | 6.3 |
| 3 | South Dakota | 5.7 | 7.7 | 6.7 | 7.0 | 5.7 | 6.0 | 5.7 | 6.0 | 6.0 | 6.1 |
| 4 | BAR VB 233 | 6.0 | 5.0 | 6.0 | 4.3 | 6.3 | 6.3 | 6.0 | 6.7 | 6.3 | 6.0 |
| 5 | Caliber | 6.0 | 5.7 | 6.0 | 5.7 | 5.7 | 5.7 | 6.3 | 6.7 | 6.0 | 6.0 |
| 6 | Baron | 6.7 | 5.0 | 6.7 | 4.7 | 5.0 | 5.7 | 6.3 | 6.7 | 6.3 | 5.8 |
| 7 | Canterbury | 5.7 | 5.7 | 6.3 | 5.7 | 6.0 | 6.3 | 5.3 | 6.0 | 5.7 | 5.8 |
| 8 | Kenblue | 5.7 | 6.7 | 7.0 | 6.3 | 5.0 | 5.7 | 6.0 | 6.0 | 5.7 | 5.8 |
| 9 | Baronie | 5.3 | 5.3 | 6.0 | 6.0 | 6.3 | 6.0 | 5.0 | 5.3 | 5.3 | 5.7 |
| 10 | Bartitia | 7.0 | 4.7 | 7.0 | 4.0 | 4.3 | 5.7 | 7.0 | 6.3 | 6.7 | 5.7 |
| 11 | BAR VB 5649 | 6.7 | 5.7 | 6.0 | 4.3 | 5.0 | 4.7 | 5.7 | 6.3 | 5.7 | 5.3 |
| 12 | BH 95-199 | 7.0 | 6.0 | 5.7 | 5.3 | 4.3 | 5.3 | 5.3 | 6.0 | 5.7 | 5.3 |
| 13 | Blue Star | 5.0 | 4.7 | 6.0 | 4.3 | 5.0 | 5.3 | 5.0 | 5.3 | 6.0 | 5.2 |
| 14 | Baruzo | 6.0 | 5.0 | 5.7 | 5.0 | 4.3 | 4.7 | 5.0 | 5.3 | 6.3 | 5.1 |
| 15 | PST-A7-60 | 7.0 | 4.0 | 6.3 | 3.7 | 3.7 | 5.3 | 6.3 | 6.0 | 5.7 | 5.1 |
| 16 | Dragon (ZPS-429) | 7.3 | 5.7 | 5.7 | 4.3 | 3.7 | 5.3 | 5.7 | 5.7 | 5.3 | 5.0 |
| 17 | PST-B9-196 | 6.3 | 6.7 | 4.7 | 4.3 | 5.0 | 5.0 | 4.7 | 5.3 | 5.0 | 4.9 |
| 18 | VB 16015 | 7.3 | 6.7 | 5.0 | 3.7 | 3.7 | 4.3 | 5.0 | 5.3 | 6.0 | 4.7 |
| 19 | MTT 683 | 7.0 | 4.0 | 6.0 | 3.3 | 3.7 | 4.7 | 5.3 | 5.3 | 4.7 | 4.5 |
| 20 | Lipoa | 6.7 | 5.3 | 6.0 | 3.7 | 3.3 | 4.0 | 4.3 | 4.7 | 5.3 | 4.2 |
| 21 | BAR VB 6820 | 6.7 | 5.0 | 5.3 | 2.7 | 3.0 | 3.3 | 4.0 | 4.7 | 4.7 | 3.7 |
| | $LSD_{0.05}$ | 1.2 | 1.2 | 0.8 | 1.3 | 1.4 | 1.3 | 1.5 | 1.4 | 2.2 | 0.9 |

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

**Table 3.** The 1997 turf ratings for the 1995 NTEP high-maintenance, irrigated Kentucky bluegrass traffic test. Traffic treatments will begin in 1998.

| | | | | | | | | | Turf Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultivar | Gcol | Grn | Leaf | Sden | Suden | Fden | % cov | April | May | June | July | Aug | Sept | Oct | Mean |
| 1 | NJ 1190 | 4.3 | 7.0 | 8.3 | 5.3 | 7.7 | 8.3 | 97.7 | 6.3 | 6.0 | 8.0 | 7.7 | 7.7 | 8.7 | 8.7 | 7.6 |
| 2 | Unique | 5.3 | 2.7 | 6.0 | 5.3 | 5.7 | 8.7 | 99.0 | 7.0 | 7.0 | 7.7 | 6.7 | 7.3 | 8.7 | 8.7 | 7.6 |
| 3 | Chateau | 4.3 | 5.7 | 5.0 | 7.0 | 7.7 | 7.0 | 99.0 | 8.0 | 8.3 | 7.3 | 7.7 | 6.3 | 7.3 | 7.3 | 7.5 |
| 4 | PST-A7-245A | 4.3 | 6.0 | 5.0 | 7.3 | 8.0 | 7.3 | 99.0 | 7.0 | 7.3 | 8.0 | 7.7 | 6.7 | 7.7 | 7.7 | 7.4 |
| 5 | BA 75-490 | 5.3 | 7.7 | 5.3 | 5.7 | 7.7 | 7.3 | 99.0 | 7.3 | 7.3 | 6.3 | 7.3 | 7.0 | 8.0 | 8.0 | 7.3 |
| 6 | Rugby II (MED-18) | 7.3 | 4.3 | 6.3 | 6.0 | 6.3 | 7.7 | 99.0 | 6.3 | 6.3 | 8.0 | 7.3 | 7.0 | 8.0 | 8.0 | 7.3 |
| 7 | BA 81-270 | 4.7 | 5.0 | 5.0 | 7.3 | 7.3 | 7.0 | 99.0 | 7.3 | 7.3 | 7.3 | 6.7 | 6.7 | 7.7 | 7.7 | 7.2 |
| 8 | BAR VB 3115B | 5.0 | 6.3 | 6.0 | 5.3 | 6.7 | 7.7 | 99.0 | 6.0 | 6.0 | 7.7 | 7.0 | 7.0 | 8.3 | 8.3 | 7.2 |
| 9 | Blacksburg | 7.0 | 4.7 | 6.3 | 5.3 | 6.7 | 8.3 | 97.7 | 6.0 | 6.3 | 7.7 | 7.0 | 7.0 | 8.3 | 8.3 | 7.2 |
| 10 | PST-BO-141 | 5.3 | 3.3 | 6.3 | 7.0 | 5.3 | 8.0 | 97.7 | 7.0 | 7.0 | 7.3 | 6.3 | 7.0 | 8.0 | 8.0 | 7.2 |
| 11 | Allure | 4.0 | 5.3 | 5.0 | 6.7 | 7.0 | 6.7 | 99.0 | 7.0 | 7.3 | 7.7 | 6.7 | 6.7 | 7.3 | 7.3 | 7.1 |
| 12 | BA 81-227 | 5.0 | 6.3 | 5.0 | 6.0 | 7.0 | 6.7 | 97.7 | 6.3 | 6.7 | 7.7 | 7.0 | 7.0 | 7.7 | 7.7 | 7.1 |
| 13 | Champagne (LTP-621) | 4.7 | 6.3 | 6.0 | 5.3 | 6.3 | 8.0 | 99.0 | 6.7 | 7.0 | 6.7 | 6.7 | 7.0 | 8.0 | 8.0 | 7.1 |
| 14 | Conni | 5.7 | 2.7 | 7.3 | 5.7 | 7.0 | 8.3 | 99.0 | 5.7 | 5.3 | 8.0 | 7.3 | 7.0 | 8.3 | 8.3 | 7.1 |
| 15 | Coventry | 4.3 | 6.3 | 5.0 | 6.3 | 7.3 | 6.7 | 94.3 | 6.7 | 7.0 | 7.3 | 7.3 | 6.7 | 7.3 | 7.7 | 7.1 |
| 16 | Eclipse | 5.7 | 4.7 | 6.0 | 6.0 | 6.0 | 7.3 | 97.7 | 6.0 | 6.0 | 7.7 | 7.0 | 7.0 | 8.0 | 8.0 | 7.1 |
| 17 | Limousine | 5.3 | 3.3 | 7.7 | 5.7 | 7.7 | 9.0 | 99.0 | 5.7 | 5.7 | 7.7 | 7.3 | 7.0 | 8.3 | 8.3 | 7.1 |
| 18 | Princeton 105 | 5.3 | 4.0 | 6.0 | 5.7 | 6.7 | 7.3 | 99.0 | 6.0 | 6.0 | 7.7 | 7.0 | 7.0 | 8.0 | 8.0 | 7.1 |
| 19 | Classic | 4.0 | 6.3 | 6.3 | 5.7 | 6.0 | 7.3 | 99.0 | 6.3 | 6.3 | 6.3 | 6.7 | 7.0 | 8.0 | 8.0 | 7.0 |
| 20 | LKB-95 | 5.3 | 5.3 | 7.7 | 5.7 | 6.7 | 7.7 | 97.7 | 6.0 | 6.0 | 6.7 | 7.0 | 7.0 | 8.3 | 8.3 | 7.0 |
| 21 | Nimbus | 5.7 | 4.7 | 5.3 | 5.0 | 7.3 | 6.3 | 99.0 | 5.0 | 5.0 | 8.0 | 8.0 | 6.7 | 8.0 | 8.0 | 7.0 |
| 22 | PST-B2-42 | 5.3 | 3.7 | 6.3 | 6.3 | 6.3 | 8.3 | 99.0 | 5.7 | 5.7 | 7.0 | 6.3 | 7.3 | 8.7 | 8.7 | 7.0 |
| 23 | PST-BO-165 | 4.7 | 5.3 | 5.0 | 6.0 | 7.0 | 7.0 | 97.7 | 6.7 | 7.0 | 6.7 | 7.3 | 6.3 | 7.3 | 7.3 | 7.0 |
| 24 | Total Eclipse (Tcr-1738) | 7.0 | 4.7 | 6.0 | 5.7 | 6.0 | 7.3 | 99.0 | 5.7 | 6.0 | 7.3 | 7.0 | 7.0 | 8.0 | 8.0 | 7.0 |
| 25 | America | 5.3 | 3.0 | 6.0 | 5.3 | 5.7 | 8.3 | 97.7 | 6.0 | 6.0 | 7.0 | 6.3 | 7.0 | 8.0 | 8.0 | 6.9 |
| 26 | PST-B3-180 | 5.3 | 3.7 | 6.3 | 6.7 | 6.7 | 7.3 | 96.0 | 6.3 | 6.3 | 7.3 | 6.7 | 6.3 | 7.7 | 7.3 | 6.9 |
| 27 | PST-P46 | 6.0 | 4.3 | 6.0 | 5.7 | 6.3 | 7.3 | 99.0 | 5.3 | 5.3 | 8.0 | 7.7 | 6.7 | 7.7 | 7.7 | 6.9 |
| 28 | Wildwood | 7.7 | 3.7 | 7.0 | 5.0 | 6.3 | 7.3 | 97.7 | 5.7 | 5.3 | 8.7 | 6.3 | 6.3 | 8.0 | 8.0 | 6.9 |
| 29 | ZPS-309 | 7.3 | 4.7 | 6.7 | 5.0 | 7.3 | 7.3 | 99.0 | 6.0 | 6.0 | 6.7 | 7.7 | 6.7 | 7.7 | 7.7 | 6.9 |
| 30 | Absolute (MED-1497) | 7.7 | 4.7 | 6.0 | 5.3 | 6.0 | 7.0 | 94.7 | 5.3 | 5.3 | 7.0 | 7.3 | 7.0 | 7.7 | 7.7 | 6.8 |
| 31 | Challenger | 6.0 | 6.0 | 6.0 | 5.7 | 5.3 | 7.3 | 97.7 | 5.7 | 6.0 | 7.7 | 6.3 | 6.7 | 7.7 | 7.7 | 6.8 |
| 32 | Explorer (Pick-3561) | 5.7 | 3.7 | 6.0 | 5.7 | 6.3 | 7.0 | 97.7 | 6.3 | 6.3 | 6.7 | 7.0 | 6.3 | 7.3 | 7.3 | 6.8 |
| 33 | Jefferson | 5.0 | 6.3 | 6.3 | 5.3 | 6.0 | 7.3 | 99.0 | 5.7 | 5.7 | 6.0 | 6.3 | 7.3 | 8.3 | 8.3 | 6.8 |
| 34 | Midnight | 6.7 | 3.7 | 6.3 | 5.7 | 5.3 | 7.0 | 97.7 | 6.3 | 6.3 | 7.3 | 6.7 | 6.3 | 7.3 | 7.3 | 6.8 |
| 35 | Misty (BA 76-372) | 5.7 | 6.3 | 6.0 | 5.7 | 6.3 | 6.3 | 96.0 | 6.0 | 5.7 | 7.0 | 6.7 | 6.3 | 7.7 | 8.0 | 6.8 |
| 36 | Moonlight (PST-A418) | 7.3 | 7.0 | 5.3 | 6.0 | 6.3 | 7.0 | 97.7 | 6.3 | 6.3 | 7.3 | 7.3 | 6.0 | 7.0 | 7.0 | 6.8 |
| 37 | Odessey (J-1561) | 7.3 | 3.7 | 6.0 | 6.3 | 6.0 | 7.3 | 99.0 | 6.0 | 6.0 | 7.0 | 6.3 | 6.7 | 7.7 | 7.7 | 6.8 |
| 38 | PST-A7-60 | 8.0 | 2.7 | 7.7 | 5.0 | 6.7 | 8.0 | 96.0 | 4.7 | 4.7 | 8.3 | 7.0 | 6.7 | 8.0 | 8.0 | 6.8 |
| 39 | Shamrock | 4.7 | 6.7 | 6.0 | 5.0 | 6.0 | 7.3 | 96.3 | 6.7 | 6.3 | 6.0 | 6.3 | 6.7 | 7.7 | 7.7 | 6.8 |

| | Cultivar | Gcol | Grn | Leaf | Sden | Suden | Fden | % cov | Turf Quality April | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | Arcadia (J-1936) | 6.3 | 4.7 | 6.0 | 6.0 | 5.7 | 7.3 | 97.7 | 6.0 | 6.0 | 6.7 | 6.7 | 6.7 | 7.7 | 7.0 | 6.7 |
| 41 | Ascot | 6.7 | 3.3 | 5.7 | 5.7 | 6.3 | 7.0 | 97.7 | 5.3 | 5.3 | 7.3 | 6.7 | 6.7 | 7.7 | 7.7 | 6.7 |
| 42 | BAR VB 233 | 7.0 | 6.0 | 6.3 | 5.3 | 6.7 | 7.0 | 97.7 | 5.7 | 5.7 | 6.7 | 7.0 | 6.3 | 7.7 | 7.7 | 6.7 |
| 43 | Baronie | 4.7 | 4.0 | 6.0 | 5.0 | 5.3 | 7.3 | 99.0 | 5.7 | 5.7 | 7.0 | 6.7 | 6.7 | 7.7 | 7.7 | 6.7 |
| 44 | Bartitia | 6.3 | 4.7 | 7.0 | 5.0 | 6.3 | 7.7 | 94.7 | 5.3 | 5.0 | 7.0 | 7.7 | 6.7 | 7.7 | 7.7 | 6.7 |
| 45 | PICK-855 | 6.3 | 4.7 | 8.0 | 4.3 | 7.3 | 8.0 | 97.7 | 5.3 | 5.0 | 7.7 | 8.0 | 6.3 | 7.3 | 7.3 | 6.7 |
| 46 | SR 2109 | 6.0 | 5.0 | 6.3 | 5.0 | 6.0 | 7.0 | 86.3 | 5.3 | 5.0 | 7.0 | 7.0 | 6.7 | 8.0 | 8.0 | 6.7 |
| 47 | ZPS-2183 | 7.0 | 6.3 | 5.0 | 5.0 | 6.7 | 7.0 | 96.3 | 5.7 | 5.3 | 8.0 | 7.3 | 6.3 | 7.3 | 7.0 | 6.7 |
| 48 | ZPS-2572 | 7.0 | 5.0 | 6.3 | 5.0 | 6.3 | 7.3 | 94.7 | 5.7 | 5.7 | 7.0 | 7.0 | 6.7 | 7.7 | 7.3 | 6.7 |
| 49 | Award | 7.7 | 4.7 | 5.7 | 5.7 | 5.7 | 7.3 | 94.7 | 6.0 | 6.0 | 7.0 | 6.3 | 6.3 | 7.3 | 7.3 | 6.6 |
| 50 | BA 75-163 | 5.7 | 6.3 | 5.3 | 5.0 | 6.7 | 6.7 | 99.0 | 6.3 | 6.3 | 6.7 | 6.7 | 6.0 | 7.0 | 7.0 | 6.6 |
| 51 | Nustar | 5.7 | 4.7 | 6.0 | 5.3 | 6.3 | 7.0 | 99.0 | 6.0 | 6.0 | 6.3 | 6.3 | 7.0 | 7.3 | 7.3 | 6.6 |
| 52 | Rambo (J-2579) | 5.7 | 4.7 | 6.3 | 5.3 | 6.0 | 8.0 | 93.0 | 5.3 | 5.3 | 6.3 | 7.0 | 6.7 | 7.7 | 8.0 | 6.6 |
| 53 | Seabring (BA 79-260) | 7.0 | 2.3 | 6.3 | 6.3 | 6.3 | 6.3 | 99.0 | 6.3 | 6.3 | 7.0 | 6.7 | 6.0 | 7.0 | 7.0 | 6.6 |
| 54 | BA 81-058 | 5.3 | 5.3 | 5.7 | 5.7 | 5.3 | 6.7 | 99.0 | 6.3 | 6.3 | 7.0 | 6.0 | 6.0 | 7.0 | 7.0 | 6.5 |
| 55 | Blackstone (PST-638) | 7.7 | 7.3 | 5.0 | 4.7 | 6.0 | 6.3 | 97.7 | 5.7 | 5.7 | 7.7 | 6.3 | 6.3 | 7.0 | 7.0 | 6.5 |
| 56 | MED-1580 | 5.7 | 5.0 | 6.3 | 5.0 | 6.3 | 7.0 | 97.7 | 5.3 | 5.3 | 7.3 | 7.0 | 6.3 | 7.0 | 7.0 | 6.5 |
| 57 | NJ-54 | 5.0 | 5.0 | 6.0 | 5.3 | 6.0 | 6.7 | 99.0 | 6.3 | 6.3 | 6.3 | 6.7 | 6.0 | 7.0 | 7.0 | 6.5 |
| 58 | NJ-GD | 5.0 | 5.7 | 5.7 | 5.0 | 6.3 | 7.3 | 94.3 | 5.7 | 5.7 | 5.7 | 6.7 | 6.3 | 7.7 | 7.7 | 6.5 |
| 59 | Nuglade | 7.0 | 4.3 | 6.0 | 5.0 | 6.0 | 7.0 | 88.0 | 5.3 | 5.3 | 7.0 | 6.7 | 6.3 | 7.3 | 7.3 | 6.5 |
| 60 | Pick 8 | 5.7 | 5.7 | 6.3 | 4.7 | 6.0 | 7.0 | 99.0 | 5.3 | 5.3 | 7.7 | 6.0 | 6.3 | 7.7 | 7.3 | 6.5 |
| 61 | Quantum Leap (J-1567) | 6.3 | 4.0 | 6.0 | 5.3 | 5.7 | 7.3 | 96.3 | 6.0 | 6.0 | 5.7 | 6.7 | 6.3 | 7.3 | 7.3 | 6.5 |
| 62 | SRX 2205 | 6.3 | 5.3 | 6.0 | 4.3 | 6.7 | 7.3 | 99.0 | 5.3 | 5.3 | 7.0 | 7.0 | 6.3 | 7.3 | 7.3 | 6.5 |
| 63 | BA 70-060 | 5.7 | 5.3 | 5.7 | 5.0 | 7.0 | 6.3 | 97.7 | 6.0 | 6.0 | 7.3 | 6.3 | 6.0 | 6.7 | 6.7 | 6.4 |
| 64 | BAR VB 6820 | 7.0 | 4.3 | 6.7 | 5.7 | 6.0 | 7.3 | 94.7 | 5.3 | 5.0 | 6.7 | 7.0 | 6.3 | 7.3 | 7.3 | 6.4 |
| 65 | Chicago (J-2582) | 5.7 | 5.0 | 6.0 | 5.3 | 6.0 | 7.7 | 99.0 | 5.7 | 5.7 | 6.3 | 6.0 | 6.7 | 7.3 | 7.3 | 6.4 |
| 66 | HV 130 | 5.7 | 4.7 | 6.3 | 4.3 | 6.3 | 7.7 | 97.7 | 5.0 | 5.0 | 6.0 | 6.7 | 7.0 | 7.7 | 7.3 | 6.4 |
| 67 | J-1576 | 6.3 | 4.7 | 6.0 | 5.0 | 5.3 | 7.0 | 91.7 | 5.7 | 5.7 | 6.0 | 6.3 | 6.7 | 7.3 | 7.3 | 6.4 |
| 68 | Marquis | 5.3 | 4.7 | 6.0 | 5.7 | 5.3 | 6.7 | 99.0 | 6.0 | 5.7 | 6.3 | 6.7 | 6.0 | 7.0 | 7.0 | 6.4 |
| 69 | Bluechip (MED-1991) | 5.3 | 5.0 | 6.0 | 5.0 | 6.0 | 6.7 | 99.0 | 5.3 | 5.3 | 6.3 | 6.3 | 6.3 | 7.3 | 7.3 | 6.3 |
| 70 | Caliber | 5.0 | 4.3 | 6.0 | 5.0 | 5.3 | 7.3 | 99.0 | 5.0 | 5.0 | 6.0 | 6.3 | 6.7 | 7.7 | 7.7 | 6.3 |
| 71 | Glade | 5.7 | 5.3 | 6.0 | 5.3 | 6.0 | 6.7 | 96.0 | 6.3 | 6.3 | 6.0 | 6.0 | 5.7 | 6.7 | 7.0 | 6.3 |
| 72 | Haga | 4.0 | 4.7 | 6.7 | 5.7 | 5.3 | 7.3 | 99.0 | 5.7 | 6.0 | 6.7 | 6.0 | 6.0 | 7.0 | 7.0 | 6.3 |
| 73 | Livingston | 5.0 | 5.3 | 6.0 | 5.0 | 5.3 | 7.0 | 91.0 | 5.7 | 5.7 | 6.0 | 6.3 | 6.7 | 7.0 | 7.0 | 6.3 |
| 74 | Platini | 6.3 | 3.7 | 6.0 | 5.3 | 6.7 | 7.3 | 99.0 | 5.3 | 5.3 | 6.3 | 6.3 | 6.3 | 7.3 | 7.3 | 6.3 |
| 75 | SR 2100 | 5.0 | 4.7 | 5.0 | 5.3 | 6.3 | 6.7 | 94.3 | 5.3 | 5.7 | 6.7 | 6.3 | 6.0 | 7.0 | 7.0 | 6.3 |
| 76 | VB 16015 | 6.7 | 6.7 | 5.7 | 5.0 | 6.0 | 6.7 | 97.7 | 5.7 | 5.7 | 6.3 | 6.3 | 6.0 | 7.0 | 7.0 | 6.3 |
| 77 | A88-744 | 6.0 | 6.3 | 6.0 | 5.3 | 5.7 | 7.0 | 97.7 | 5.7 | 5.7 | 6.0 | 6.0 | 6.3 | 7.0 | 7.0 | 6.2 |
| 78 | BA 73-373 | 5.0 | 4.3 | 5.3 | 4.7 | 5.7 | 6.0 | 99.0 | 5.7 | 5.7 | 6.7 | 6.0 | 6.3 | 6.7 | 6.7 | 6.2 |
| 79 | BAR VB 5649 | 5.7 | 3.7 | 5.7 | 4.7 | 5.0 | 7.3 | 96.3 | 5.3 | 5.3 | 6.0 | 5.7 | 6.3 | 7.3 | 7.3 | 6.2 |

| | | | | | | | | | Turf Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultivar | Gcol | Grn | Leaf | Sden | Suden | Fden | % cov | April | May | June | July | Aug | Sept | Oct | Mean |
| 80 | Cardiff | 6.7 | 6.3 | 6.0 | 5.0 | 6.0 | 7.0 | 97.7 | 5.0 | 5.3 | 5.7 | 6.7 | 6.3 | 7.3 | 7.3 | 6.2 |
| 81 | J-1555 | 5.3 | 4.3 | 6.0 | 6.0 | 5.3 | 6.3 | 99.0 | 5.7 | 5.7 | 6.7 | 6.0 | 5.7 | 6.7 | 7.0 | 6.2 |
| 82 | Lipoa | 7.7 | 5.0 | 7.0 | 5.0 | 6.0 | 6.3 | 96.0 | 4.3 | 4.3 | 7.3 | 6.7 | 6.3 | 7.3 | 7.3 | 6.2 |
| 83 | LTP-620 | 5.0 | 5.7 | 5.7 | 6.3 | 5.7 | 7.0 | 99.0 | 5.3 | 5.3 | 6.0 | 6.0 | 6.3 | 7.3 | 7.3 | 6.2 |
| 84 | Sidekick | 4.0 | 6.3 | 5.0 | 5.3 | 5.7 | 6.3 | 99.0 | 5.7 | 6.0 | 5.3 | 6.3 | 6.3 | 7.0 | 7.0 | 6.2 |
| 85 | Abbey | 5.3 | 4.7 | 5.3 | 4.0 | 6.0 | 6.3 | 92.7 | 5.3 | 5.0 | 6.3 | 6.0 | 6.3 | 7.0 | 7.0 | 6.1 |
| 86 | BA 77-702 | 5.3 | 4.3 | 5.0 | 5.0 | 5.3 | 6.7 | 97.7 | 5.0 | 5.0 | 6.3 | 6.3 | 6.3 | 7.0 | 7.0 | 6.1 |
| 87 | Dragon (ZPS-429) | 5.0 | 5.7 | 5.7 | 4.7 | 6.0 | 7.0 | 97.7 | 4.7 | 4.7 | 6.3 | 6.3 | 6.3 | 7.3 | 7.3 | 6.1 |
| 88 | Fortuna | 5.7 | 5.3 | 5.7 | 5.3 | 5.7 | 6.3 | 94.3 | 5.7 | 5.7 | 6.7 | 6.0 | 5.7 | 6.7 | 6.7 | 6.1 |
| 89 | Sodnet | 8.0 | 4.7 | 6.7 | 5.0 | 5.7 | 7.0 | 97.7 | 5.0 | 5.0 | 7.0 | 6.7 | 6.0 | 6.7 | 6.7 | 6.1 |
| 90 | SR 2000 | 6.0 | 5.7 | 4.7 | 6.0 | 5.7 | 7.0 | 84.7 | 5.7 | 5.7 | 5.7 | 6.0 | 6.0 | 7.0 | 7.0 | 6.1 |
| 91 | Baron | 5.0 | 4.7 | 5.7 | 5.3 | 5.3 | 6.3 | 97.7 | 5.3 | 5.0 | 5.7 | 6.0 | 6.3 | 7.0 | 6.7 | 6.0 |
| 92 | Pepaya (DP 37-192) | 7.7 | 2.7 | 5.7 | 5.3 | 5.7 | 6.3 | 96.3 | 4.7 | 4.0 | 7.3 | 6.3 | 6.3 | 6.7 | 6.7 | 6.0 |
| 93 | Raven | 5.0 | 5.3 | 5.7 | 4.3 | 5.3 | 6.3 | 99.0 | 4.7 | 4.7 | 7.3 | 6.0 | 5.7 | 6.7 | 6.7 | 6.0 |
| 94 | BA 75-173 | 6.0 | 4.7 | 5.3 | 4.7 | 5.3 | 6.0 | 99.0 | 5.0 | 5.0 | 7.0 | 6.3 | 5.3 | 6.3 | 6.3 | 5.9 |
| 95 | Baruzo | 5.0 | 4.0 | 6.3 | 4.3 | 5.0 | 6.3 | 97.7 | 4.3 | 4.3 | 6.0 | 6.3 | 6.3 | 7.0 | 7.0 | 5.9 |
| 96 | BA 76-197 | 4.7 | 4.7 | 5.0 | 4.7 | 5.7 | 6.7 | 86.3 | 5.0 | 4.7 | 5.3 | 5.3 | 6.0 | 7.0 | 7.0 | 5.8 |
| 97 | BA 81-113 | 5.3 | 5.0 | 5.7 | 4.7 | 5.7 | 6.0 | 97.7 | 5.3 | 5.0 | 5.7 | 5.7 | 5.3 | 6.3 | 7.0 | 5.8 |
| 98 | Compact | 4.0 | 4.7 | 5.7 | 5.7 | 5.7 | 6.7 | 99.0 | 6.0 | 6.0 | 4.3 | 6.0 | 5.3 | 6.0 | 6.0 | 5.7 |
| 99 | H86-690 | 5.7 | 5.7 | 5.7 | 4.7 | 4.7 | 6.3 | 96.0 | 5.0 | 4.7 | 5.0 | 5.0 | 6.3 | 7.0 | 7.0 | 5.7 |
| 100 | BA 81-220 | 5.0 | 4.7 | 5.3 | 4.0 | 5.7 | 5.7 | 89.7 | 5.0 | 4.7 | 6.7 | 5.7 | 5.3 | 6.0 | 6.0 | 5.6 |
| 101 | Goldrush (BA 87-102) | 5.3 | 4.7 | 6.0 | 5.7 | 5.0 | 6.0 | 91.3 | 5.3 | 5.0 | 5.7 | 6.0 | 5.3 | 6.0 | 6.0 | 5.6 |
| 102 | HV 242 | 5.3 | 4.7 | 6.0 | 4.0 | 5.0 | 6.0 | 96.0 | 4.3 | 4.3 | 5.3 | 5.0 | 5.7 | 6.3 | 6.3 | 5.3 |
| 103 | Kenblue | 5.7 | 6.3 | 8.3 | 4.3 | 6.0 | 6.0 | 99.0 | 4.3 | 4.3 | 5.3 | 5.7 | 4.7 | 5.7 | 6.3 | 5.2 |
| | $LSD_{0.05}$ | 1.2 | 1.6 | 0.7 | 1.4 | 1.4 | 1.0 | 11.8 | 1.6 | 1.4 | 1.5 | 1.5 | 1.2 | 1.2 | 1.3 | 0.8 |

Gcol (Genetic color): 9 = dark green and 1 = light green.
Leaf (Leaf texture): 9 = fine and 1 = coarse.
Grn (Greenup): 9 = best and 1 = poorest greenup.
Sden (spring density), Suden (summer density), Fden (fall density)
Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.

# Regional Tall Fescue Cultivar Evaluation - Established 1996

*Nick. E. Christians and James R. Dickson*

This was the first 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 $ft^2$) plots were established for each cultivar in the spring of 1996. The trial is maintained at a 2-inch mowing height, 3 lbs N/1000 $ft^2$ were applied during the growing season, and the area was irrigated when needed to prevent drought. Preemergence herbicide was applied once in the spring.

Seedling vigor (Svig) was rated on a 9 to 1 scale: 9 = best vigor and 1 = worst vigor. Turf quality was evaluated for May through October and was assessed on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable, and 1 = poorest quality. Genetic color (Gcol), greenup (Grnp), and leaf texture (Ltex) data also are included.

Initial establishment was poor due to damage in the winter of 1996-97 and none of the cultivars had a satisfactory quality rating for the entire season. The September and October ratings show that several of the varieties were well established by the fall of 1997.

**Table 1.** The 1997 ratings for the tall fescue regional cultivar trial.

| | | | | | | Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultivar | Svig | Gcol | Grnp | Ltex | May | June | July | Aug | Sept | Oct | Mean |
| 1 | Titan 2 | 8.0 | 6.7 | 6.7 | 5.3 | 6.0 | 5.3 | 4.3 | 5.7 | 6.0 | 6.0 | 5.6 |
| 2 | Shenandoah | 7.7 | 6.0 | 6.3 | 5.3 | 6.0 | 5.3 | 4.3 | 5.7 | 6.0 | 5.7 | 5.5 |
| 3 | Arid | 7.3 | 5.7 | 6.0 | 5.3 | 5.3 | 5.0 | 4.0 | 6.0 | 6.0 | 6.0 | 5.4 |
| 4 | Renegade | 8.0 | 6.3 | 7.0 | 6.0 | 5.7 | 5.0 | 4.3 | 5.7 | 5.3 | 6.0 | 5.3 |
| 5 | Kentucky-31 w/endo | 7.7 | 5.0 | 5.0 | 4.7 | 6.0 | 5.3 | 3.7 | 5.3 | 5.0 | 6.0 | 5.2 |
| 6 | Safari | 8.0 | 7.3 | 6.0 | 5.7 | 5.7 | 4.7 | 4.7 | 5.0 | 5.0 | 5.0 | 5.1 |
| 7 | CU9501T | 7.7 | 6.3 | 7.0 | 5.3 | 5.0 | 4.7 | 3.7 | 5.3 | 5.3 | 5.7 | 4.9 |
| 8 | DLF-1 | 7.0 | 6.0 | 6.7 | 5.7 | 5.3 | 5.0 | 3.7 | 5.0 | 5.3 | 5.3 | 4.9 |
| 9 | ISI-TF11 | 7.3 | 6.7 | 7.0 | 5.3 | 4.7 | 4.7 | 4.0 | 5.3 | 5.3 | 5.7 | 4.9 |
| 10 | Pixie E+ | 7.0 | 6.7 | 7.3 | 7.0 | 4.3 | 5.0 | 4.3 | 5.3 | 5.3 | 5.3 | 4.9 |
| 11 | AA-A91 | 7.3 | 7.0 | 7.3 | 6.3 | 5.3 | 4.7 | 4.0 | 5.0 | 5.0 | 5.0 | 4.8 |
| 12 | Crossfire II | 6.0 | 7.0 | 7.0 | 5.0 | 4.7 | 4.3 | 3.7 | 5.3 | 5.0 | 5.7 | 4.8 |
| 13 | Marksman | 7.3 | 7.0 | 7.3 | 5.3 | 4.7 | 5.0 | 4.3 | 5.3 | 5.0 | 4.7 | 4.8 |
| 14 | PST-523 | 7.0 | 6.0 | 6.7 | 6.0 | 5.3 | 5.0 | 4.3 | 4.7 | 4.7 | 4.7 | 4.8 |
| 15 | Regiment | 7.3 | 6.3 | 6.0 | 5.3 | 4.7 | 5.0 | 4.0 | 5.3 | 4.3 | 5.3 | 4.8 |
| 16 | Southern Choice | 7.7 | 6.7 | 7.7 | 6.0 | 5.7 | 5.0 | 4.0 | 5.0 | 4.3 | 5.0 | 4.8 |
| 17 | WVPB-1D | 6.3 | 6.7 | 6.3 | 5.7 | 5.0 | 4.7 | 3.7 | 5.3 | 4.7 | 5.3 | 4.8 |
| 18 | Duster | 7.0 | 7.0 | 7.3 | 5.3 | 5.0 | 4.7 | 3.7 | 4.7 | 4.3 | 5.7 | 4.7 |
| 19 | Milleniun (TMI-RBR) | 7.7 | 6.7 | 7.3 | 6.3 | 5.3 | 4.7 | 3.7 | 5.3 | 4.3 | 5.0 | 4.7 |
| 20 | Pennington-1901 | 7.3 | 6.3 | 7.3 | 5.7 | 5.0 | 4.0 | 4.0 | 5.0 | 4.7 | 5.7 | 4.7 |
| 21 | PST-R5AE | 7.0 | 7.0 | 6.7 | 6.3 | 5.0 | 4.3 | 4.0 | 5.3 | 4.7 | 5.0 | 4.7 |
| 22 | DP 7952 | 7.3 | 5.7 | 6.0 | 5.7 | 4.3 | 4.7 | 3.7 | 5.0 | 5.3 | 4.7 | 4.6 |
| 23 | Finelawn Petite | 6.7 | 7.0 | 6.7 | 5.3 | 5.3 | 4.0 | 63.7 | 4.7 | 4.7 | 5.3 | 4.6 |

| | Cultivar | Svig | Gcol | Grnp | Ltex | Quality May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Genesis | 7.7 | 7.0 | 6.7 | 6.0 | 4.07 | 5.0 | 4.0 | 4.7 | 4.7 | 4.7 | 4.6 |
| 25 | MB 216 | 7.0 | 7.3 | 7.3 | 5.7 | 5.0 | 4.3 | 3.7 | 4.7 | 5.0 | 5.0 | 4.6 |
| 26 | MB 28 | 7.7 | 7.0 | 6.7 | 6.0 | 5.0 | 4.7 | 4.0 | 4.3 | 4.7 | 5.0 | 4.6 |
| 27 | TMI-AZ | 7.0 | 6.3 | 6.7 | 6.0 | 4.3 | 4.3 | 4.0 | 5.0 | 4.7 | 5.0 | 4.6 |
| 28 | Falcon II | 7.7 | 6.3 | 7.3 | 6.7 | 5.0 | 4.7 | 3.7 | 5.0 | 4.0 | 4.7 | 4.5 |
| 29 | Mustang II | 7.0 | 6.7 | 6.0 | 5.7 | 4.7 | 5.0 | 3.3 | 5.0 | 4.0 | 5.0 | 4.5 |
| 30 | PC-AO | 7.3 | 6.7 | 7.0 | 6.3 | 4.7 | 4.3 | 4.0 | 4.7 | 4.7 | 4.7 | 4.5 |
| 31 | Shortstop II | 7.0 | 6.7 | 7.0 | 6.7 | 4.0 | 4.7 | 4.0 | 5.0 | 4.3 | 5.0 | 4.5 |
| 32 | SR 8210 | 7.3 | 6.7 | 7.0 | 5.3 | 4.7 | 4.0 | 3.7 | 5.3 | 4.7 | 4.7 | 4.5 |
| 33 | WVPB-1C | 7.3 | 6.3 | 6.7 | 5.7 | 5.0 | 4.7 | 3.3 | 4.7 | 4.3 | 5.0 | 4.5 |
| 34 | Bar FA6 US6F | 6.7 | 6.7 | 7.3 | 5.7 | 4.3 | 4.0 | 3.3 | 4.3 | 4.7 | 5.7 | 4.4 |
| 35 | Coronado | 6.3 | 7.0 | 7.0 | 6.7 | 4.7 | 4.3 | 3.7 | 4.7 | 4.7 | 4.3 | 4.4 |
| 36 | JTTFA-96 | 7.3 | 6.3 | 6.0 | 5.7 | 4.7 | 4.3 | 3.7 | 4.7 | 4.3 | 4.7 | 4.4 |
| 37 | JTTFC-96 | 7.0 | 6.3 | 6.3 | 5.7 | 4.7 | 4.7 | 3.3 | 4.7 | 4.7 | 4.7 | 4.4 |
| 38 | MB 29 | 6.7 | 7.0 | 8.0 | 6.0 | 4.7 | 4.3 | 3.7 | 4.3 | 4.3 | 5.3 | 4.4 |
| 39 | OF1-96-31 | 6.7 | 7.0 | 6.7 | 6.0 | 4.7 | 4.0 | 3.0 | 4.3 | 4.7 | 5.7 | 4.4 |
| 40 | Pick FA B-93 | 6.0 | 6.7 | 6.3 | 5.7 | 4.3 | 4.3 | 3.0 | 5.3 | 4.3 | 5.0 | 4.4 |
| 41 | RG-93 | 6.3 | 7.0 | 7.3 | 5.3 | 5.0 | 4.7 | 3.7 | 4.3 | 4.3 | 4.7 | 4.4 |
| 42 | ATF-038 | 5.7 | 6.7 | 7.0 | 5.7 | 4.3 | 4.3 | 3.3 | 4.3 | 4.3 | 5.0 | 4.3 |
| 43 | AV-1 | 6.3 | 6.3 | 6.0 | 5.3 | 4.3 | 4.3 | 3.3 | 4.7 | 4.7 | 4.3 | 4.3 |
| 44 | EC-101 | 7.3 | 6.3 | 7.7 | 6.0 | 4.3 | 4..3 | 3.7 | 4.3 | 4.3 | 5.0 | 4.3 |
| 45 | Equinox (Bullet) | 6.7 | 6.7 | 7.0 | 6.0 | 4.3 | 3.7 | 3.3 | 4.3 | 5.0 | 5.0 | 4.3 |
| 46 | Gazelle | 7.0 | 7.0 | 7.3 | 5.7 | 4.7 | 3.7 | 3.3 | 4.7 | 4.3 | 5.3 | 4.3 |
| 47 | J-101 | 6.7 | 7.0 | 7.0 | 5.7 | 4.3 | 4.7 | 3.3 | 4.3 | 4.3 | 4.7 | 4.3 |
| 48 | Leprchaun | 6.7 | 6.7 | 6.3 | 6.0 | 4.7 | 4.0 | 3.7 | 4.3 | 4.7 | 4.7 | 4.3 |
| 49 | MB 210 | 7.3 | 7.0 | 7.0 | 6.3 | 4.7 | 4.3 | 3.7 | 4.7 | 3.7 | 5.0 | 4.3 |
| 50 | MB 212 | 7.3 | 7.0 | 6.0 | 6.3 | 4.3 | 4.3 | 3.3 | 5.0 | 4.0 | 5.0 | 4.3 |
| 51 | OFI-931 | 7.0 | 6.7 | 6.7 | 5.7 | 4.3 | 4.3 | 3.7 | 4.7 | 4.3 | 4.7 | 4.3 |
| 52 | OFI-96-32 | 6.3 | 7.0 | 7.3 | 6.0 | 4.7 | 4.3 | 3.3 | 4.7 | 4.0 | 4.7 | 4.3 |
| 53 | PSII-TF-9 | 7.7 | 6.7 | 7.0 | 5.3 | 4.0 | 4.7 | 3.7 | 5.0 | 4.0 | 4.7 | 4.3 |
| 54 | PST-R5TK | 7.3 | 6.7 | 7.0 | 5.3 | 4.3 | 4.3 | 3.0 | 4.7 | 4.7 | 4.7 | 4.3 |
| 55 | TA-7 | 7.0 | 7.3 | 7.3 | 6.3 | 4.3 | 4.0 | 3.3 | 5.0 | 4.3 | 5.0 | 4.3 |
| 56 | TMI-FMN | 7.0 | 6.3 | 6.3 | 5.3 | 4.0 | 4.0 | 4.0 | 5.0 | 4.3 | 4.3 | 4.3 |
| 57 | Tulsa | 6.7 | 7.3 | 6.3 | 6.0 | 4.3 | 4.0 | 3.3 | 5.0 | 4.0 | 5.0 | 4.3 |
| 58 | WRS2 | 7.0 | 6.7 | 7.0 | 5.7 | 4.3 | 4.0 | 3.7 | 4.7 | 4.3 | 4.7 | 4.3 |
| 59 | ZPS-5LZ | 6.7 | 7.3 | 7.3 | 6.3 | 4.7 | 3.3 | 4.0 | 5.0 | 4.0 | 5.0 | 4.3 |
| 60 | AA-989 | 7.3 | 7.0 | 7.0 | 5.3 | 4.7 | 4.0 | 3.3 | 4.3 | 4.0 | 4.7 | 4.2 |
| 61 | Alamo E+ | 7.3 | 6.3 | 6.7 | 5.7 | 4.0 | 4.3 | 3.7 | 4.3 | 4.3 | 4.3 | 4.2 |
| 62 | ATF-253 | 6.3 | 6.0 | 6.0 | 5.3 | 4.3 | 4.7 | 3.3 | 4.0 | 4.3 | 4.3 | 4.2 |
| 63 | Coyote | 6.7 | 7.3 | 7.7 | 6.7 | 4.7 | 4.0 | 3.3 | 4.7 | 4.3 | 4.3 | 4.2 |
| 64 | EA 41 | 6.3 | 7.0 | 6.3 | 5.7 | 4.3 | 4.3 | 3.7 | 4.3 | 4.0 | 4.3 | 4.2 |
| 65 | Jaguar 3 | 6.3 | 6.7 | 7.3 | 6.0 | 4.0 | 4.0 | 3.7 | 4.3 | 4.3 | 4.7 | 4.2 |
| 66 | MB 213 | 6.7 | 7.0 | 7.7 | 6.0 | 4.3 | 4.0 | 3.3 | 4.7 | 4.0 | 4.7 | 4.2 |
| 67 | MB 214 | 7.0 | 7.3 | 7.0 | 6.0 | 4.3 | 4.3 | 3.3 | 4.3 | 4.0 | 4.7 | 4.2 |

| | Cultivar | Svig | Gcol | Grnp | Ltex | Quality May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | OFI-FWY | 6.0 | 7.0 | 7.0 | 6.3 | 3.7 | 4.0 | 3.7 | 4.7 | 4.0 | 5.0 | 4.2 |
| 69 | PSII-TF-10 | 7.0 | 7.0 | 6.7 | 5.7 | 4.3 | 4.0 | 3.3 | 4.7 | 4.3 | 4.7 | 4.2 |
| 70 | SRX 8084 | 7.3 | 6.0 | 7.0 | 6.3 | 4.3 | 4.3 | 3.7 | 4.0 | 4.0 | 4.7 | 4.2 |
| 71 | SRX 8500 | 7.0 | 7.0 | 7.0 | 7.0 | 3.7 | 4.0 | 3.7 | 4.7 | 4.3 | 5.0 | 4.2 |
| 72 | SS45DW | 7.0 | 6.3 | 7.3 | 6.3 | 5.0 | 4.0 | 3.3 | 4.7 | 4.0 | 4.3 | 4.2 |
| 73 | TMI-TW | 6.3 | 7.0 | 7.0 | 5.0 | 4.0 | 3.3 | 3.7 | 4.7 | 4.3 | 5.0 | 4.2 |
| 74 | WX3-275 | 6.7 | 6.7 | 6.7 | 6.0 | 4.3 | 4.0 | 3.7 | 4.7 | 4.7 | 4.0 | 4.2 |
| 75 | ATF-020 | 6.0 | 6.3 | 6.0 | 6.3 | 4.3 | 4.0 | 3.3 | 4.3 | 3.7 | 4.7 | 4.1 |
| 76 | ATF-192 | 6.3 | 6.3 | 6.7 | 5.3 | 3.7 | 4.0 | 3.3 | 1.7 | 4.0 | 5.0 | 4.1 |
| 77 | ATF-196 | 7.0 | 7.0 | 7.3 | 7.0 | 4.0 | 4.0 | 3.7 | 4.3 | 4.3 | 4.0 | 4.1 |
| 78 | BAR FA 6LV | 7.0 | 7.0 | 6.7 | 6.7 | 4.7 | 4.3 | 3.7 | 4.3 | 4.0 | 3.7 | 4.1 |
| 79 | BAR FA6 US2U | 6.3 | 7.0 | 7.0 | 7.3 | 4.3 | 4.0 | 3.3 | 4.3 | 4.3 | 4.0 | 4.1 |
| 80 | CU9502T | 7.3 | 6.0 | 6.7 | 7.0 | 4.3 | 4.0 | 3.7 | 4.0 | 4.3 | 4.3 | 4.1 |
| 81 | Empress | 6.3 | 7.0 | 7.3 | 6.3 | 4.0 | 4.0 | 3.0 | 4.7 | 4.3 | 4.7 | 4.1 |
| 82 | JSC-1 | 6.3 | 6.3 | 6.3 | 5.3 | 4.3 | 4.0 | 3.3 | 4.3 | 4.0 | 4.7 | 4.1 |
| 83 | KOOS 96-14 | 7.0 | 7.0 | 7.0 | 5.7 | 4.0 | 4.0 | 3.3 | 4.3 | 4.0 | 4.7 | 4.1 |
| 84 | Masterpiece (LTP-SD-TF) | 6.0 | 6.7 | 7.3 | 6.3 | 4.0 | 4.3 | 3.3 | 4.3 | 4.0 | 4.7 | 4.1 |
| 85 | MB 215 | 6.3 | 6.7 | 7.3 | 5.3 | 4.3 | 4.3 | 3.0 | 4.3 | 3.7 | 4.7 | 4.1 |
| 86 | PST-5M5 | 6.3 | 7.3 | 7.3 | 5.7 | 3.7 | 3.3 | 3.3 | 4.7 | 4.3 | 5.0 | 4.1 |
| 87 | PST-5RT | 7.3 | 7.0 | 7.0 | 6.0 | 4.0 | 4.3 | 3.3 | 4.3 | 4.3 | 4.0 | 4.1 |
| 88 | ZPS-2PTF | 6.0 | 7.0 | 6.7 | 6.0 | 4.3 | 3.3 | 3.3 | 4.7 | 4.3 | 4.3 | 4.1 |
| 89 | ATF-257 | 7.0 | 6.7 | 6.7 | 5.3 | 4.3 | 3.7 | 3.3 | 4.3 | 4.0 | 4.3 | 4.0 |
| 90 | Bonsai | 6.3 | 6.0 | 6.0 | 6.0 | 3.7 | 3.7 | 3.7 | 4.3 | 4.0 | 4.7 | 4.0 |
| 91 | Lion | 6.3 | 7.0 | 7.3 | 6.0 | 4.0 | 3.7 | 3.3 | 4.3 | 4.3 | 4.3 | 4.0 |
| 92 | PST-5E5 | 7.0 | 6.7 | 6.3 | 6.0 | 4.0 | 4.0 | 3.7 | 4.0 | 4.0 | 4.3 | 4.0 |
| 93 | Rmbrandt (LTP-4026 E+) | 6.7 | 7.0 | 7.3 | 6.7 | 3.7 | 3.7 | 3.3 | 4.3 | 4.3 | 4.7 | 4.0 |
| 94 | Tarheel | 7.7 | 6.3 | 6.7 | 6.3 | 4.0 | 3.7 | 3.3 | 4.7 | 4.0 | 4.3 | 4.0 |
| 95 | Apache II | 7.3 | 7.0 | 7.3 | 6.0 | 4.0 | 3.7 | 3.0 | 4.3 | 3.7 | 4.7 | 3.9 |
| 96 | ATF-022 | 6.0 | 7.0 | 7.3 | 5.0 | 4.0 | 3.3 | 3.3 | 4.3 | 4.0 | 4.3 | 3.9 |
| 97 | ATF-188 | 6.3 | 6.7 | 6.7 | 6.3 | 3.7 | 3.7 | 3.0 | 4.3 | 3.7 | 5.0 | 3.9 |
| 98 | J-98 | 6.3 | 7.0 | 7.0 | 6.7 | 3.7 | 4.0 | 3.3 | 4.3 | 4.0 | 4.3 | 3.9 |
| 99 | Pick FA 6-91 | 6.3 | 6.7 | 7.0 | 6.0 | 3.7 | 4.0 | 3.3 | 4.3 | 3.7 | 4.3 | 3.9 |
| 100 | PRO 8430 | 6.3 | 7.0 | 6.3 | 6.0 | 3.3 | 4.3 | 3.0 | 4.0 | 4.7 | 4.3 | 3.9 |
| 101 | SSDE31 | 7.0 | 6.7 | 6.3 | 6.0 | 4.7 | 4.3 | 3.3 | 4.3 | 3.0 | 3.7 | 3.9 |
| 102 | BAR FA6D USA | 6.3 | 7.3 | 6.7 | 6.0 | 4.3 | 4.0 | 3.0 | 4.0 | 3.7 | 4.0 | 3.8 |
| 103 | ISI-TF10 | 5.7 | 7.3 | 6.7 | 5.3 | 3.7 | 3.3 | 3.3 | 4.3 | 4.0 | 4.3 | 3.8 |
| 104 | ISI-TF9 | 7.0 | 6.7 | 6.7 | 5.0 | 4.0 | 3.7 | 3.0 | 4.3 | 3.7 | 4.3 | 3.8 |
| 105 | R5AU | 7.3 | 7.3 | 6.7 | 6.3 | 4.0 | 3.3 | 3.3 | 4.0 | 4.0 | 4.3 | 3.8 |
| 106 | TNI-N91 | 6.3 | 6.3 | 6.7 | 6.0 | 3.7 | 4.0 | 3.0 | 4.3 | 3.7 | 4.0 | 3.8 |
| 107 | Tomahwak -E | 6.7 | 7.0 | 7.3 | 6.7 | 4.0 | 3.0 | 2.7 | 4.3 | 4.3 | 4.3 | 3.8 |
| 108 | WVPB-1B | 5.7 | 7.0 | 6.3 | 6.0 | 3.7 | 3.7 | 3.3 | 4.0 | 3.7 | 4.7 | 3.8 |
| 109 | BAR FA 6D | 6.3 | 7.0 | 7.0 | 6.7 | 4.0 | 3.7 | 3.0 | 4.0 | 3.3 | 4.3 | 3.7 |

| | Cultivar | Svig | Gcol | Grnp | Ltex | Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | May | June | July | Aug | Sept | Oct | Mean |
| 110 | BAR FA6 US1 | 6.7 | 6.7 | 6.7 | 7.0 | 3.7 | 4.0 | 3.3 | 4.3 | 3.3 | 3.7 | 3.7 |
| 111 | BAR FA6 US3 | 6.0 | 7.0 | 7.3 | 6.3 | 4.3 | 3.3 | 3.7 | 4.3 | 3.7 | 3.0 | 3.7 |
| 112 | Cochise II | 6.0 | 6.7 | 6.7 | 6.0 | 3.3 | 3.3 | 3.3 | 4.0 | 4.0 | 4.3 | 3.7 |
| 113 | MB 211 | 6.0 | 7.0 | 7.0 | 6.0 | 4.3 | 3.7 | 3.0 | 3.7 | 3.7 | 3.7 | 3.7 |
| 114 | MB 26 | 6.7 | 7.3 | 7.0 | 6.3 | 4.0 | 3.7 | 3.3 | 4.0 | 3.7 | 3.7 | 3.7 |
| 115 | DP 50-9011 | 6.3 | 6.3 | 7.0 | 5.7 | 4.0 | 3.3 | 2.7 | 4.3 | 3.3 | 3.7 | 3.6 |
| 116 | OFI-951 | 6.0 | 7.0 | 6.7 | 6.7 | 3.7 | 3.7 | 3.0 | 4.0 | 3.3 | 4.0 | 3.6 |
| 117 | Pick GA-96 | 6.0 | 7.0 | 7.3 | 6.3 | 3.3 | 3.0 | 3.3 | 3.7 | 4.3 | 4.0 | 3.6 |
| 118 | Pick RT-95 | 6.0 | 6.7 | 7.0 | 6.7 | 3.3 | 3.3 | 3.3 | 3.7 | 4.0 | 4.0 | 3.6 |
| 119 | ATF-182 | 6.3 | 6.0 | 6.7 | 5.7 | 3.7 | 4.0 | 2.3 | 4.0 | 3.3 | 3.7 | 3.5 |
| 120 | Pick FA XK-95 | 6.3 | 7.3 | 7.3 | 6.7 | 3.3 | 3.0 | 3.0 | 3.7 | 4.0 | 4.0 | 3.5 |
| 121 | Pick FA 15-92 | 5.7 | 7.0 | 6.3 | 6.7 | 3.3 | 3.7 | 3.0 | 4.0 | 3.0 | 3.3 | 3.4 |
| 122 | Pick FA 20-92 | 6.3 | 7.0 | 7.0 | 7.0 | 3.7 | 3.3 | 3.0 | 4.0 | 3.3 | 3.3 | 3.4 |
| 123 | Sunpro | 5.7 | 7.0 | 7.0 | 5.7 | 3.3 | 3.7 | 2.7 | 4.0 | 3.3 | 3.7 | 3.4 |
| 124 | J-5 | 5.7 | 7.0 | 7.3 | 6.3 | 3.3 | 3.3 | 2.7 | 3.7 | 3.3 | 3.3 | 3.3 |
| 125 | AA-983 | 6.0 | 7.0 | 6.7 | 6.7 | 3.0 | 3.0 | 2.7 | 4.0 | 3.0 | 3.3 | 3.2 |
| 126 | Pick FA UT-93 | 5.7 | 7.0 | 7.3 | 7.3 | 3.0 | 2.7 | 2.7 | 3.7 | 3.7 | 3.3 | 3.2 |
| 127 | PST-5TO | 5.7 | 7.0 | 6.3 | 6.0 | 2.7 | 3.0 | 2.7 | 3.7 | 3.3 | 3.3 | 3.1 |
| 128 | J-3 | 5.7 | 7.0 | 7.0 | 5.7 | 3.0 | 3.3 | 2.0 | 3.0 | 3.0 | 3.3 | 2.9 |
| 129 | Pick FA N-93 | 6.0 | 7.3 | 6.7 | 6.7 | 2.7 | 3.0 | 2.3 | 3.3 | 3.0 | 3.3 | 2.9 |
| | $LSD_{0.05}$ | | 0.9 | 1.3 | 1.6 | 1.4 | 1.7 | 1.8 | 2.0 | 1.7 | 2.1 | 1.1 |

# Regional Fine Fescue Cultivar Evaluation - 1993

*Nick. E. Christians and James R. Dickson*

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

Visual quality was based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = worst quality. Data on spring greenup are also included.

**Table 1.** The 1998 quality ratings for the fineleaf fescue regional cultivar trial.

| | Cultivar | Species | Greenup | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PST-4VB Endo. | STC | 7.7 | 8.0 | 6.3 | 7.7 | 4.7 | 7.3 | 7.0 | 6.8 |
| 2 | Rondo | STC | 6.0 | 6.3 | 6.7 | 7.0 | 7.0 | 6.7 | 7.3 | 6.8 |
| 3 | Shadow II (PST-44D) | CF | 6.7 | 6.3 | 6.3 | 6.3 | 6.3 | 7.7 | 7.7 | 6.8 |
| 4 | Jasper (E) | STC | 7.3 | 7.0 | 6.7 | 6.7 | 6.0 | 7.0 | 6.7 | 6.7 |
| 5 | PST-4ST | STC | 7.0 | 7.3 | 6.0 | 7.0 | 6.3 | 7.0 | 6.3 | 6.7 |
| 6 | K-2 (MB 65-93) | CF | 7.3 | 8.0 | 6.0 | 6.3 | 5.7 | 6.3 | 6.3 | 6.4 |
| 7 | Victory (E) | CF | 6.7 | 6.3 | 6.7 | 6.3 | 6.7 | 6.3 | 6.0 | 6.4 |
| 8 | Victory II (PICK 4-91W) | CF | 6.3 | 6.7 | 5.7 | 5.7 | 5.3 | 6.7 | 7.7 | 6.3 |
| 9 | Aruba | STC | 6.7 | 6.3 | 6.3 | 8.0 | 4.7 | 6.0 | 5.7 | 6.2 |
| 10 | Banner III (MB 61-93) | CF | 7.0 | 6.7 | 5.3 | 5.7 | 5.7 | 6.7 | 7.3 | 6.2 |
| 11 | BAR UR 204 | STC | 6.0 | 6.3 | 5.7 | 7.0 | 6.0 | 6.3 | 6.0 | 6.2 |
| 12 | Shademaster II | STC | 7.0 | 6.7 | 6.7 | 6.7 | 4.7 | 6.3 | 6.0 | 6.2 |
| 13 | Banner II | CF | 6.0 | 6.3 | 5.7 | 5.7 | 6.3 | 6.3 | 6.0 | 6.1 |
| 14 | Columbra (MB 64-93) | CF | 7.7 | 6.7 | 5.7 | 6.0 | 6.0 | 6.7 | 5.3 | 6.1 |
| 15 | Jamestown II | CF | 6.3 | 6.7 | 6.0 | 5.7 | 6.0 | 6.0 | 6.3 | 6.1 |
| 16 | Medina | CF | 7.3 | 6.7 | 6.3 | 5.3 | 5.7 | 6.3 | 6.3 | 6.1 |
| 17 | PST-4DT | STC | 7.0 | 6.7 | 7.0 | 7.0 | 4.0 | 6.7 | 5.3 | 6.1 |
| 18 | Tiffany | CF | 6.7 | 6.0 | 5.7 | 6.7 | 5.3 | 6.3 | 6.3 | 6.1 |
| 19 | WX3-FF54 | CF | 6.3 | 7.0 | 5.7 | 5.7 | 6.0 | 6.0 | 6.3 | 6.1 |
| 20 | Brittany | CF | 6.7 | 7.0 | 5.7 | 6.0 | 6.0 | 5.3 | 6.0 | 6.0 |
| 21 | CAS-FR13 | STC | 7.7 | 6.7 | 5.7 | 6.3 | 5.3 | 6.3 | 5.7 | 6.0 |
| 22 | Flyer II (ZPS-4BN) | STC | 7.3 | 6.3 | 6.3 | 6.7 | 5.0 | 6.0 | 5.7 | 6.0 |
| 23 | Shadow (E) | CF | 7.0 | 6.7 | 5.7 | 5.7 | 5.7 | 6.7 | 5.7 | 6.0 |
| 24 | Treazure (ZPS-MG) | CF | 6.7 | 7.3 | 5.7 | 5.7 | 5.0 | 6.7 | 5.7 | 6.0 |
| 25 | ECO (MB 63-93) | CF | 6.0 | 6.7 | 5.3 | 5.7 | 5.3 | 6.7 | 6.0 | 5.9 |
| 26 | Discovery | HF | 6.0 | 6.7 | 6.3 | 6.7 | 4.0 | 5.7 | 5.7 | 5.8 |
| 27 | MB 82-93 | HF | 7.0 | 6.3 | 6.0 | 5.3 | 5.3 | 5.3 | 6.7 | 5.8 |
| 28 | Common Creeping | STC | 7.7 | 6.7 | 5.3 | 6.0 | 4.3 | 6.0 | 5.7 | 5.7 |
| 29 | Dawson | SLC | 5.3 | 5.3 | 6.3 | 6.7 | 4.7 | 5.3 | 5.7 | 5.7 |
| 30 | ISI-FC-62 | CF | 7.3 | 6.7 | 5.7 | 5.3 | 5.3 | 6.3 | 4.7 | 5.7 |
| 31 | Bridgeport | CF | 6.7 | 6.3 | 5.7 | 6.0 | 5.0 | 5.3 | 5.3 | 5.6 |
| 32 | Molinda | CF | 6.7 | 6.0 | 5.7 | 5.3 | 6.3 | 5.3 | 5.0 | 5.6 |

| | Cultivar | Species | Greenup | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 33 | NJ F-93 | CF | 6.0 | 5.3 | 5.3 | 5.3 | 5.3 | 6.3 | 6.0 | 5.6 |
| 34 | SR 5100 | CF | 5.7 | 5.7 | 5.7 | 5.7 | 4.7 | 6.0 | 5.7 | 5.6 |
| 35 | BAR FRR 4ZBD | STC | 7.7 | 6.7 | 6.0 | 6.3 | 5.7 | 4.3 | 4.0 | 5.5 |
| 36 | Flyer | STC | 6.3 | 6.3 | 6.0 | 6.0 | 4.7 | 4.7 | 5.3 | 5.5 |
| 37 | Darwin | CF | 7.3 | 5.0 | 6.0 | 5.7 | 4.7 | 6.7 | 4.3 | 5.4 |
| 38 | Ecostar | HF | 5.7 | 5.7 | 6.3 | 5.7 | 4.0 | 6.7 | 4.3 | 5.4 |
| 39 | MB 66-93 | CF | 5.3 | 5.3 | 6.0 | 6.3 | 5.0 | 4.3 | 5.0 | 5.4 |
| 40 | Osprey (PRO 92/24) | HF | 5.7 | 6.0 | 6.7 | 6.0 | 3.7 | 5.3 | 4.7 | 5.4 |
| 41 | Quatro | SF | 6.0 | 5.3 | 6.0 | 5.7 | 5.3 | 5.7 | 4.3 | 5.4 |
| 42 | Seabreeze | SLC | 6.3 | 5.7 | 6.3 | 6.0 | 5.0 | 4.7 | 4.7 | 5.4 |
| 43 | WX3-FFG6 | STC | 6.7 | 6.0 | 5.7 | 5.7 | 5.0 | 6.0 | 4.0 | 5.4 |
| 44 | Sandpiper (PRO 92/20) | CF | 6.3 | 5.3 | 5.3 | 6.0 | 5.0 | 4.7 | 4.7 | 5.2 |
| 45 | Defiant (MB 81-93) | HF | 6.0 | 5.3 | 5.3 | 5.7 | 4.0 | 5.3 | 4.3 | 5.0 |
| 46 | Jamestown | CF | 6.0 | 6.0 | 5.3 | 5.7 | 3.7 | 4.7 | 4.7 | 5.0 |
| 47 | TMI-3CE | CF | 6.3 | 5.3 | 5.0 | 5.3 | 4.3 | 5.0 | 5.0 | 5.0 |
| 48 | Reliant II | HF | 5.0 | 5.0 | 5.7 | 6.0 | 4.0 | 4.7 | 4.3 | 4.9 |
| 49 | SR 3100 | HF | 5.3 | 4.7 | 6.3 | 6.0 | 3.3 | 4.7 | 4.3 | 4.9 |
| 50 | Aurora w/endo | HF | 5.3 | 5.3 | 5.3 | 5.0 | 3.7 | 4.7 | 4.0 | 4.7 |
| 51 | Pamela | HF | 5.7 | 5.3 | 5.7 | 4.7 | 4.3 | 4.0 | 4.0 | 4.7 |
| 52 | Brigade | HF | 5.7 | 5.0 | 5.0 | 5.0 | 4.3 | 4.3 | 4.0 | 4.6 |
| 53 | Vernon (MB 83-93) | HF | 5.3 | 4.3 | 5.3 | 5.3 | 3.7 | 5.3 | 3.3 | 4.6 |
| 54 | Nordic | HF | 5.0 | 4.7 | 5.0 | 5.0 | 4.3 | 4.0 | 4.0 | 4.5 |
| 55 | Silverlawn (WVPB-STCR-101) | HF | 6.7 | 5.3 | 4.7 | 4.7 | 4.3 | 4.3 | 3.7 | 4.5 |
| 56 | Spartan | HF | 6.0 | 5.3 | 4.7 | 5.0 | 4.3 | 4.0 | 3.3 | 4.4 |
| 57 | Cascade | CF | 5.7 | 4.7 | 5.0 | 5.0 | 4.0 | 4.0 | 3.3 | 4.3 |
| 58 | Scaldis | HF | 5.7 | 5.0 | 4.7 | 5.3 | 3.7 | 3.7 | 3.0 | 4.2 |
| 59 | 67135 | SF | 4.7 | 4.7 | 4.7 | 4.3 | 3.3 | 4.3 | 3.0 | 4.1 |
| | $LSD_{(0.05)}$ | | 1.4 | 1.3 | 2.7 | 1.0 | 2.2 | 1.9 | 1.7 | 0.7 |

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

Spring greenup (Greenup): 9 = dark green and 1 = light green.

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

NS = not significant at the 0.05 level.

# Perennial Ryegrass Study - Established 1994

*James R. Dickson and Nick E. Christians*

This trial began in the fall of 1994 with the establishment of 96 cultivars of perennial ryegrass at the Iowa State University Horticulture Research Station. The study was established on an irrigated area that was maintained at a 2-inch mowing height and fertilized with 3 to 4 lb. N/1000 $ft^2$/yr. The area receives preemergence herbicide in the spring and was treated with a broadleaf herbicide in September of 1994.

Cultivars were evaluated for turf quality each month of the growing season. Visual quality was based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. The values listed under each month in Table 1 are the averages of ratings made on three replicated plots for the three studies. Yearly means of data from each month are listed in the last column. The cultivars are listed in descending order of average quality. Data on genetic color (Gcol), greenup (Grn), and leaf texture (Leaf) also are included.

Notice that the first 77 cultivars received mean ratings of 6 or above for the 1997 season. There is now a wide selection of high-quality perennial ryegrass varieties to choose from for this region. Perennial ryegrass is quite susceptible to winter damage. There was no winter damage in the spring of 1997. Last year's report contains information on the effect of winter damage.

**Table 1.** The 1997 quality and other ratings for the national perennial ryegrass study established in 1994.

| | Cultivar | Gcol | Grn | Leaf | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Premier II (Bar USA 94-II) | 6.0 | 6.3 | 5.7 | 6.0 | 7.0 | 6.3 | 7.0 | 8.0 | 7.3 | 6.9 |
| 2 | Riviera II | 5.0 | 6.3 | 5.0 | 6.7 | 6.3 | 6.7 | 6.7 | 7.7 | 7.3 | 6.9 |
| 3 | Secretariat (RPBD) | 5.7 | 6.3 | 5.7 | 6.3 | 7.0 | 6.7 | 7.0 | 7.0 | 7.3 | 6.9 |
| 4 | Manhattan 3 | 5.7 | 5.7 | 5.0 | 6.3 | 6.7 | 6.0 | 6.3 | 7.7 | 7.7 | 6.8 |
| 5 | Divine | 5.7 | 6.3 | 4.7 | 6.7 | 6.3 | 6.7 | 6.7 | 7.0 | 7.0 | 6.7 |
| 6 | Line Drive (MB 47) | 5.7 | 6.3 | 5.3 | 6.3 | 5.7 | 5.7 | 7.0 | 8.0 | 7.7 | 6.7 |
| 7 | Majesty (MB 43) | 5.7 | 6.0 | 5.7 | 6.3 | 7.0 | 6.0 | 6.3 | 7.3 | 7.3 | 6.7 |
| 8 | Palmer III (LRF-94-MPRH) | 6.0 | 5.3 | 5.0 | 6.0 | 6.3 | 6.3 | 7.0 | 7.3 | 7.0 | 6.7 |
| 9 | Wind Star (PST-28M) | 5.0 | 6.3 | 5.0 | 6.0 | 7.0 | 6.3 | 7.0 | 7.0 | 6.7 | 6.7 |
| 10 | Calypso II | 5.0 | 5.7 | 5.3 | 6.0 | 6.0 | 6.3 | 6.0 | 7.7 | 7.3 | 6.6 |
| 11 | ISI-MHB | 4.7 | 5.3 | 5.0 | 6.3 | 7.0 | 6.3 | 6.7 | 6.7 | 6.7 | 6.6 |
| 12 | Mardigras (ZPS-2NV) | 4.7 | 5.7 | 5.3 | 6.3 | 6.0 | 7.0 | 6.3 | 6.7 | 7.0 | 6.6 |
| 13 | MB 45 | 6.0 | 5.7 | 5.0 | 6.3 | 6.3 | 5.3 | 6.0 | 7.7 | 7.7 | 6.6 |
| 14 | Passport (PST-2FF) | 5.0 | 6.3 | 5.0 | 6.7 | 7.0 | 6.0 | 6.7 | 6.7 | 6.7 | 6.6 |
| 15 | Prizm | 5.3 | 6.0 | 5.3 | 6.0 | 6.7 | 6.0 | 7.0 | 7.0 | 7.0 | 6.6 |
| 16 | Assure | 5.0 | 7.0 | 5.3 | 6.7 | 5.7 | 6.3 | 6.3 | 7.0 | 7.0 | 6.5 |
| 17 | Blackhawk (TMI-EXFLP94) | 4.7 | 5.7 | 5.0 | 6.7 | 6.0 | 6.3 | 6.7 | 6.7 | 6.7 | 6.5 |
| 18 | Caddieshack (MED 5071) | 5.3 | 6.0 | 5.0 | 5.7 | 6.3 | 6.3 | 7.3 | 6.7 | 6.7 | 6.5 |
| 19 | Elf | 5.7 | 7.0 | 6.0 | 6.3 | 6.7 | 6.0 | 6.7 | 6.7 | 6.7 | 6.5 |
| 20 | J-1706 | 5.3 | 5.7 | 5.3 | 5.0 | 5.7 | 6.3 | 6.7 | 7.7 | 7.7 | 6.5 |
| 21 | SR 4200 | 4.7 | 6.3 | 5.0 | 6.3 | 6.7 | 5.7 | 7.0 | 6.3 | 7.0 | 6.5 |
| 22 | Stallion Select | 5.0 | 6.7 | 5.0 | 6.0 | 6.7 | 6.3 | 7.0 | 6.3 | 6.7 | 6.5 |

| | Cultivar | Gcol | Grn | Leaf | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Wizard (MB 41) | 5.7 | 7.0 | 5.3 | 6.3 | 7.0 | 6.0 | 6.3 | 6.7 | 6.7 | 6.5 |
| 24 | DLP 1305 | 4.0 | 6.3 | 5.0 | 6.3 | 6.7 | 6.0 | 5.7 | 6.7 | 7.0 | 6.4 |
| 25 | Excel (MB 1-5) | 5.7 | 7.0 | 5.3 | 6.0 | 6.7 | 5.0 | 6.0 | 7.3 | 7.3 | 6.4 |
| 26 | Express | 4.0 | 6.0 | 5.0 | 6.0 | 6.3 | 6.0 | 6.3 | 6.7 | 7.0 | 6.4 |
| 27 | MB 44 | 6.0 | 5.7 | 5.7 | 5.3 | 6.7 | 6.0 | 6.3 | 7.0 | 7.0 | 6.4 |
| 28 | Omega3 (ZPS-2DR-94) | 5.7 | 6.0 | 5.3 | 6.0 | 6.0 | 6.0 | 6.3 | 7.0 | 7.0 | 6.4 |
| 29 | Panther (ZPS-PR1) | 5.3 | 5.7 | 5.7 | 6.0 | 6.3 | 5.7 | 7.3 | 6.7 | 6.3 | 6.4 |
| 30 | Pennant II (MB 42) | 6.0 | 5.3 | 5.0 | 5.7 | 5.3 | 6.0 | 6.3 | 7.7 | 7.7 | 6.4 |
| 31 | R2 (ISI-R2) | 4.3 | 5.7 | 5.0 | 5.7 | 6.3 | 6.0 | 7.0 | 6.3 | 7.3 | 6.4 |
| 32 | Sonata (PST-2R3) | 5.3 | 5.3 | 5.7 | 5.0 | 5.7 | 6.0 | 6.7 | 7.7 | 7.3 | 6.4 |
| 33 | SR 4400 (SRX 4400) | 4.3 | 5.7 | 5.0 | 5.7 | 6.0 | 7.0 | 6.3 | 7.0 | 6.7 | 6.4 |
| 34 | Top Hat | 5.0 | 5.7 | 5.7 | 6.3 | 6.3 | 6.7 | 7.0 | 6.0 | 6.3 | 6.4 |
| 35 | WVPB 92-4 | 4.3 | 6.0 | 5.0 | 5.7 | 6.7 | 6.7 | 6.0 | 6.7 | 6.7 | 6.4 |
| 36 | WVPB-PR-C-2 | 5.0 | 6.0 | 5.0 | 6.3 | 7.3 | 5.7 | 6.3 | 6.3 | 6.7 | 6.4 |
| 37 | Accent | 5.0 | 5.3 | 5.0 | 5.7 | 6.3 | 6.0 | 7.0 | 6.3 | 6.7 | 6.3 |
| 38 | APR 106 | 4.3 | 5.7 | 5.0 | 5.3 | 6.3 | 6.3 | 6.7 | 6.7 | 6.3 | 6.3 |
| 39 | Blazer III (Pick 928) | 4.7 | 5.7 | 5.3 | 5.3 | 6.3 | 6.0 | 6.0 | 7.0 | 7.0 | 6.3 |
| 40 | Brightstar | 5.3 | 5.0 | 5.0 | 5.3 | 5.7 | 6.3 | 5.7 | 7.3 | 7.3 | 6.3 |
| 41 | CAS-LP23 | 5.3 | 6.3 | 5.3 | 6.0 | 6.0 | 6.0 | 6.0 | 7.0 | 6.7 | 6.3 |
| 42 | Legacy II (Lesco-TWF) | 5.7 | 5.3 | 5.0 | 6.0 | 5.7 | 5.7 | 6.7 | 6.7 | 7.0 | 6.3 |
| 43 | Night Hawk | 5.0 | 6.0 | 5.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.7 | 7.0 | 6.3 |
| 44 | Nobility | 4.7 | 5.0 | 5.0 | 5.3 | 6.3 | 5.7 | 6.7 | 6.7 | 7.0 | 6.3 |
| 45 | Omni | 5.0 | 5.7 | 5.3 | 5.7 | 6.0 | 6.3 | 6.3 | 6.3 | 7.0 | 6.3 |
| 46 | Precision | 4.3 | 6.0 | 5.0 | 6.3 | 6.0 | 6.3 | 6.3 | 6.7 | 6.3 | 6.3 |
| 47 | PS-D-9 | 5.3 | 5.3 | 5.3 | 5.7 | 6.0 | 6.3 | 6.7 | 6.3 | 7.0 | 6.3 |
| 48 | Saturn II (ZPS-2ST) | 5.7 | 6.3 | 5.0 | 6.3 | 6.0 | 5.7 | 6.3 | 6.7 | 7.0 | 6.3 |
| 49 | WX3-93 | 5.0 | 5.0 | 5.7 | 5.7 | 6.0 | 6.0 | 6.0 | 7.0 | 7.0 | 6.3 |
| 50 | Academy (PC-93-1) | 5.0 | 5.3 | 5.0 | 5.3 | 6.0 | 5.7 | 6.3 | 6.7 | 7.0 | 6.2 |
| 51 | Achiever | 5.3 | 6.0 | 5.0 | 5.7 | 6.3 | 6.0 | 5.7 | 6.7 | 6.7 | 6.2 |
| 52 | Advantage | 5.7 | 5.3 | 5.0 | 5.0 | 6.0 | 5.7 | 6.7 | 7.0 | 6.7 | 6.2 |
| 53 | Catalina (PST-GH-94) | 5.7 | 5.0 | 5.7 | 5.3 | 5.3 | 6.0 | 6.3 | 7.3 | 7.0 | 6.2 |
| 54 | Cutter | 5.0 | 5.3 | 5.0 | 5.7 | 5.7 | 6.7 | 6.0 | 6.3 | 7.0 | 6.2 |
| 55 | Esquire | 5.0 | 5.7 | 5.0 | 5.7 | 6.7 | 6.0 | 6.0 | 6.0 | 6.7 | 6.2 |
| 56 | MVF-4-1 | 4.7 | 6.3 | 5.3 | 6.0 | 5.7 | 6.3 | 6.0 | 6.3 | 6.7 | 6.2 |
| 57 | Navajo | 5.0 | 6.7 | 5.0 | 6.3 | 5.7 | 5.3 | 6.0 | 7.0 | 7.0 | 6.2 |
| 58 | Pick LP 102-92 | 6.0 | 5.7 | 5.3 | 6.0 | 5.3 | 5.7 | 6.7 | 6.7 | 6.7 | 6.2 |
| 59 | SR 4010 (SRX 4010) | 4.7 | 5.7 | 5.0 | 5.3 | 5.3 | 6.7 | 7.3 | 6.3 | 6.3 | 6.2 |
| 60 | Stallion Supreme (PSI-E-1) | 5.0 | 5.7 | 5.3 | 5.7 | 5.7 | 5.7 | 6.0 | 7.0 | 7.0 | 6.2 |
| 61 | Stardance (PST-2FE) | 5.3 | 5.7 | 5.0 | 5.0 | 5.7 | 6.0 | 6.0 | 7.3 | 7.3 | 6.2 |
| 62 | Top Gun (J-1703) | 5.0 | 6.0 | 5.0 | 5.3 | 6.0 | 6.0 | 6.3 | 6.7 | 7.0 | 6.2 |
| 63 | Williamsburg | 4.3 | 6.3 | 5.3 | 5.7 | 7.0 | 5.7 | 6.3 | 6.3 | 6.3 | 6.2 |
| 64 | WVPB-93-KFK | 5.0 | 6.0 | 5.0 | 6.0 | 6.7 | 5.7 | 6.0 | 6.3 | 6.7 | 6.2 |

| | Cultivar | Gcol | Grn | Leaf | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | APR 066 | 4.7 | 5.0 | 5.0 | 5.3 | 5.7 | 6.3 | 6.3 | 6.0 | 6.7 | 6.1 |
| 66 | BAR ER 5813 | 4.7 | 5.0 | 5.0 | 5.0 | 6.7 | 5.0 | 6.0 | 7.0 | 7.0 | 6.1 |
| 67 | Brightstar II (PST-2M3) | 6.0 | 5.3 | 5.3 | 5.0 | 5.3 | 5.3 | 6.3 | 7.3 | 7.0 | 6.1 |
| 68 | Citation III (PST-2DGR) | 5.7 | 6.0 | 5.3 | 5.7 | 5.0 | 5.7 | 6.0 | 7.0 | 7.3 | 6.1 |
| 69 | Edge | 5.0 | 6.3 | 5.0 | 5.7 | 6.3 | 6.0 | 5.3 | 6.3 | 6.7 | 6.1 |
| 70 | Head Start (Pick PR 84-91) | 5.0 | 4.7 | 5.0 | 5.0 | 5.7 | 6.0 | 5.3 | 7.3 | 7.0 | 6.1 |
| 71 | Koos 93-6 | 4.7 | 5.3 | 5.3 | 5.7 | 6.0 | 6.0 | 6.0 | 6.3 | 6.3 | 6.1 |
| 72 | Pegasus | 4.7 | 6.0 | 5.0 | 5.7 | 5.7 | 6.0 | 6.0 | 6.7 | 6.7 | 6.1 |
| 73 | Quickstart | 4.7 | 6.3 | 5.0 | 5.3 | 5.7 | 6.3 | 6.7 | 6.3 | 6.3 | 6.1 |
| 74 | Vivid | 5.0 | 4.7 | 5.0 | 5.3 | 5.3 | 6.3 | 6.0 | 6.3 | 7.0 | 6.1 |
| 75 | Wind Dancer (MB 46) | 5.7 | 5.0 | 5.3 | 5.3 | 6.0 | 5.7 | 6.3 | 6.3 | 6.7 | 6.1 |
| 76 | Dancer | 5.0 | 5.3 | 5.3 | 5.0 | 6.3 | 5.3 | 6.0 | 6.7 | 6.7 | 6.0 |
| 77 | PST-2CB | 5.3 | 6.7 | 5.0 | 5.0 | 5.3 | 6.0 | 6.3 | 6.7 | 6.7 | 6.0 |
| 78 | APR 124 | 4.7 | 5.3 | 5.0 | 5.0 | 6.0 | 6.3 | 5.7 | 6.0 | 6.7 | 5.9 |
| 79 | APR 131 | 4.7 | 5.7 | 5.0 | 5.7 | 5.3 | 5.7 | 6.3 | 6.3 | 6.3 | 5.9 |
| 80 | Chaparral (PST-2DLM) | 6.0 | 5.7 | 5.0 | 4.7 | 5.7 | 6.0 | 6.0 | 6.7 | 6.3 | 5.9 |
| 81 | Imagine | 5.7 | 5.3 | 4.7 | 4.3 | 5.7 | 5.7 | 6.0 | 7.0 | 7.0 | 5.9 |
| 82 | Koos 93-3 | 4.7 | 5.7 | 5.0 | 4.7 | 6.0 | 5.3 | 6.7 | 6.3 | 6.3 | 5.9 |
| 83 | Morning Star | 4.7 | 5.7 | 5.0 | 5.3 | 6.0 | 6.3 | 6.3 | 5.7 | 6.0 | 5.9 |
| 84 | Repell III (LRF-94-C7) | 6.0 | 5.3 | 5.7 | 4.7 | 5.7 | 5.3 | 6.0 | 7.0 | 7.0 | 5.9 |
| 85 | Saturn | 4.0 | 6.3 | 5.0 | 5.7 | 5.3 | 5.3 | 5.7 | 6.7 | 6.7 | 5.9 |
| 86 | Figaro | 4.7 | 5.3 | 5.3 | 4.7 | 6.0 | 5.3 | 5.7 | 6.3 | 6.7 | 5.8 |
| 87 | Laredo | 5.7 | 5.3 | 5.3 | 4.7 | 5.3 | 5.7 | 6.3 | 6.3 | 6.7 | 5.8 |
| 88 | LRF-94-CB | 6.0 | 6.0 | 5.0 | 5.3 | 6.0 | 5.0 | 6.0 | 6.3 | 6.3 | 5.8 |
| 89 | Prelude III (LRF-94-86) | 6.0 | 5.7 | 5.3 | 5.0 | 5.7 | 5.3 | 5.7 | 6.0 | 7.0 | 5.8 |
| 90 | WX3-91 | 4.7 | 6.3 | 4.7 | 5.3 | 6.0 | 5.0 | 5.7 | 6.0 | 6.0 | 5.7 |
| 91 | Roadrunner (PST-2ET) | 5.3 | 6.0 | 5.0 | 5.0 | 4.7 | 5.3 | 6.0 | 6.3 | 6.3 | 5.6 |
| 92 | Nine-o-one | 5.3 | 6.0 | 5.7 | 4.7 | 4.7 | 5.3 | 5.7 | 6.0 | 6.7 | 5.5 |
| 93 | DSV NA 9401 | 4.0 | 4.7 | 5.0 | 5.0 | 5.0 | 3.7 | 5.7 | 5.3 | 5.7 | 5.1 |
| 94 | DSV NA 9402 | 4.0 | 4.7 | 5.0 | 4.3 | 5.7 | 4.0 | 5.0 | 5.3 | 6.0 | 5.1 |
| 95 | Pennfine | 4.0 | 5.3 | 4.7 | 4.3 | 4.3 | 6.3 | 4.3 | 4.3 | 4.3 | 4.7 |
| 96 | Linn | 3.3 | 3.0 | 4.3 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 4.0 | 3.3 |
| | $LSD_{(0.05)}$ | 0.7 | 2.6 | 1.1 | 1.9 | 2.1 | 1.4 | 1.3 | 0.9 | 1.0 | 0.7 |

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

# Shade Adaptation Study - 1997

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

The first shade adaptation study was established in the fall of 1987 to evaluate the performance of 35 species and cultivars of grasses. The data included below is from the 10th complete season. The species include chewings fescue (C.F.), creeping red fescue (C.R.F.), hard fescue (H.F.), tall fescue (T.F.), Kentucky bluegrass (K.B., and rough bluegrass (*Poa trivialis*).

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

Monthly quality data are collected from May through October (Table 1). Visual quality was based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = worst quality. This trial has been observed through the extremes of the drought year 1988 and the very wet conditions of 1993. Turf quality among species varied greatly with moisture conditions. In dry weather, the fine fescues, especially the hard fescues, do well, whereas rough bluegrass quickly deteriorates. In extended wet periods, rough bluegrass does very well. Some of the tall fescues and chewings fescues also tend to perform better in wet conditions. The 1997 season began with high rainfall and cool temperatures and ended cool and dry.

A second shade trial was added adjacent to the original trial 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.* Data are collected in the same way (Table 2). The lower ratings in this trial are due to a greater shade in the second trial. Overhanging branches were trimmed late in the 1997 season to improve turf quality.

**Table 1.** 1997 Visual quality[1] data for turfgrass culitvars in the Shade Trial established in 1987.

| | Cultivar | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|
| 1. | Victor (C.F.) | 6.3 | 7.0 | 6.0 | 7.7 | 7.7 | 7.7 | 7.1 |
| 2. | Shadow (C.F.) | 6.0 | 6.0 | 6.0 | 6.3 | 7.7 | 7.3 | 6.6 |
| 3. | Atlanta (C.F.) | 5.7 | 7.3 | 6.3 | 6.3 | 7.0 | 6.7 | 6.6 |
| 4. | Waldorf (C.F.) | 6.0 | 6.3 | 6.3 | 6.7 | 7.3 | 7.0 | 6.6 |
| 5. | Banner (C.F.) | 6.0 | 6.3 | 6.0 | 5.7 | 7.0 | 6.7 | 6.3 |
| 6. | Pennlawn (C.R.F.) | 5.7 | 6.3 | 5.7 | 6.0 | 6.7 | 6.7 | 6.2 |
| 7. | Mary (C.F.) | 6.3 | 6.0 | 5.7 | 6.0 | 6.7 | 6.7 | 6.2 |
| 8. | Jamestown (C.F.) | 6.0 | 6.7 | 5.0 | 5.3 | 6.7 | 6.7 | 6.1 |
| 9. | Wintergreen (C.F.) | 5.3 | 6.0 | 6.0 | 6.0 | 6.3 | 6.0 | 5.9 |
| 10. | Waldina (H.F.) | 4.7 | 5.0 | 5.7 | 6.3 | 7.0 | 6.7 | 5.9 |
| 11. | Bar Fo 81-225 (H.F.) | 5.0 | 5.7 | 6.0 | 6.0 | 6.3 | 6.7 | 5.9 |
| 12. | St-2 (SR3000) (H.F.) | 4.7 | 5.7 | 6.0 | 6.3 | 6.0 | 6.3 | 5.8 |
| 13. | Agram (C.F.) | 5.3 | 5.3 | 5.3 | 5.7 | 6.0 | 6.0 | 5.6 |
| 14. | Koket (C.F.) | 4.7 | 5.7 | 4.7 | 5.3 | 6.3 | 5.7 | 5.4 |
| 15. | Biljart (H.F.) | 4.0 | 4.7 | 5.3 | 5.3 | 5.3 | 5.7 | 5.1 |
| 16. | Highlight (C.F.) | 4.7 | 4.7 | 5.0 | 5.0 | 5.7 | 5.7 | 5.1 |
| 17. | Sabre (*Poa trivialis*) | 4.0 | 5.7 | 6.3 | 5.0 | 5.3 | 3.7 | 5.0 |
| 18. | Reliant (H.F.) | 5.0 | 5.0 | 5.0 | 4.3 | 5.3 | 5.3 | 5.0 |
| 19. | Ensylva (C.R.F.) | 4.3 | 4.3 | 4.7 | 4.3 | 6.0 | 5.7 | 4.9 |
| 20. | Spartan (H.F.) | 3.7 | 4.0 | 5.0 | 5.0 | 5.7 | 5.7 | 4.8 |
| 21. | Scaldis (H.F.) | 4.3 | 5.0 | 4.3 | 3.7 | 4.7 | 5.3 | 4.6 |
| 22. | Rebel (T.F.) | 3.7 | 4.7 | 4.7 | 4.0 | 4.7 | 5.3 | 4.5 |

| | Cultivar | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|
| 23. | Estica (C.R.F.) | 3.0 | 4.0 | 3.7 | 4.7 | 5.0 | 5.3 | 4.3 |
| 24. | Falcon (T.F.) | 3.7 | 5.7 | 3.7 | 3.7 | 4.3 | 4.3 | 4.2 |
| 25. | Rebel II (T.F.) | 3.3 | 4.3 | 4.3 | 3.7 | 5.0 | 4.0 | 4.1 |
| 26. | Bonanza (T.F.) | 2.7 | 4.7 | 4.0 | 3.7 | 5.0 | 4.3 | 4.1 |
| 27. | Midnight (K.B.) | 2.3 | 4.3 | 3.7 | 4.0 | 4.7 | 4.3 | 3.9 |
| 28. | Coventry (K.B.) | 2.7 | 4.0 | 3.7 | 3.3 | 3.3 | 4.0 | 3.5 |
| 29. | Apache (T.F.) | 2.3 | 3.3 | 3.0 | 3.0 | 4.0 | 3.7 | 3.2 |
| 30. | Ram I (K.B.) | 2.0 | 2.7 | 3.0 | 2.3 | 2.7 | 3.7 | 2.7 |
| 31. | Arid (T.F.) | 3.0 | 3.0 | 3.0 | 2.7 | 2.3 | 2.0 | 2.7 |
| 32. | Bristol (K.B.) | 2.3 | 3.0 | 2.7 | 2.0 | 2.7 | 2.0 | 2.4 |
| 33. | Glade (K.B.) | 2.0 | 2.7 | 2.7 | 2.0 | 2.3 | 2.3 | 2.3 |
| 34. | Nassau (K.B.) | 2.0 | 2.3 | 2.0 | 1.7 | 2.0 | 2.0 | 2.0 |
| 35. | Chateau (K.B.) | 2.0 | 2.0 | 1.7 | 1.7 | 2.0 | 2.0 | 1.9 |
| | $LSD_{0.05}$ | 1.5 | 2.1 | 2.0 | 2.3 | 2.2 | 1.8 | 1.7 |

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

**Table 2.** 1997 Visual quality[1] data for turfgrass culitvars in the Shade Trial established in 1994.

| | Cultivar | May | June | July | Aug | Sept | Oct | Mean |
|---|---|---|---|---|---|---|---|---|
| 1. | SR 5100 (C.F.) | 5.0 | 5.7 | 4.7 | 5.0 | 5.3 | 5.3 | 5.2 |
| 2. | Bridgeport (C.F.) | 5.0 | 5.0 | 4.3 | 4.7 | 5.7 | 5.7 | 5.1 |
| 3. | Saber (*Poa trivialis*) | 5.7 | 5.3 | 5.0 | 4.7 | 5.0 | 4.0 | 4.9 |
| 4. | Waldina (H.F.) | 4.7 | 5.3 | 4.7 | 4.7 | 5.0 | 5.0 | 4.9 |
| 5. | Banner (C.F.) | 4.7 | 4.7 | 4.3 | 4.7 | 4.7 | 5.3 | 4.7 |
| 6. | Molinda (C.F.) | 4.7 | 4.3 | 4.0 | 4.0 | 5.0 | 5.3 | 4.6 |
| 7. | Nordic (H.F.) | 3.7 | 4.3 | 4.0 | 4.7 | 4.7 | 5.3 | 4.4 |
| 8. | Shadow (C.F.) | 4.7 | 5.0 | 4.3 | 4.0 | 4.0 | 4.7 | 4.4 |
| 9. | Banner II (C.F.) | 4.3 | 5.0 | 4.3 | 3.7 | 4.7 | 4.3 | 4.4 |
| 10. | Cypress (*Poa trivialis*) | 4.7 | 4.0 | 4.7 | 4.0 | 4.3 | 4.0 | 4.3 |
| 11. | Polder (*Poa trivialis*) | 4.7 | 4.0 | 4.7 | 4.0 | 5.0 | 3.7 | 4.3 |
| 12. | Silvana (H.F.) | 4.0 | 4.3 | 4.0 | 4.0 | 5.0 | 4.3 | 4.3 |
| 13. | Southport (C.F.) | 3.7 | 4.3 | 4.0 | 4.7 | 4.7 | 4.7 | 4.3 |
| 14. | Flyer (C.R.F.) | 3.7 | 4.7 | 3.7 | 4.3 | 4.7 | 4.3 | 4.2 |
| 15. | Victory (C.F.) | 4.3 | 3.7 | 3.3 | 3.7 | 4.3 | 5.0 | 4.1 |
| 16. | Spartan (H.F.) | 3.3 | 4.0 | 4.0 | 3.3 | 4.3 | 4.3 | 3.9 |
| 17. | Bonanza (T.F.) | 2.7 | 4.3 | 3.3 | 3.7 | 4.0 | 5.0 | 3.8 |
| 18. | Midnight (K.B.) | 2.7 | 4.0 | 3.3 | 2.3 | 4.7 | 5.0 | 3.7 |
| 19. | Ascot (K.B.) | 2.7 | 3.7 | 3.3 | 3.3 | 4.7 | 4.0 | 3.6 |
| 20. | Glade (K.B.) | 3.0 | 4.3 | 3.0 | 3.0 | 3.7 | 4.0 | 3.5 |
| 21. | Shenandoah (T.F.) | 2.3 | 4.3 | 3.0 | 3.0 | 3.7 | 4.3 | 3.4 |
| 22. | Bonanza II (T.F.) | 2.7 | 2.7 | 3.0 | 3.7 | 3.3 | 3.7 | 3.2 |
| 23. | Rebel II (T.F.) | 3.3 | 3.3 | 2.3 | 2.7 | 3.0 | 4.0 | 3.1 |
| 24. | Coventry (K.B.) | 2.3 | 3.7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| 25. | Arid (T.F.) | 3.0 | 3.3 | 2.7 | 2.0 | 3.3 | 2.7 | 2.8 |
| 26. | Bristol (K.B.) | 2.7 | 2.3 | 3.0 | 2.3 | 2.7 | 3.3 | 2.7 |
| 27. | Adobe (T.F.) | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.7 | 2.4 |
| 28. | Buckingham (K.B.) | 2.0 | 2.7 | 2.7 | 1.7 | 2.3 | 2.7 | 2.3 |
| 29. | Brigade (H.F.) | 2.0 | 2.3 | 2.0 | 1.7 | 2.3 | 2.7 | 2.2 |
| 30. | Rebel (T.F.) | 1.3 | 3.3 | 1.7 | 1.3 | 2.3 | 2.7 | 2.1 |
| 31. | Bonsai (T.F.) | 2.0 | 2.7 | 2.0 | 1.3 | 2.0 | 2.3 | 2.1 |
| 32. | Falcon II (T.F.) | 2.0 | 2.3 | 1.7 | 1.3 | 2.3 | 2.7 | 2.1 |
| 33. | Aztec (T.F.) | 1.7 | 2.3 | 1.7 | 1.7 | 3.0 | 2.3 | 2.1 |
| 34. | Mirage (T.F.) | 1.7 | 2.3 | 2.0 | 1.3 | 2.3 | 2.7 | 2.1 |
| 35. | Supranova (*Poa supina*) | 1.3 | 1.7 | 1.7 | 1.3 | 1.7 | 1.7 | 1.6 |
| | $LSD_{0.05}$ | 1.9 | 1.7 | 1.9 | 2.4 | 2.3 | 2.1 | 1.8 |

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

**Table 3.** The average quality ratings for grasses in the Shade Trial: 1990 - 1997.

| | Cultivar | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | Ave.* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Victor (C.F.) | 6.1 | 4.3 | 5.9 | 7.2 | 7.1 | 6.6 | 6.6 | 7.1 | 6.45 |
| 2 | ST-2 (SR 3000) (H.F.) | 7.3 | 5.1 | 6.3 | 5.7 | 6.1 | 6.1 | 5.5 | 5.8 | 6.25 |
| 3 | Waldorf (C.F.) | 6.2 | 5.5 | 7.3 | 5.9 | 6.2 | 5.8 | 6.1 | 6.6 | 6.19 |
| 4 | Mary (C.F.) | 6.3 | 3.9 | 6.4 | 6.7 | 6.6 | 6.7 | 6.3 | 6.2 | 6.16 |
| 5 | BAR FO 81-225 (H.F.) | 7.1 | 4.9 | 6.5 | 5.5 | 6.1 | 6.5 | 5.7 | 5.9 | 6.08 |
| 6 | Jamestown (C.F.) | 6.0 | 4.2 | 6.0 | 6.5 | 6.6 | 6.2 | 5.9 | 6.1 | 6.02 |
| 7 | Shadow (C.F.) | 5.2 | 4.7 | 6.0 | 6.6 | 6.6 | 5.9 | 5.9 | 6.6 | 5.99 |
| 8 | Atlanta (C.F.) | 5.7 | 4.9 | 6.1 | 5.8 | 5.7 | 5.5 | 6.7 | 6.6 | 5.93 |
| 9 | Rebel (T.F.) | 6.6 | 5.3 | 6.0 | 6.9 | 5.9 | 5.7 | 4.6 | 4.5 | 5.88 |
| 10 | Pennlawn (C.R.F.) | 5.6 | 4.7 | 6.2 | 6.3 | 5.5 | 5.5 | 5.9 | 6.2 | 5.84 |
| 11 | Sabre (Poa trivialis) | 5.0 | 6.9 | 6.4 | 7.4 | 6.2 | 4.8 | 4.9 | 5.0 | 5.84 |
| 12 | Waldina (H.F.) | 6.8 | 4.1 | 5.5 | 5.5 | 5.8 | 5.8 | 5.1 | 5.9 | 5.84 |
| 13 | Estica (C.R.F.) | 7.0 | 4.1 | 5.6 | 6.6 | 6.1 | 5.6 | 4.3 | 4.3 | 5.83 |
| 14 | Bonanza (T.F.) | 6.4 | 6.5 | 6.9 | 6.3 | 6.2 | 5.2 | 4.2 | 4.1 | 5.79 |
| 15 | Biljart (H.F.) | 7.0 | 5.1 | 6.1 | 5.0 | 5.1 | 5.1 | 4.8 | 5.1 | 5.75 |
| 16 | Banner (C.F.) | 6.0 | 4.5 | 5.0 | 6.0 | 5.6 | 5.3 | 6.2 | 6.3 | 5.74 |
| 17 | Falcon (T.F.) | 6.3 | 5.3 | 6.0 | 6.5 | 6.3 | 5.2 | 4.2 | 4.2 | 5.70 |
| 18 | Rebel II (T.F.) | 6.8 | 5.3 | 5.6 | 6.1 | 6.2 | 5.1 | 4.3 | 4.1 | 5.61 |
| 19 | Apache (T.F.) | 6.8 | 6.0 | 6.0 | 6.3 | 5.4 | 5.3 | 3.7 | 3.2 | 5.60 |
| 20 | Wintergreen (C.F.) | 5.5 | 4.6 | 5.9 | 5.0 | 5.0 | 5.0 | 6.0 | 5.9 | 5.46 |
| 21 | Agram (C.F.) | 5.3 | 3.9 | 5.9 | 5.4 | 5.3 | 5.1 | 5.5 | 5.6 | 5.43 |
| 22 | Arid (T.F.) | 6.3 | 6.0 | 7.1 | 6.7 | 5.6 | 4.7 | 2.9 | 2.7 | 5.41 |
| 23 | Spartan (H.F.) | 7.2 | 3.5 | 4.2 | 4.7 | 5.1 | 4.9 | 5.0 | 4.8 | 5.39 |
| 24 | Ensylva (C.R.F.) | 5.2 | 4.0 | 5.1 | 5.9 | 5.4 | 4.4 | 5.3 | 4.9 | 5.27 |
| 25 | Koket (C.F.) | 4.9 | 4.2 | 5.2 | 5.2 | 5.7 | 4.6 | 4.6 | 5.4 | 5.15 |
| 26 | Scaldis (H.F.) | 5.8 | 3.7 | 5.2 | 4.6 | 4.4 | 4.8 | 4.1 | 4.6 | 5.02 |
| 27 | Coventry (K.B.) | 5.3 | 5.7 | 5.4 | 6.0 | 4.7 | 3.8 | 3.9 | 3.5 | 4.85 |
| 28 | Highlight (C.F.) | 4.8 | 3.5 | 4.6 | 5.0 | 4.8 | 4.7 | 4.9 | 5.1 | 4.74 |
| 29 | RAM I (K.B.) | 5.2 | 5.0 | 5.0 | 5.9 | 4.3 | 3.3 | 2.8 | 2.7 | 4.65 |
| 30 | Midnight (K.B.) | 4.7 | 5.9 | 5.5 | 6.4 | 4.6 | 4.4 | 4.0 | 3.9 | 4.56 |
| 31 | Chateau (K.B.) | 5.5 | 6.2 | 5.5 | 5.2 | 4.1 | 3.0 | 2.2 | 1.9 | 4.48 |
| 32 | Reliant (H.F.) | 3.9 | 3.1 | 3.5 | 4.2 | 4.9 | 4.8 | 4.9 | 5.0 | 4.33 |
| 33 | Glade (K.B.) | 5.4 | 5.5 | 4.8 | 5.3 | 3.3 | 2.8 | 2.8 | 2.3 | 4.26 |
| 34 | Bristol (K.B.) | 4.3 | 3.9 | 3.9 | 5.0 | 4.1 | 3.6 | 2.8 | 2.4 | 3.95 |
| 35 | Nassau (K.B.) | 3.7 | 3.4 | 3.8 | 4.3 | 3.3 | 2.4 | 2.1 | 2.0 | 3.34 |

Quality Based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
*Average includes 1988 and 1989 data (not listed).
Compiled by Gary Peterson, ISU Extension Commercial Horticulture Field Specialist

# Fairway Height Bentgrass Study - Established 1993

*Nick E. Christians and James R. Dickson*

This is the fourth year of data from the Fairway Height Bentgrass Cultivar trial established in the fall of 1993. The last season for this trial will be 1998 and it is scheduled for replacement in the fall of that year. Data collection began after the cultivars were fully established in July, 1994. The area is maintained at a 0.5-inch mowing height. This is a National Turfgrass Evaluation (NTEP) trial and is being conducted at several research stations in the U.S. It contains 21 of the newest seeded cultivars and a number of experimentals.

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

Table 1 contains monthly visual quality ratings for the 1997 season. Visual quality is based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality. Data on genetic color (Gcolor), leaf texture (Ltex), and greenup (Grnup) ratings are also included.

Southshore was the highest rated cultivar in 1997, followed by Cato and Crenshaw. There are no statistically significant differences among the first 13 cultivars.

**Table 1.** The 1997 quality ratings for the fairway height bentgrass study.

| | | | | | Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultivar | Gcolor | Ltex | Grnup | May | June | July | Aug | Sept | Oct | Mean |
| 1 | Southshore | 6.3 | 7.0 | 7.0 | 6.3 | 7.7 | 6.7 | 7.0 | 7.3 | 7.7 | 7.1 |
| 2 | Cato | 7.7 | 6.7 | 7.0 | 6.3 | 6.3 | 6.3 | 7.0 | 7.3 | 8.0 | 6.9 |
| 3 | Crenshaw | 7.3 | 6.7 | 6.0 | 5.7 | 7.0 | 6.7 | 6.7 | 7.7 | 8.0 | 6.9 |
| 4 | Lopez | 7.3 | 6.0 | 6.7 | 6.3 | 7.0 | 6.0 | 7.0 | 7.0 | 7.0 | 6.7 |
| 5 | Bar WS 42102 | 6.7 | 8.0 | 6.3 | 5.3 | 7.0 | 6.3 | 7.0 | 6.7 | 7.0 | 6.6 |
| 6 | Penn G-6 (G-6) | 6.7 | 7.0 | 7.0 | 6.0 | 6.3 | 7.0 | 6.3 | 7.0 | 7.0 | 6.6 |
| 7 | Penneagle | 6.7 | 7.3 | 6.7 | 6.0 | 6.7 | 6.0 | 7.3 | 6.7 | 7.0 | 6.6 |
| 8 | Pro/Cup | 7.3 | 6.3 | 6.7 | 6.3 | 6.7 | 6.0 | 6.3 | 7.0 | 7.0 | 6.6 |
| 9 | Trueline | 6.7 | 6.3 | 7.0 | 6.7 | 7.3 | 6.3 | 6.3 | 6.7 | 6.3 | 6.6 |
| 10 | Providenxe | 7.0 | 6.7 | 7.0 | 6.0 | 6.0 | 6.0 | 6.3 | 6.7 | 7.0 | 6.3 |
| 11 | Seaside II (DF-1) | 6.3 | 7.3 | 6.3 | 5.3 | 6.3 | 6.0 | 6.7 | 6.7 | 6.7 | 6.3 |
| 12 | 18th Green | 7.3 | 6.7 | 7.3 | 5.7 | 5.7 | 6.3 | 7.0 | 6.7 | 6.0 | 6.2 |
| 13 | Penn G-2 (G-2) | 6.7 | 6.0 | 6.3 | 5.7 | 6.0 | 6.0 | 6.3 | 6.0 | 7.3 | 6.2 |
| 14 | Penncross | 7.0 | 5.7 | 6.7 | 5.7 | 6.3 | 5.7 | 6.0 | 6.0 | 5.7 | 5.9 |
| 15 | Seaside | 6.0 | 5.0 | 6.3 | 5.0 | 5.7 | 5.3 | 5.7 | 6.3 | 5.7 | 5.6 |
| 16 | ISI-AT-90162* | 5.7 | 6.0 | 7.0 | 4.7 | 5.7 | 5.7 | 5.3 | 6.0 | 5.0 | 5.4 |
| 17 | Bar AS 492 | 6.7 | 6.3 | 6.0 | 5.3 | 5.3 | 5.0 | 5.7 | 5.7 | 5.0 | 5.3 |
| 18 | Exeter* | 6.7 | 6.0 | 6.0 | 5.0 | 5.3 | 5.0 | 5.3 | 5.7 | 5.7 | 5.3 |
| 19 | Pebble (OM-AT-90163)* | 6.0 | 6.0 | 6.3 | 5.0 | 5.3 | 5.0 | 5.0 | 6.0 | 5.7 | 5.3 |
| 20 | Tendenz* | 6.3 | 5.3 | 6.7 | 5.0 | 5.0 | 4.7 | 5.7 | 5.3 | 5.7 | 5.2 |
| 21 | SR 7100* | 5.7 | 6.7 | 7.3 | 4.7 | 5.3 | 4.7 | 4.7 | 4.7 | 5.3 | 4.9 |
| | $LSD_{(0.05)}$ | 1.9 | 1.1 | 1.2 | 1.6 | 1.0 | 1.9 | 1.8 | 2.0 | 1.2 | 0.9 |

* Colonial Bentgrass
Gcolor (Genetic color): 9 = dark green and 1 = light green.
Ltex (Leaf texture): 9 = fine and 1 = coarse.
Grnup (Greenup): 9 = best and 1 = poorest greenup.
Quality based on a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, and 1 = poorest quality.
NS = means are not significantly different at the 0.05 level.

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

*Nick E. Christians and James R. Dickson*

This is the fourth year of data from the Green Height Bentgrass Cultivar trial established in the fall of 1993. The area was maintained at a 3/16-inch mowing height. This is a National Turfgrass Evaluation Program (NTEP) trial and is being conducted at several research stations in the U.S. It contains 28 seeded cultivars including a number of experimentals. This trial will be replaced with a new study at the end of the 1998 season.

The cultivars are maintained with a fertilizer program of 1/4 to 1/2 lb. N applied at 14-day intervals with a total of 3 to 4 lb. N/1000 $ft^2$/growing season. Fungicides are used as needed in a preventive program. Herbicides and insecticides are applied as needed.

Penn A-4 (A-4) was the highest rated cultivar in 1997 (Table 1). Penncross, which has traditionally been a good performer at the ISU research area fell to 23rd place this year. The reason for that drop is unknown. The first 13 cultivars are statistically the same. Data on genetic color (Gcolor), leaf texture (Ltex), and green up (Grnup), ratings are also included in Table 1. This was the fourth full year of data.

**Table 1.** The 1997 ratings for the green height bentgrass trial.

| | | | | | Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultivar | Gcolor | Ltex | Grnup | May | June | July | Aug | Sept | Oct | Mean |
| 1 | Penn A-4(A-4) | 7.7 | 7.7 | 6.0 | 5.7 | 6.7 | 7.0 | 8.0 | 7.7 | 6.7 | 6.9 |
| 2 | Century (Syn 92-1) | 6.3 | 7.3 | 6.0 | 5.7 | 6.0 | 7.0 | 7.7 | 8.0 | 6.3 | 6.8 |
| 3 | Penn G-2 (G-2) | 6.7 | 7.7 | 6.7 | 6.3 | 6.3 | 6.7 | 6.7 | 8.0 | 6.7 | 6.8 |
| 4 | Imperial (Syn 92-5) | 7.0 | 7.0 | 6.7 | 6.0 | 6.0 | 6.7 | 7.0 | 7.3 | 7.3 | 6.7 |
| 5 | Penn A-1 (A-1) | 7.3 | 7.7 | 6.3 | 5.7 | 6.3 | 7.0 | 7.3 | 6.7 | 7.0 | 6.7 |
| 6 | Crenshaw | 7.3 | 7.3 | 6.7 | 5.3 | 6.3 | 6.0 | 7.0 | 7.7 | 7.0 | 6.6 |
| 7 | Penn G-6 (G-6) | 7.0 | 6.7 | 6.3 | 6.0 | 6.3 | 6.3 | 6.7 | 7.0 | 6.3 | 6.4 |
| 8 | Backspin (Syn 92-2) | 6.7 | 7.0 | 5.0 | 5.3 | 6.0 | 6.3 | 6.3 | 7.3 | 6.7 | 6.3 |
| 9 | Cato | 7.7 | 7.0 | 6.0 | 6.0 | 6.0 | 5.7 | 6.7 | 7.0 | 6.3 | 6.3 |
| 10 | Lofts L-93(l-93) | 7.0 | 6.7 | 6.7 | 5.7 | 6.3 | 6.3 | 6.7 | 6.7 | 6.0 | 6.3 |
| 11 | SR 1020 | 6.3 | 6.7 | 6.3 | 5.7 | 6.7 | 6.0 | 6.7 | 6.0 | 7.0 | 6.3 |
| 12 | Bar WS 42102 | 6.3 | 7.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.7 | 6.3 | 6.0 | 6.2 |
| 13 | Pennlinks | 6.3 | 6.0 | 6.3 | 6.3 | 6.0 | 5.7 | 6.3 | 6.0 | 6.0 | 6.1 |
| 14 | 18th Green | 7.3 | 5.7 | 6.3 | 6.0 | 5.3 | 6.3 | 6.3 | 6.3 | 5.7 | 6.0 |
| 15 | Regent | 6.0 | 6.0 | 6.3 | 6.3 | 6.0 | 5.7 | 6.0 | 6.0 | 6.0 | 6.0 |
| 16 | DG-P | 6.7 | 6.3 | 5.3 | 5.7 | 6.0 | 5.7 | 6.7 | 6.0 | 5.3 | 5.9 |
| 17 | Pro/Cup | 6.7 | 6.3 | 6.0 | 5.3 | 6.0 | 6.3 | 6.0 | 6.3 | 5.7 | 5.9 |
| 18 | Providenco | 7.7 | 6.0 | 6.3 | 5.7 | 5.3 | 6.0 | 6.7 | 6.3 | 5.7 | 5.9 |
| 19 | ISI-AP-89150 | 6.7 | 6.0 | 6.0 | 6.0 | 5.7 | 6.0 | 5.7 | 5.7 | 5.7 | 5.8 |
| 20 | Lopez | 6.0 | 6.0 | 5.7 | 6.0 | 5.7 | 5.3 | 6.3 | 6.7 | 5.0 | 5.8 |
| 21 | Trueline | 6.3 | 6.0 | 6.3 | 6.0 | 5.7 | 5.3 | 6.3 | 6.0 | 5.3 | 5.8 |
| 22 | Mariner (Syn-1-88) | 6.3 | 6.0 | 6.3 | 5.3 | 6.0 | 5.3 | 5.7 | 6.0 | 6.0 | 5.7 |
| 23 | Penncross | 6.0 | 5.7 | 6.0 | 5.7 | 5.3 | 5.0 | 5.7 | 6.0 | 6.0 | 5.6 |
| 24 | Msueb | 5.7 | 6.0 | 6.0 | 6.0 | 4.7 | 5.0 | 5.3 | 6.0 | 5.3 | 5.4 |
| 25 | Southshore | 6.3 | 6.7 | 6.0 | 5.3 | 5.0 | 5.3 | 5.3 | 6.0 | 5.7 | 5.4 |
| 26 | Bar AS 492 | 6.0 | 6.0 | 6.7 | 5.3 | 5.3 | 5.0 | 5.3 | 4.7 | 4.7 | 5.1 |
| 27 | Seaside | 5.7 | 5.3 | 5.7 | 5.3 | 5.0 | 4.7 | 4.7 | 5.0 | 5.3 | 5.0 |
| 28 | Tendenz | 5.7 | 5.7 | 5.7 | 4.7 | 4.0 | 4.0 | 4.7 | 4.7 | 5.0 | 4.5 |
| | $LSD_{(0.05)}$ | 1.3 | 0.9 | 2.5 | 2.0 | 1.9 | 1.2 | 1.3 | 1.0 | 1.4 | 0.8 |

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

# 1997 Preemergence Annual Weed Control Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to screen various preemergent (PRE) and postemergent (POST) herbicides for their efficacy in controlling annual weeds in turfgrass. The study was conducted at the Iowa State University Horticulture Research Station north of Ames, IA. The experimental plot was in 'common' Kentucky bluegrass. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 2.4% organic matter, a pH of 6.5, 7 ppm P, and 97 ppm K.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with three replications. There were 38 treatments including an untreated control (Table 1). Eleven of the treatments were screened in combination with methylene urea (39-0-0). Barricade 65WG, Pendimethalin 60WDG, and Dimension 1EC were screened at various rates in single preemergent (PRE) and split PRE and postemergent (POST) applications in combination with fertilizer. Three granular Dimension plus fertilizer formulations (AND444, AND445, and AND442) and a fertilized control also were included. Turf that received treatments two through twelve was given an equivalent amount of nitrogen at the time of both PRE and POST applications.

Three granular herbicides from The Scotts Company (S-7135, S-6619, and S-2452) were included. These materials were applied in single PRE and split PRE plus POST treatments. Preclaim 3.09EC was screened as an early-post and mid-postemergence material at two different rates for AgrEvo. Acclaim Extra 0.57EW also was included as an early-postemergence treatment and Pendimethalin 60WDG was applied as a PRE material. An experimental formulation from Rhone-Poulenc, MY-100, was applied as a PRE treatment at three different rates. Barricade 65WG was screened at various rates in single PRE and in split PRE and POST applications for Novartis. In addition, Pendimethalin and Dimension 1EC were applied in single PRE and split PRE and POST treatments. Ronstar 2G was screened as a PRE material.

Granular formulations were applied using 'shaker dispensers'. Liquids were applied at 30 psi using a $CO_2$ backpack sprayer equipped with TeeJet™ #8006 flat fan nozzles. Preemergent (PRE) treatments were made on May 1. Crabgrass germination was noted on June 7. This was considerably later than usual for this location. Sequential applications of treatments 2 - 12 were made on July 3, 60 days after the initial application (Table 1). Postemergent applications of treatments 14, 16, and 18 were made on June 18, six to eight weeks after the initials. Early-postemergence applications of treatments 19, 20, and 23 were made on June 11 when the crabgrass was in the 1- to 4-leaf stage. Mid-postemergence applications of treatments 21 and 22 were made on July 10 when the crabgrass had one to three tillers. Postemergent applications of treatments 35 - 38 were made on July 3, 60 days after the initial application.

Visual turf quality data were taken May 12 through August 20 (Tables 2 and 3). Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. Crabgrass control was reported as the percentage of area per plot covered by crabgrass. Crabgrass data were taken on July 2, July 10, July 15, July 30, and August 20 (Table 4). In addition, these data were converted to express percentage reduction in crabgrass cover as compared with the untreated control (Table 5).

All data were analyzed with the Statistical Analysis System (SAS, Version 6.10) and the Analysis of Variance (ANOVA) procedure. Fisher's Least Significant Difference (LSD) test was used to compare visual quality and crabgrass control means.

Turf that received the herbicide plus methylene urea treatments (Barricade 65WG, Pendimethalin 60WDG, and Dimension 1EC), the 'AND' Dimension plus fertilizer formulations (AND444, AND445, and AND442), and the fertilized control had significantly better quality than the untreated control and turf treated with the other herbicides for the entire season (Tables 2 and 3). Bluegrass treated with the other materials exhibited quality similar to the untreated control.

Throughout the season on each data collection date, at least 36 of the herbicides significantly reduced crabgrass cover when compared with the untreated control (Table 4). Crabgrass cover reductions ≥ 90% (when compared with the untreated control) were reported in turf treated with 20 herbicides on July 2, 23 on July 10, and 15 on July 15 (Table 5). By August 20, only 11 materials produced crabgrass reductions at this same level. Seven treatments produced reductions ≥ 90% for the entire season.

**Table 1.** Materials, rates, and application dates for herbicides and fertilizers used in the 1997 Pre- & Postemergence Annual Weed Control Study.

| | | Initial Application (PRE)[2] | | Sequential Application 45-60 DAT (POST)[2] | |
|---|---|---|---|---|---|
| | Materials | Rate lb a.i./A. | Fertilizer blank/plot (39-0-0) | Rate lb a.i./A. | Fertilizer blank/plot (39-0-0) |
| 1 | Untreated control | NA | NA | NA | NA |
| 2 | Barricade 65WG[1] | 0.650 | 45.20 g | none | 45.20 g |
| 3 | Pendimethalin 60WDG[1] | 1.500 | 45.20 g | none | 45.20 g |
| 4 | Dimension 1EC[1] | 0.250 | 45.20 g | none | 45.20 g |
| 5 | Dimension 1EC[1] | 0.380 | 45.20 g | none | 45.20 g |
| 6 | Dimension 1EC[1] | 0.125 | 45.20 g | 0.125 | 45.20 g |
| 7 | Dimension 1EC[1] | 0.250 | 45.20 g | 0.125 | 45.20 g |
| 8 | AND444 Dimension FG 0.072 + fertilizer[1] | 0.125 | none | none | 45.20 g |
| 9 | AND445 Dimension FG 0.164 + fertilizer[1] | 0.250 | 5.52 g | none | 45.20 g |
| 10 | AND442 Dimension FG 0.035 + fertilizer[1] | 0.060 | 0.57 g | 0.060 | 0.57 g |
| 11 | AND444 Dimension FG 0.072 + fertilizer[1] | 0.125 | none | 0.125 | none |
| 12 | Fertilized control[1] | NA | 45.20 g | NA | 45.20 g |

| | | Initial Application (PRE)[4] | Sequential Application (POST)[4] |
|---|---|---|---|
| | | Rate grams product /ft$^2$ | Rate grams product /ft$^2$ |
| 13 | S-7135[3] | 1.19 | none |
| 14 | S-7135[3] | 1.19 | 1.19 |
| 15 | S-6619[3] | 1.14 | none |
| 16 | S-6619[3] | 1.14 | 1.14 |
| 17 | S-2452[3] | 0.92 | none |
| 18 | S-2452[3] | 0.92 | 0.92 |

(Table 1 continued on next page)

Table 1. (continued)

| | Materials | Rate lb a.i./A | Timing of applications[6] |
|---|---|---|---|
| 19 | Preclaim 3.09 EC[5] | 1.54 | EARLY POST |
| 20 | Preclaim 3.09 EC[5] | 2.06 | EARLY POST |
| 21 | Preclaim 3.09 EC[5] | 2.06 | MID POST |
| 22 | Preclaim 3.09 EC[5] | 3.09 | MID POST |
| 23 | Acclaim Extra 0.57 EW[5] | 0.06 | EARLY POST |
| 24 | Pendimethalin 60WDG[5 & 7] | 1.50 | PRE |

| | | product/ 1000 $ft^2$ (ml) | Timing of applications[8] |
|---|---|---|---|
| 25 | MY - 100 (30% SC)[7] | 3.00 | PRE |
| 26 | MY - 100 (30% SC)[7] | 4.50 | PRE |
| 27 | MY - 100 (30% SC)[7] | 6.00 | PRE |

| | | Initial Application (PRE)[9] | Sequential Application 60 DAT (POST)[9] |
|---|---|---|---|
| | | Rate lb a.i./A. | Rate lb a.i./A. |
| 28 | Barricade 65WG[10] | 0.32 | none |
| 29 | Barricade 65WG[10] | 0.38 | none |
| 30 | Barricade 65WG[10] | 0.48 | none |
| 31 | Barricade 65WG[10] | 0.65 | none |
| 32 | Pendimethalin 60WDG[10&11] | 1.50 | none |
| 33 | Ronstar 2G[10] | 2.00 | none |
| 34 | Dimension 1EC[10] | 0.25 | none |
| 35 | Barricade 65WG[10] | 0.25 | 0.25 |
| 36 | Barricade 65WG[10] | 0.33 | 0.17 |
| 37 | Pendimethalin 60WDG[10&11] | 0.75 | 0.75 |
| 38 | Dimension 1EC[10] | 0.125 | 0.125 |

[1]These materials were screened for Rohm & Haas. Methylene urea (39-0-0) was the nitrogen source in the 'AND' materials and was used as the fertilizer blank. Fertilizers were applied at 4 lb product/1000 $ft^2$ for each of 2 applications.

[2]Initial applications (PRE) were made on May 1 before crabgrass germination and POST applications were applied 45 to 60 days later on June 30.

[3]These products were screened for The Scotts Company.

[4]PRE applications were made on May 1 before crabgrass emergence and POST applications were made 6 - 8 weeks later on June 18.

[5]These materials were screened for AgrEvo.

[6]PRE applications were made on May 1 before crabgrass germination, EARLY POST on June 11 when the crabgrass was in the 1- to 4-leaf stage, and MID POST on July 10 when the crabgrass had 1 to 3 tillers.

[7]These materials were screened for Rhone-Poulenc Ag Company.

[8]PRE applications were made on May 1 before crabgrass germination.

[9]PRE applications were made on May 1 before crabgrass germination and Post were made 60 days later on July 3.

[10]These materials were screened for Novartis.

[11]Pendimethalin 60WDG was substituted for Pendulum 60DG.

PRE applications were made on May 1 (treatments 1-18, 24-27, and 28-38). Crabgrass germination was on June 7.

**Table 2.** Visual turf quality[1] of Kentucky bluegrass treated with herbicide materials in the 1997 Pre- & Postemergence Annual Grass Control Study (May 12 through July 2).

| | Material | Rate lb a.i./A (unless noted) | May 12 | May 21 | June 5 | June 18 | June 25 | July 2 |
|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 7 | 6 | 5 | 5 | 7 | 5 |
| 2 | Barricade 65WG + fertilizer | 0.650 | 9 | 8 | 7 | 8 | 9 | 9 |
| 3 | Pendimethalin 60WDG + fertilizer | 1.500 | 8 | 8 | 7 | 8 | 8 | 9 |
| 4 | Dimension 1EC + fertilizer | 0.250 | 8 | 9 | 7 | 9 | 9 | 9 |
| 5 | Dimension 1EC + fertilizer | 0.380 | 9 | 7 | 7 | 9 | 9 | 9 |
| 6 | Dimension 1EC + fertilizer | 0.125 fb 0.125 | 9 | 8 | 7 | 9 | 9 | 9 |
| 7 | Dimension 1EC + fertilizer | 0.250 fb 0.125 | 8 | 8 | 7 | 9 | 9 | 9 |
| 8 | AND444 Dimension FG 0.072 | 0.125 | 8 | 8 | 7 | 9 | 9 | 9 |
| 9 | AND445 Dimension FG 0.164 | 0.250 | 9 | 8 | 7 | 9 | 9 | 9 |
| 10 | AND442 Dimension FG 0.035 | 0.060 fb 0.060 | 8 | 8 | 7 | 9 | 8 | 9 |
| 11 | AND444 Dimension FG 0.072 | 0.125 fb 0.125 | 8 | 9 | 7 | 9 | 9 | 9 |
| 12 | Fertilized control | NA | 8 | 8 | 7 | 9 | 9 | 8 |
| 13 | S-7135 | 1.19[2] | 7 | 6 | 5 | 5 | 7 | 5 |
| 14 | S-7135 | 1.19[2] | 7 | 6 | 5 | 5 | 7 | 5 |
| 15 | S-6619 | 1.14[2] | 7 | 6 | 5 | 5 | 7 | 5 |
| 16 | S-6619 | 1.14[2] | 7 | 6 | 5 | 5 | 7 | 5 |
| 17 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 7 | 7 | 5 | 5 | 7 | 5 |
| 18 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 7 | 6 | 5 | 5 | 7 | 5 |
| 19 | Preclaim 3.09EC (early post) | 1.54 | 7 | 6 | 5 | 5 | 7 | 5 |
| 20 | Preclaim 3.09EC (early post) | 2.06 | 7 | 7 | 5 | 5 | 7 | 5 |
| 21 | Preclaim 3.09EC (mid post) | 2.06 | 7 | 6 | 5 | 5 | 7 | 5 |
| 22 | Preclaim 3.09EC (mid post) | 3.09 | 7 | 6 | 5 | 5 | 7 | 5 |
| 23 | Acclaim Extra 0.57EW | 0.06 | 7 | 6 | 5 | 5 | 7 | 5 |
| 24 | Pendimethalin 60WDG | 1.50 | 7 | 6 | 5 | 5 | 7 | 5 |
| 25 | MY - 100 (30% SC) | 3.00[3] | 7 | 6 | 5 | 5 | 7 | 5 |
| 26 | MY - 100 (30% SC) | 4.50[3] | 7 | 6 | 5 | 5 | 7 | 5 |
| 27 | MY - 100 (30% SC) | 6.00[3] | 7 | 6 | 6 | 5 | 7 | 5 |
| 28 | Barricade 65WG | 0.32 | 7 | 6 | 5 | 5 | 7 | 5 |
| 29 | Barricade 65WG | 0.38 | 7 | 6 | 5 | 5 | 7 | 5 |
| 30 | Barricade 65WG | 0.48 | 7 | 6 | 5 | 5 | 7 | 5 |
| 31 | Barricade 65WG | 0.65 | 7 | 6 | 5 | 5 | 7 | 5 |
| 32 | Pendimethalin 60WDG | 1.50 | 7 | 6 | 6 | 5 | 7 | 5 |
| 33 | Ronstar 2G | 2.00 | 7 | 6 | 5 | 5 | 7 | 5 |
| 34 | Dimension 1EC | 0.25 | 7 | 7 | 5 | 5 | 7 | 5 |
| 35 | Barricade 65WG | 0.25 fb 0.25 | 7 | 6 | 5 | 5 | 7 | 5 |
| 36 | Barricade 65WG | 0.33 fb 0.17 | 7 | 6 | 5 | 5 | 7 | 5 |
| 37 | Pendimethalin 60WDG | 0.75 fb 0.75 | 7 | 6 | 5 | 5 | 7 | 5 |
| 38 | Dimension 1EC | 0.125 fb 0.125 | 7 | 6 | 5 | 5 | 7 | 5 |
| | $LSD_{0.05}$ | | 1 | 1 | 1 | 1 | 1 | 1 |

[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, & 1 = worst quality.
[2]The rate for these products is in grams product/$ft^2$.
[3]The rate for these products is in ml product/1000 $ft^2$.

**Table 3.** Visual turf quality[1] of Kentucky bluegrass treated with herbicide materials in the 1997 Pre- & Postemergence Annual Grass Control Study (July 10 through August 20).

| | Material | Rate lb a.i./A (unless noted) | July 10 | July 15 | July 30 | August 20 | Mean |
|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 7 | 7 | 6 | 6 | 6 |
| 2 | Barricade 65WG + fertilizer | 0.650 | 9 | 9 | 8 | 8 | 8 |
| 3 | Pendimethalin 60WDG + fertilizer | 1.500 | 9 | 9 | 8 | 8 | 8 |
| 4 | Dimension 1EC + fertilizer | 0.250 | 9 | 9 | 8 | 8 | 9 |
| 5 | Dimension 1EC + fertilizer | 0.380 | 9 | 9 | 8 | 8 | 8 |
| 6 | Dimension 1EC + fertilizer | 0.125 fb 0.125 | 9 | 9 | 8 | 8 | 8 |
| 7 | Dimension 1EC + fertilizer | 0.250 fb 0.125 | 9 | 9 | 8 | 8 | 8 |
| 8 | AND444 Dimension FG 0.072 | 0.125 | 9 | 9 | 8 | 8 | 8 |
| 9 | AND445 Dimension FG 0.164 | 0.250 | 9 | 9 | 8 | 8 | 8 |
| 10 | AND442 Dimension FG 0.035 | 0.060 fb 0.060 | 9 | 9 | 8 | 8 | 8 |
| 11 | AND444 Dimension FG 0.072 | 0.125 fb 0.125 | 9 | 9 | 8 | 8 | 8 |
| 12 | Fertilized control | NA | 9 | 9 | 8 | 8 | 8 |
| 13 | S-7135 | 1.19[2] | 7 | 7 | 6 | 6 | 6 |
| 14 | S-7135 | 1.19[2] | 7 | 7 | 6 | 6 | 6 |
| 15 | S-6619 | 1.14[2] | 7 | 7 | 6 | 6 | 6 |
| 16 | S-6619 | 1.14[2] | 7 | 7 | 6 | 6 | 6 |
| 17 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 7 | 7 | 6 | 6 | 6 |
| 18 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 7 | 7 | 6 | 6 | 6 |
| 19 | Preclaim 3.09EC (early post) | 1.54 | 7 | 7 | 6 | 6 | 6 |
| 20 | Preclaim 3.09EC (early post) | 2.06 | 7 | 7 | 6 | 6 | 6 |
| 21 | Preclaim 3.09EC (mid post) | 2.06 | 7 | 7 | 6 | 6 | 6 |
| 22 | Preclaim 3.09EC (mid post) | 3.09 | 7 | 7 | 6 | 6 | 6 |
| 23 | Acclaim Extra 0.57EW | 0.06 | 7 | 7 | 6 | 6 | 6 |
| 24 | Pendimethalin 60WDG | 1.50 | 7 | 7 | 6 | 6 | 6 |
| 25 | MY - 100 (30% SC) | 3.00[3] | 7 | 7 | 6 | 6 | 6 |
| 26 | MY - 100 (30% SC) | 4.50[3] | 7 | 7 | 6 | 6 | 6 |
| 27 | MY - 100 (30% SC) | 6.00[3] | 7 | 7 | 6 | 6 | 6 |
| 28 | Barricade 65WG | 0.32 | 7 | 7 | 6 | 6 | 6 |
| 29 | Barricade 65WG | 0.38 | 7 | 7 | 6 | 6 | 6 |
| 30 | Barricade 65WG | 0.48 | 7 | 7 | 6 | 6 | 6 |
| 31 | Barricade 65WG | 0.65 | 7 | 7 | 6 | 6 | 6 |
| 32 | Pendimethalin 60WDG | 1.50 | 7 | 7 | 6 | 6 | 6 |
| 33 | Ronstar 2G | 2.00 | 7 | 7 | 6 | 6 | 6 |
| 34 | Dimension 1EC | 0.25 | 7 | 7 | 6 | 6 | 6 |
| 35 | Barricade 65WG | 0.25 fb 0.25 | 7 | 7 | 6 | 6 | 6 |
| 36 | Barricade 65WG | 0.33 fb 0.17 | 8 | 8 | 7 | 7 | 6 |
| 37 | Pendimethalin 60WDG | 0.75 fb 0.75 | 7 | 7 | 6 | 6 | 6 |
| 38 | Dimension 1EC | 0.125 fb 0.125 | 7 | 7 | 6 | 6 | 6 |
| | $LSD_{0.05}$ | | 1 | 1 | 1 | 1 | 1 |

[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, & 1 = worst quality.
[2]The rate for these products is in grams product/ft$^2$.
[3]The rate for these products is in ml product/1000 ft$^2$.

**Table 4.** Percentage crabgrass cover[1] in Kentucky bluegrass treated with herbicide materials in the 1997 Pre- & Postemergence Annual Grass Control Study.

| | Material | Rate lb a.i./A (unless noted) | July 2 | July 10 | July 15 | July 30 | August 20 | Mean cover |
|---|---|---|---|---|---|---|---|---|
| | | | % | | | | | |
| 1 | Untreated control | NA | 33 | 62 | 55 | 87 | 92 | 66 |
| 2 | Barricade 65WG + fertilizer | 0.650 | 1 | 4 | 2 | 5 | 9 | 4 |
| 3 | Pendimethalin 60WDG + fertilizer | 1.500 | 1 | 5 | 5 | 18 | 13 | 8 |
| 4 | Dimension 1EC + fertilizer | 0.250 | 4 | 10 | 5 | 20 | 25 | 13 |
| 5 | Dimension 1EC + fertilizer | 0.380 | 1 | 5 | 8 | 15 | 15 | 9 |
| 6 | Dimension 1EC + fertilizer | 0.125 fb 0.125 | 2 | 10 | 5 | 25 | 35 | 15 |
| 7 | Dimension 1EC + fertilizer | 0.250 fb 0.125 | 1 | 1 | 1 | 3 | 3 | 2 |
| 8 | AND444 Dimension FG 0.072 | 0.125 | 1 | 7 | 2 | 12 | 12 | 7 |
| 9 | AND445 Dimension FG 0.164 | 0.250 | 1 | 2 | 1 | 4 | 7 | 3 |
| 10 | AND442 Dimension FG 0.035 | 0.060 fb 0.060 | 4 | 6 | 3 | 12 | 15 | 8 |
| 11 | AND444 Dimension FG 0.072 | 0.125 fb 0.125 | 1 | 2 | 1 | 1 | 2 | 1 |
| 12 | Fertilized control | NA | 15 | 30 | 30 | 60 | 68 | 41 |
| 13 | S-7135 | 1.19[2] | 1 | 9 | 2 | 8 | 12 | 6 |
| 14 | S-7135 | 1.19[2] | 3 | 7 | 3 | 2 | 5 | 4 |
| 15 | S-6619 | 1.14[2] | 4 | 9 | 7 | 10 | 14 | 9 |
| 16 | S-6619 | 1.14[2] | 1 | 1 | 0 | 1 | 3 | 1 |
| 17 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 2 | 10 | 5 | 17 | 18 | 10 |
| 18 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 4 | 7 | 1 | 4 | 4 | 4 |
| 19 | Preclaim 3.09 EC (early-post) | 1.54 | 0 | 2 | 2 | 7 | 17 | 5 |
| 20 | Preclaim 3.09 EC (early-post) | 2.06 | 0 | 2 | 1 | 2 | 5 | 2 |
| 21 | Preclaim 3.09 EC (mid-post) | 2.06 | 22 | 42 | 35 | 1 | 1 | 20 |
| 22 | Preclaim 3.09 EC (mid-post) | 3.09 | 27 | 50 | 22 | 0 | 1 | 20 |
| 23 | Acclaim Extra 0.57 EW | 0.06 | 22 | 40 | 45 | 72 | 83 | 52 |
| 24 | Pendimethalin 60WDG | 1.50 | 2 | 4 | 5 | 13 | 25 | 10 |
| 25 | MY - 100 (30% SC) | 3.00[3] | 13 | 30 | 37 | 60 | 78 | 44 |
| 26 | MY - 100 (30% SC) | 4.50[3] | 13 | 23 | 25 | 42 | 60 | 33 |
| 27 | MY - 100 (30% SC) | 6.00[3] | 7 | 15 | 10 | 27 | 33 | 18 |
| 28 | Barricade 65WG | 0.32 | 2 | 12 | 5 | 18 | 22 | 12 |
| 29 | Barricade 65WG | 0.38 | 2 | 1 | 0 | 7 | 5 | 3 |
| 30 | Barricade 65WG | 0.48 | 2 | 8 | 4 | 12 | 17 | 9 |
| 31 | Barricade 65WG | 0.65 | 3 | 7 | 2 | 8 | 13 | 7 |
| 32 | Pendimethalin 60WDG | 1.50 | 2 | 6 | 3 | 7 | 20 | 8 |
| 33 | Ronstar 2G | 2.00 | 5 | 17 | 15 | 35 | 60 | 26 |
| 34 | Dimension 1EC | 0.25 | 4 | 8 | 2 | 20 | 27 | 12 |
| 35 | Barricade 65WG | 0.25 fb 0.25 | 15 | 22 | 15 | 25 | 47 | 25 |
| 36 | Barricade 65WG | 0.33 fb 0.17 | 2 | 10 | 7 | 13 | 15 | 9 |
| 37 | Pendimethalin 60WDG | 0.75 fb 0.75 | 13 | 22 | 17 | 33 | 53 | 28 |
| 38 | Dimension 1EC | 0.125 fb 0.125 | 8 | 15 | 12 | 30 | 27 | 18 |
| | $LSD_{0.05}$ | | 8 | 15 | 19 | 20 | 23 | 14 |

[1]Percent crabgrass cover was estimated as the area per plot occupied by crabgrass.
[2]The rate for these products is in grams product/ft$^2$.
[3]The rate for these products is in ml product/1000 ft$^2$.

**Table 5.** Percentage reductions in crabgrass cover[1] in Kentucky bluegrass treated with herbicide materials in the 1997 Pre- & Postemergence Annual Grass Control Study.

| | Material | Rate lb a.i./A (unless noted) | July 2 | July 10 | July 15 | July 30 | August 20 | Mean reduction |
|---|---|---|---|---|---|---|---|---|
| | | | % | | | | | |
| 1 | Untreated control | NA | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Barricade 65WG + fertilizer | 0.650 | 99 | 94 | 97 | 94 | 91 | 94 |
| 3 | Pendimethalin 60WDG + fertilizer | 1.500 | 99 | 91 | 91 | 79 | 86 | 87 |
| 4 | Dimension 1EC + fertilizer | 0.250 | 89 | 83 | 91 | 77 | 72 | 81 |
| 5 | Dimension 1EC + fertilizer | 0.380 | 97 | 91 | 85 | 83 | 83 | 86 |
| 6 | Dimension 1EC + fertilizer | 0.125 fb 0.125 | 94 | 84 | 90 | 71 | 62 | 77 |
| 7 | Dimension 1EC + fertilizer | 0.250 fb 0.125 | 99 | 99 | 99 | 96 | 96 | 98 |
| 8 | AND444 Dimension FG 0.072 | 0.125 | 97 | 89 | 96 | 87 | 87 | 90 |
| 9 | AND445 Dimension FG 0.164 | 0.250 | 98 | 96 | 99 | 96 | 93 | 96 |
| 10 | AND442 Dimension FG 0.035 | 0.060 fb 0.060 | 88 | 91 | 94 | 87 | 84 | 88 |
| 11 | AND444 Dimension FG 0.072 | 0.125 fb 0.125 | 98 | 97 | 99 | 99 | 98 | 98 |
| 12 | Fertilized control | NA | 55 | 52 | 45 | 31 | 26 | 38 |
| 13 | S-7135 | 1.19[2] | 97 | 86 | 96 | 90 | 87 | 90 |
| 14 | S-7135 | 1.19[2] | 90 | 89 | 94 | 97 | 94 | 94 |
| 15 | S-6619 | 1.14[2] | 89 | 86 | 88 | 88 | 85 | 87 |
| 16 | S-6619 | 1.14[2] | 98 | 99 | 100 | 99 | 96 | 98 |
| 17 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 93 | 84 | 91 | 81 | 80 | 84 |
| 18 | S-2452 Pendimethalin 1.71% GR | 0.92[2] | 89 | 89 | 99 | 96 | 96 | 94 |
| 19 | Preclaim 3.09 EC (early post) | 1.54 | 100 | 97 | 97 | 92 | 82 | 92 |
| 20 | Preclaim 3.09 EC (early post) | 2.06 | 100 | 97 | 99 | 97 | 95 | 97 |
| 21 | Preclaim 3.09 EC (mid post) | 2.06 | 34 | 33 | 36 | 99 | 99 | 70 |
| 22 | Preclaim 3.09 EC (mid post) | 3.09 | 19 | 19 | 61 | 100 | 99 | 70 |
| 23 | Acclaim Extra 0.57 EW | 0.06 | 34 | 35 | 18 | 18 | 9 | 21 |
| 24 | Pendimethalin 60WDG | 1.50 | 94 | 94 | 90 | 85 | 73 | 85 |
| 25 | MY - 100 (30% SC) | 3.00[3] | 60 | 52 | 33 | 31 | 15 | 34 |
| 26 | MY - 100 (30% SC) | 4.50[3] | 60 | 62 | 55 | 52 | 35 | 51 |
| 27 | MY - 100 (30% SC) | 6.00[3] | 80 | 76 | 81 | 69 | 64 | 72 |
| 28 | Barricade 65WG | 0.32 | 94 | 81 | 91 | 79 | 76 | 82 |
| 29 | Barricade 65WG | 0.38 | 93 | 98 | 100 | 92 | 94 | 95 |
| 30 | Barricade 65WG | 0.48 | 93 | 87 | 93 | 87 | 82 | 87 |
| 31 | Barricade 65WG | 0.65 | 90 | 89 | 97 | 90 | 86 | 90 |
| 32 | Pendimethalin 60WDG | 1.50 | 94 | 91 | 94 | 92 | 78 | 88 |
| 33 | Ronstar 2G | 2.00 | 84 | 73 | 73 | 60 | 35 | 60 |
| 34 | Dimension 1EC | 0.25 | 88 | 87 | 96 | 77 | 71 | 81 |
| 35 | Barricade 65WG | 0.25 fb 0.25 | 55 | 65 | 73 | 71 | 49 | 63 |
| 36 | Barricade 65WG | 0.33 fb 0.17 | 93 | 84 | 88 | 85 | 84 | 86 |
| 37 | Pendimethalin 60WDG | 0.75 fb 0.75 | 60 | 65 | 70 | 62 | 42 | 58 |
| 38 | Dimension 1EC | 0.125 fb 0.125 | 75 | 76 | 79 | 66 | 71 | 72 |
| | $LSD_{0.05}$ | | 23 | 24 | 34 | 23 | 25 | 21 |

[1]Reductions in percent crabgrass cover was estimated as the area per plot occupied by crabgrass.
[2]The rate for these products is in grams product/ft$^2$.
[3]The rate for these products is in ml product/1000 ft$^2$.

# 1997 Preemergence Annual Grass Control Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to evaluate the efficacy of Team Pro as a preemergent annual weed herbicide in turfgrass. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, IA. The experimental plot was in 'Nassau' Kentucky bluegrass. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 2.2% organic matter, a pH of 6.7, 3 ppm P, and 54 ppm K. Irrigation was used to supplement rainfall and maintain the turf in good growing condition.

The study design was a randomized complete block. Individual plot size was 5 x 5 ft with three replications and one row per replication. DowElanco furnished five herbicide + fertilizer granular formulations for this study. Team Pro 0.86GR (0.43% benefin and 0.43% trifluralin) + fertilizer (NAF-324), Team 0.87GR (0.58% benefin and 0.29% trifluralin) + fertilizer (NAF-323), and Pendimethalin 0.86GR + fertilizer were applied in single preemergence (PRE) applications at 2.0 lb a.i./A and in split PRE and postemergence (POST) applications at 1.5 lb a.i./A. Dimension 0.09GR + fertilizer was applied in a single PRE application at 0.38 lb a.i./A and Barricade 0.22GR + fertilizer was applied in a single PRE application at 0.50 lb a.i./A. There were a total of nine treatments including an untreated control (Table 1).

The herbicides were applied with 'shaker dispensers' to ensure uniform distribution. Following the PRE applications, the materials were 'watered in' with the irrigation system. The plot was mowed regularly at 2 inches.

Initial applications were made preemergently on May 7 before crabgrass germination. Crabgrass germination was detected in the untreated control plots on June 18. Sequential (postemergent) applications were made on June 2, eight weeks after the initial applications.

Phytotoxicity data were taken on May 12 and May 15. Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage and 1 = dead grass (Table 1). Visual quality data were taken on May 21, June 5, June 10, June 18, and June 25 (Table 2). Visual turf quality was evaluated with a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. Crabgrass control was determined by estimating percentage crabgrass cover per plot and subsequently calculating percent reduction as compared with the untreated controls. Percentage cover data were taken on July 2, July 10, July 15, July 30, and August 20 (Table 3). Percentage crabgrass reduction data were calculated for each of these collection dates (Table 4)

Data were analyzed with the Statistical Analysis System (SAS, version 6.10) using the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

There were no phytotoxicity symptoms on treated bluegrass (Table 1). The visual quality of all treated bluegrass was significantly better from May 21 through August 20. The quality of treated bluegrass was the same from June 10 through July 2. After the sequential applications, significant quality differences were evident among the treatments for July 10 and July 15 (Table 2).

The mean quality of all treated bluegrass was significantly better than the untreated control. The best mean quality was for bluegrass treated with Team Pro (NAF-324) at 1.50 lb a.i./A followed by 1.50 lb a.i./A, Team Pro (NAF-324) at 2.00 lb a.i./A, Team (NAF-323) at 1.50 lb a.i./A followed by 1.50 lb a.i./A, and Pendimethalin 0.86GR at 1.50 lb a.i./A followed by 1.50 lb a.i./A (Table 2).

All herbicides significantly reduced percentage crabgrass cover from July 2 through August 20 when compared with the untreated control (Table 3). The mean percentage cover of all treated bluegrass was significantly lower than the untreated control. All products except Pendimethalin 0.86GR at 2.00 lb a.i./A maintained crabgrass cover below 20% through August 20. Bluegrass treated with Team Pro (NAF-324) at 2.00 lb a.i./A, Team (NAF-323) at 2.00 lb a.i./A, Dimension 0.09GR at 0.38 lb a.i./, and Barricade 0.22 GR at 0.50 lb a.i./A had the least percentage crabgrass cover as compared to other treated and untreated turf.

There were significant reductions in crabgrass cover from July 2 through August 20 in all treated bluegrass when compared with the untreated control (Table 4). Bluegrass treated with Dimension 0.09GR at 0.38 lb a.i./A, Team Pro (NAF-324) at 2.00 lb a.i./A, Team (NAF-323) at 2.00 lb a.i./A, and Barricade 0.22GR at 0.50 lb a.i./A maintained at least 85% reduction in crabgrass cover throughout the duration of the study.

**Table 1.** Kentucky bluegrass phytotoxicity[1] for the 1997 Preemergence Annual Grass Control Study.

| | | Initial application [preemergent] | Sequential application [postemergent] | Phytotxicity[1] | |
|---|---|---|---|---|---|
| | Materials | Rate (lb a.i./A) | Rate (lb a.i./A) | May 12 | May 15 |
| 1 | Untreated control | NA | NA | 9 | 9 |
| 2 | Team Pro 0.86GR + fertilizer NAF-324 | 1.5 | 1.5 | 9 | 9 |
| 3 | Team Pro 0.86GR + fertilizer NAF-324 | 2.0 | none | 9 | 9 |
| 4 | Team 0.87GR + fertilizer NAF-323 | 1.5 | 1.5 | 9 | 9 |
| 5 | Team 0.87GR + fertilizer NAF-323 | 2.0 | none | 9 | 9 |
| 6 | Pendimethalin 0.86GR + fertilizer | 1.5 | 1.5 | 9 | 9 |
| 7 | Pendimethalin 0.86GR + fertilizer | 2.0 | none | 9 | 9 |
| 8 | Dimension 0.09GR + fertilizer | 0.38 | none | 9 | 9 |
| 9 | Barricade 0.22GR + fertilizer | 0.50 | none | 9 | 9 |
| | $LSD_{0.05}$ | | | NS | NS |

[1]Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage and 1 = dead turf.
Initial (preemergent) applications were made on May 7 and sequentials (postemergent) on July 2, 1997 (8 WAT).
NS = means are not significantly different at the 0.05 level.

**Table 2.** Visual quality[1] of Kentucky bluegrass treated with herbicide + fertilizer formulations for the 1997 Preemergence Annual Weed Control Study.

| | Materials | Rate lb a.i./A | May 21 | June 5 | June 10 | June 18 | June 25 | July 2 | July 10 | July 15 | July 30 | Aug 20 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 6 | 6 | 6 | 6 | 7 | 7 | 5 | 6 | 9 | 6 | 6.4 |
| 2 | Team Pro 0.86GR + fertilizer NAF-324 | 1.50 fb 1.50 | 8 | 7 | 9 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 8.6 |
| 3 | Team Pro 0.86GR + fertilizer NAF-324 | 2.00 | 9 | 8 | 9 | 8 | 9 | 9 | 8 | 7 | 9 | 8 | 8.4 |
| 4 | Team 0.87GR + fertilizer NAF-323 | 1.50 fb 1.50 | 8 | 7 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 8.5 |
| 5 | Team 0.87GR + fertilizer NAF-323 | 2.00 | 8 | 8 | 9 | 8 | 9 | 9 | 7 | 8 | 9 | 8 | 8.3 |
| 6 | Pendimethalin 0.86GR + fertilizer | 1.50 fb 1.50 | 9 | 8 | 9 | 8 | 9 | 9 | 8 | 8 | 9 | 9 | 8.5 |
| 7 | Pendimethalin 0.86GR + fertilizer | 2.00 | 8 | 8 | 9 | 8 | 9 | 9 | 6 | 7 | 9 | 8 | 8.2 |
| 8 | Dimension 0.09GR + fertilizer | 0.38 | 8 | 8 | 9 | 8 | 8 | 9 | 7 | 8 | 9 | 8 | 8.1 |
| 9 | Barricade 0.22GR + fertilizer | 0.50 | 9 | 8 | 9 | 8 | 9 | 9 | 7 | 7 | 9 | 8 | 8.3 |
| | $LSD_{0.05}$ | | 1 | 1 | 1 | NS | NS | NS | 1 | 1 | NS | 1 | 0.3 |

[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
Initial (preemergent) applications were made on May 7 and sequentials (postemergent) on July 2, 1997 (8 WAT).
NS = means are not significantly different at the 0.05 level.

**Table 3.** Percent crabgrass cover[1] in Kentucky bluegrass treated with herbicide + fertilizer formulations for the 1997 Preemergence Annual Grass Control Study.

| | Materials | Rate lb a.i./A | July 2 | July 10 | July 15 | July 30 | August 20 | Mean cover |
|---|---|---|---|---|---|---|---|---|
| | | | % | | | | | |
| 1 | Untreated control | NA | 25 | 38 | 50 | 63 | 77 | 51 |
| 2 | Team Pro 0.86GR + fertilizer NAF-324 | 1.50 fb 1.50 | 5 | 4 | 7 | 10 | 15 | 8 |
| 3 | Team Pro 0.86GR + fertilizer NAF-324 | 2.00 | 0 | 1 | 1 | 2 | 7 | 2 |
| 4 | Team 0.87GR + fertilizer NAF-323 | 1.50 fb 1.50 | 7 | 5 | 8 | 15 | 15 | 10 |
| 5 | Team 0.87GR + fertilizer NAF-323 | 2.00 | 1 | 1 | 2 | 5 | 9 | 3 |
| 6 | Pendimethalin 0.86GR + fertilizer | 1.50 fb 1.50 | 5 | 4 | 7 | 13 | 19 | 10 |
| 7 | Pendimethalin 0.86GR + fertilizer | 2.00 | 3 | 8 | 8 | 12 | 30 | 12 |
| 8 | Dimension 0.09GR + fertilizer | 0.38 | 0 | 1 | 0 | 2 | 2 | 1 |
| 9 | Barricade 0.22GR + fertilizer | 0.50 | 3 | 2 | 2 | 7 | 10 | 5 |
| | $LSD_{0.05}$ | | 5 | 8 | 8 | 13 | 16 | 9 |

[1]Percent crabgrass cover was assessed as the percentage of area per plot covered by crabgrass.
Initial (preemergent) applications were made on May 7 and sequentials (postemergent) on July 2, 1997 (8 WAT).

**Table 4.** Percentage reduction in crabgrass populations[1] in Kentucky bluegrass treated with herbicide + fertilizer formulations for the 1997 Preemergence Annual Grass Control Study.

| | Materials | Rate lb a.i./A | July 2 | July 10 | July 15 | July 30 | August 20 | Mean reduction |
|---|---|---|---|---|---|---|---|---|
| | | | % reduction | | | | | |
| 1 | Untreated control | NA | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Team Pro 0.86GR + fertilizer NAF-324 | 1.50 fb 1.50 | 79 | 90 | 86 | 84 | 81 | 84 |
| 3 | Team Pro 0.86GR + fertilizer NAF-324 | 2.00 | 100 | 99 | 99 | 96 | 91 | 96 |
| 4 | Team 0.87GR + fertilizer NAF-323 | 1.50 fb 1.50 | 73 | 87 | 83 | 76 | 81 | 80 |
| 5 | Team 0.87GR + fertilizer NAF-323 | 2.00 | 99 | 97 | 96 | 92 | 89 | 93 |
| 6 | Pendimethalin 0.86GR + fertilizer | 1.50 fb 1.50 | 79 | 90 | 86 | 79 | 76 | 81 |
| 7 | Pendimethalin 0.86GR + fertilizer | 2.00 | 87 | 78 | 83 | 81 | 61 | 76 |
| 8 | Dimension 0.09GR + fertilizer | 0.38 | 100 | 99 | 100 | 97 | 97 | 98 |
| 9 | Barricade 0.22GR + fertilizer | 0.50 | 87 | 95 | 95 | 89 | 87 | 90 |
| | $LSD_{0.05}$ | | 22 | 20 | 16 | 20 | 21 | 17 |

[1]Percentage crabgrass reduction was calculated as percent reduction compared with crabgrass populations in the untreated controls. Initial (preemergent) applications were made on May 7 and sequentials (postemergent) on July 2, 1997 (8 WAT).

# 1997 Postemergence Broadleaf Weed Control Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to evaluate the efficacy of various postemergence broadleaf herbicides in turfgrass. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, IA. The plot was located in 'common' Kentucky bluegrass. The soil was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.2% organic matter, a pH of 7.9, 17 ppm P, and 109 ppm K. Rainfall was sporadic throughout the test so irrigation was used to maintain the bluegrass in good growing condition.

The study was designed as a randomized complete block. Individual plot size was 5 x 10 ft with three replications.

Four granular weed and feed products were included: DCDA20, DTDA20, MCDA20 and Turf Builder + 2 (Table 1). For these products the 5 x 10 ft plots were split into two-2.5 x 10 ft subplots and the north subplot was moistened with water prior to treatment and the south subplot was kept dry. One half of the material allotted for the whole plot was applied to each of the two subplots.

The balance of the herbicides were applied as liquids (Table 1). Tri-Power and Triplet were applied at 1.19, Horsepower at 0.98, Millennium at 1.10, DCDA at 0.98, DTDA at 0.98, and MCDA at 0.98 oz product/1000 ft$^2$. Gallery 75WG was applied at 0.75 lb a.i./A as an early spring material followed by a postemergent application of either Confront 3SL at 0.75 lb a.i./A or Trimec Classic 3.4SL at 1.66 lb a.i./A. Trimec Classic 3.4SL and Confront 3SL also were applied alone postemergently at these same rates. CGA #136872 (Beacon) was applied at 20.0 g product/A and at 10.0 g product/A in split applications. SCOIL MSO, a methylated seed oil spreader, was added to the tank mix of CGA #136872 (Beacon) at 0.25% V/V. Two experimental products, EH1312 and EH1342 were applied at two different rates: EH1312 at 1.0 and 1.2 and EH1342 at 0.8 and 1.0 fl oz product/1000 ft$^2$. Super Trimec was included at 1.1 fl oz product/1000 ft$^2$ for comparisons. An untreated control also was included.

Liquid materials were applied at 30 psi using a $CO_2$ backpack sprayer equipped with TeeJet™ #8006 flat fan nozzles. The materials were applied in 380 ml of water. This translates to a rate of 2 gallon/1000 ft$^2$. Granular materials were applied with a cardboard container used as a 'shaker dispenser'.

Early spring applications (treatments 13 and 14) were made on May 15. Spring postemergent applications were made on May 22, after broadleaf weed species were established. Sequential applications (treatments 17 and 18) were made on June 19, three weeks after the initial applications.

Throughout the study, the turf was examined for phytotoxic symptoms. Phytotoxicity data were taken on July 7 and July 15 (Table 2).

Weed damage was characterized on May 30 (8 DAT) as to the type and severity of phytotoxic symptoms (Table 3). Data were taken for dandelion and clover, the two predominate broadleaf species. Damage was estimated by using a 4 to 1 scale: 4 = no damage, 3 = slight leaf curling and discoloration, 2 = moderate leaf curling and sporadic discoloration, and 1 = severe leaf curling and uniform discoloration. Additional weed damage data were taken on June 10 (19 DAT), June 19 (28 DAT), and June 26 (35 DAT). These data were assessed using a 9 to 1 scale: 9 = no damage, 8 = slight damage & no mortality, 7 = some damage & no mortality, 6 = moderate damage & 10% mortality, 5 = uniform moderate damage & 25% mortality, 4 = severe damage & 50% mortality, 3 = uniform severe damage & 75% mortality, 2 = severe damage & 90% mortality and 1 = 100% mortality (Table 4). The mortality estimations represent the reduction in all broadleaf species in each plot as compared to the untreated control plots (Table 5). Counts of the surviving weeds in each plot were taken on July 3, 1997. The number of dandelion and oxalis plants per plot were counted and the percentage of area per plot covered by clover and black medic was estimated (Table 6). These counts were converted to express percent reductions in number of plants per plot when compared with the untreated controls (Table 7).

Data were analyzed with the Statistical Analysis System (SAS, version 6.10) and the Analysis of Variance (ANOVA) procedure. Means comparisons were made using Fisher's Least Significant Difference (LSD) tests.

On July 7, phytotoxicity was noted on turf treated with CGA #136872 Beacon + SCOIL MSO (Table 2). These symptoms were still present on July 15 but were gone by July 22.

By May 30, all treated dandelion and clover plants were beginning to exhibit damage (Table 3). The observed symptoms ranged from slight leaf curling and slight discoloration to severe leaf curling and a uniform discoloration. For most herbicides, the treated dandelions had more severe damage than the clover.

All treated broadleaves were exhibiting significant levels of damage by June 19 when compared with the untreated control (Table 4). There also was some level of weed mortality in all treated plots. There was severe mortality among the broadleaves treated with Triplet, Millenium, Trimec Classic 3.4SL, and Super Trimec by June 26 (Table 5). On this date, 25 herbicides produced significant reductions in broadleaf cover when compared with the untreated control (Table 5). Reductions were ≥ 70% for seven herbicides and there was a 90% broadleaf reduction in turf treated with Super Trimec.

Treatment with 21 of the herbicides resulted in dandelion numbers that were significantly less than the untreated control (Table 6). Percentage reductions in dandelions were > 80% in turf treated with either Triplet, MCDA, Gallery 75WG + Confront 3SL, Confront 3SL, Super Trimec, and MCDA20 (on wet foliage) (Table 7). Control of dandelions was better for DCDA20, DTDA20, MCDA20, and Turf Builder + 2 applied to wet foliage than applied to dry foliage.

Populations of the annual broadleaf, oxalis, were quite high this year. Oxalis numbers were higher in some of the treated plots than in the untreated control (Table 6). When compared to the untreated control, Super Trimec produced an 80% numerical reduction in the oxalis population, although statistically this reduction was not significant (Table 7).

Some of the treated turf had a higher percentage clover cover than the untreated control (Table 6). Millenium, Gallery 75WG + Confront 3SL, Confront 3SL, and Super Trimec treated turf contained no clover. Turf treated with either Tri-Power, Triplet, Horsepower, CGA #13872 (Beacon) at 10 g product/A in split applications, DCDA20 (on wet foliage), or MCDA20 (on wet foliage) had percentage clover reductions ≥ 90% (Table 7).

All but one of the herbicides produced significant reductions in black medic percentage cover when compared with the untreated control (Table 7). Treatment with 22 of the materials resulted in reductions in black medic populations ≥ 93% (Table 7).

**Table 1.** Rates and timing of application for broadleaf herbicides used in the 1997 Postemergence Broadleaf Weed Control Study.

| | Materials | Spring application (POST) Rate product/1000 $ft^2$ | ml water /plot |
|---|---|---|---|
| 1 | Untreated control | NA | NA |
| 2 | Tri-Power [60.36%][1] | 1.19 oz | 380 |
| 3 | Triplet [49.67%][1] | 1.19 oz | 380 |
| 4 | Horsepower [59.40%][1] | 0.98 oz | 380 |
| 5 | Millenium[55.80%][1] | 1.10 oz | 380 |
| 6 | DCDA [47.06%][1] | 0.98 oz | 380 |
| 7 | DTDA [47.33%][1] | 0.98 oz | 380 |
| 8 | MCDA [58.04%][1] | 0.98 oz | 380 |
| 9 | DCDA20[1&2] [dry foliage] | 4.00 lb | none |
| 10 | DTDA20[1&2] [dry foliage] | 4.00 lb | none |
| 11 | MCDA20[1&2] [dry foliage] | 4.00 lb | none |
| 12 | Turf Builder + 2[1&2] [dry foliage] | 2.94 lb | none |

| | | Early spring application (PRE) Rate lb a.i./A | ml water /plot[2] | Spring application (POST) Rate (lb a.i./A) | ml water /plot |
|---|---|---|---|---|---|
| 13 | Gallery 75WG [FN-3133] | 0.75 | | none | |
| | + Confront 3SL [XRM-5085][3] | none | 380 | 0.75 | 380 |
| 14 | Gallery 75WG [FN-3133] | 0.75 | | none | |
| | + Trimec Classic 3.4SL[3] | none | 380 | 1.66 | 380 |
| 15 | Trimec Classic 3.4SL[3] | none | | 1.66 | 380 |
| 16 | Confront 3SL [XRM-5085][3] | none | | 0.75 | 380 |

| | | Spring application (POST) Rate product/A | ml water /plot[2] | Sequential application (3 weeks after initial)[5] Rate product/A | ml water /plot |
|---|---|---|---|---|---|
| 17 | CGA #136872 (Beacon) | 20.00 g | | | |
| | + SCOIL MSO[4] | + .25% v/v | 380 | none | 380 |
| 18 | CGA #136872 (Beacon) | 10.00 g | | 10.00 g | |
| | + SCOIL MSO[4] | + .25% v/v | 380 | +.25%v/v[5] | 380 |

(Table 1 continued on next page)

Table 1. (Continued)

| | Materials | Spring application (POST) Rate fl oz product/1000 ft² | ml water/plot |
|---|---|---|---|
| 19 | Trimec Classic 3.4SL[6] | 1.0 | 380 |
| 20 | EH1312[6] | 1.0 | 380 |
| 21 | EH1312[6] | 1.2 | 380 |
| 22 | EH1342[6] | 0.8 | 380 |
| 23 | EH1342[6] | 1.0 | 380 |
| 24 | Super Trimec | 1.1 | 380 |

| | | Rate product/1000 ft² | ml water/plot |
|---|---|---|---|
| 25 | DCDA20[1&2] [wet foliage] | 4.00 lb | enough to wet the foliage |
| 26 | DTDA20[1&2] [wet foliage] | 4.00 lb | enough to wet the foliage |
| 27 | MCDA20[1&2] [wet foliage] | 4.00 lb | enough to wet the foliage |
| 28 | Turf Builder + 2[1&2] [wet foliage] | 2.94 lb | enough to wet the foliage |

[1]These materials were screened for Riverdale Chemical Co.

[2]Test plots receiving these materials were divided into two - 2.5 x 10 ft [25 ft²] subplots and the north subplot was moistened before application and the south subplot was kept dry.

These materials were screened for DowElanco[3], and Novartis [Ciba][4] .

[5]Sequential applications were made on June 19 approximately 3 weeks after the initials.

[6]These materials were screened for PBI/Gordon.

Early spring applications (PRE) (trts 13 & 14) made on May 15; Spring applications (POST) made on May 22.

Sequential (3 WAT) materials (trts 17 & 18) were applied June 19.

380 ml water per plot is equivalent to 2 gal/1000 ft².

**Table 2.** Phytotoxicity[1] on July 15 on turf treated with broadleaf herbicides in the 1997 Postemergence Broadleaf Weed Control Study.

| | Materials | Rate lb a.i./A (unless noted) | July 7 | July 15 |
|---|---|---|---|---|
| 1 | Untreated control | NA | 9 | 9 |
| 2 | Tri-Power [60.36%] | 1.19 fl oz[2] | 9 | 9 |
| 3 | Triplet [49.67%] | 1.19 fl oz[2] | 9 | 9 |
| 4 | Horsepower [59.40%] | 0.98 fl oz[2] | 9 | 9 |
| 5 | Millenium[55.80%] | 1.10 fl oz[2] | 9 | 9 |
| 6 | DCDA [47-.06%] | 0.98 fl oz[2] | 9 | 9 |
| 7 | DTDA [47.33%] | 0.98 fl oz[2] | 9 | 9 |
| 8 | MCDA [58.04%] | 0.98 fl oz[2] | 9 | 9 |
| 9 | DCDA20 [dry foliage] | 4.00 lb[3] | 9 | 9 |
| 10 | DTDA20 [dry foliage] | 4.00 lb[3] | 9 | 9 |
| 11 | MCDA20 [dry foliage] | 4.00 lb[3] | 9 | 9 |
| 12 | Turf Builder + 2 [dry foliage] | 2.94 lb[3] | 9 | 9 |
| 13 | Gallery 75WG [FN-3133] (PRE) + Confront 3SL [XRM-5085] (POST) | 0.75 lb + 0.75 lb | 9 | 9 |
| 14 | Gallery 75WG [FN-3133] (PRE) + Trimec Classic 3.4SL (POST) | 0.75 lb + 1.66 lb | 9 | 9 |
| 15 | Trimec Classic 3.4SL[3] (POST) | 1.66 lb | 9 | 9 |
| 16 | Confront 3SL [XRM-5085] (POST) | 0.75 lb | 9 | 9 |
| 17 | CGA #136872 (Beacon) + SCOIL MSO | 20.00 g[4] | 5 | 5 |
| 18 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 fb 10.0 g[4] | 5 | 5 |
| 19 | Trimec Classic 3.4SL | 1.00 fl oz[2] | 9 | 9 |
| 20 | EH1312 | 1.00 fl oz[2] | 9 | 9 |
| 21 | EH1312 | 1.20 fl oz[2] | 9 | 9 |
| 22 | EH1342 | 0.80 fl oz[2] | 9 | 9 |
| 23 | EH1342 | 1.00 fl oz[2] | 9 | 9 |
| 24 | Super Trimec | 1.10 fl oz[2] | 9 | 9 |
| 25 | DCDA20 [wet foliage] | 4.00 lb[3] | 9 | 9 |
| 26 | DTDA20 [wet foliage] | 4.00 lb[3] | 9 | 9 |
| 27 | MCDA20 [wet foliage] | 4.00 lb[3] | 9 | 9 |
| 28 | Turf Builder + 2 [wet foliage] | 2.94 lb[3] | 9 | 9 |

[1]Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 7 = slight discoloration, 5 = moderate discoloration and tip burn, and 3 = severe damage.

[2]These rates are in fl oz product/1000 ft$^2$. [3]These rates are in lb product/1000 ft$^2$. [4]These rates are in grams product/A.

**Table 3.** Weed damage[1] from May 30 (8 DAT) for dandelion and clover treated with herbicides in the 1997 Postemergence Broadleaf Weed Control Study.

| | Materials | Rate lb a.i./A (unless noted) | Dandelion damage | Clover damage |
|---|---|---|---|---|
| 1 | Untreated control | NA | 4 | 4 |
| 2 | Tri-Power [60.36%] | 1.19 fl oz[2] | 1 | 2 |
| 3 | Triplet [49.67%] | 1.19 fl oz[2] | 2 | 2 |
| 4 | Horsepower [59.40%] | 0.98 fl oz[2] | 3 | 3 |
| 5 | Millenium[55.80%] | 1.10 fl oz[2] | 2 | 2 |
| 6 | DCDA [47-.06%] | 0.98 fl oz[2] | 1 | 2 |
| 7 | DTDA [47.33%] | 0.98 fl oz[2] | 2 | 2 |
| 8 | MCDA [58.04%] | 0.98 fl oz[2] | 1 | 2 |
| 9 | DCDA20 [dry foliage] | 4.00 lb[3] | 2 | 1 |
| 10 | DTDA20 [dry foliage] | 4.00 lb[3] | 3 | 3 |
| 11 | MCDA20 [dry foliage] | 4.00 lb[3] | 2 | 3 |
| 12 | Turf Builder + 2 [dry foliage] | 2.94 lb[3] | 2 | 3 |
| 13 | Gallery 75WG [FN-3133] (PRE) + Confront 3SL [XRM-5085] (POST) | 0.75 lb + 0.75 lb | 2 | 3 |
| 14 | Gallery 75WG [FN-3133] (PRE) + Trimec Classic 3.4SL (POST) | 0.75 lb + 1.66 lb | 2 | 2 |
| 15 | Trimec Classic 3.4SL[3] (POST) | 1.66 lb | 2 | 2 |
| 16 | Confront 3SL [XRM-5085] (POST) | 0.75 lb | 2 | 2 |
| 17 | CGA #136872 (Beacon) + SCOIL MSO | 20.00 g[4] | 3 | 3 |
| 18 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 fb 10.0 g[4] | 3 | 3 |
| 19 | Trimec Classic 3.4SL | 1.00 fl oz[2] | 2 | 3 |
| 20 | EH1312 | 1.00 fl oz[2] | 1 | 2 |
| 21 | EH1312 | 1.20 fl oz[2] | 2 | 2 |
| 22 | EH1342 | 0.80 fl oz[2] | 3 | 3 |
| 23 | EH1342 | 1.00 fl oz[2] | 2 | 2 |
| 24 | Super Trimec | 1.10 fl oz[2] | 1 | 1 |
| 25 | DCDA20 [wet foliage] | 4.00 lb[3] | 2 | 1 |
| 26 | DTDA20 [wet foliage] | 4.00 lb[3] | 3 | 3 |
| 27 | MCDA20 [wet foliage] | 4.00 lb[3] | 2 | 3 |
| 28 | Turf Builder + 2 [wet foliage] | 2.94 lb[3] | 1 | 3 |

[1]Damage was assessed using a 4 to 1 scale: 4 = no damage, 3 = slight leaf curling and discoloration, 2 = moderate leaf curling and sporadic discoloration, and 1 = severe leaf curling and uniform discoloration.
Ratings are based on data from 3 replications.
[2]These rates are in fl oz product/1000 $ft^2$.
[3]These rates are in lb product/1000 $ft^2$.
[4]These rates are in grams product/A.

**Table 4.** Weed damage[1] from June 10 (19 DAT), June 19 (28 DAT) and June 26 (35 DAT) for dandelion and clover treated with herbicides in the 1997 Broadleaf Weed Control Study.

| | Materials | Rate lb a.i./A (unless noted) | June 10 | June 19 | June 26 | Mean damage |
|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 9 | 9 | 7 | 8 |
| 2 | Tri-Power [60.36%] | 1.19 fl oz[2] | 8 | 4 | 3 | 5 |
| 3 | Triplet [49.67%] | 1.19 fl oz[2] | 6 | 3 | 3 | 4 |
| 4 | Horsepower [59.40%] | 0.98 fl oz[2] | 8 | 4 | 4 | 5 |
| 5 | Millenium[55.80%] | 1.10 fl oz[2] | 5 | 3 | 3 | 4 |
| 6 | DCDA [47-.06%] | 0.98 fl oz[2] | 8 | 4 | 4 | 5 |
| 7 | DTDA [47.33%] | 0.98 fl oz[2] | 7 | 4 | 4 | 5 |
| 8 | MCDA [58.04%] | 0.98 fl oz[2] | 5 | 4 | 3 | 4 |
| 9 | DCDA20 | 4.00 lb[3] | 7 | 4 | 5 | 5 |
| 10 | DTDA20 | 4.00 lb[3] | 7 | 5 | 6 | 6 |
| 11 | MCDA20 | 4.00 lb[3] | 8 | 4 | 4 | 5 |
| 12 | Turf Builder + 2 | 2.94 lb[3] | 8 | 5 | 5 | 6 |
| 13 | Gallery 75WG [FN-3133] | 0.75 lb | | | | |
| | + Confront 3SL [XRM-5085] | + 0.75 lb | 6 | 4 | 3 | 4 |
| 14 | Gallery 75WG [FN-3133] | 0.75 lb | | | | |
| | + Trimec Classic 3.4SL | + 1.66 lb | 8 | 4 | 3 | 5 |
| 15 | Trimec Classic 3.4SL[3] | 1.66 lb | 7 | 3 | 3 | 5 |
| 16 | Confront 3SL [XRM-5085] | 0.75 lb | 5 | 4 | 4 | 4 |
| 17 | CGA #136872 (Beacon) + SCOIL MSO | 20.00 g[4] | 8 | 5 | 5 | 6 |
| 18 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 fb 10.0 g[4] | 8 | 5 | 6 | 6 |
| 19 | Trimec Classic 3.4SL | 1.00 fl oz[2] | 8 | 4 | 5 | 6 |
| 20 | EH1312 | 1.00 fl oz[2] | 6 | 4 | 4 | 5 |
| 21 | EH1312 | 1.20 fl oz[2] | 8 | 4 | 4 | 5 |
| 22 | EH1342 | 0.80 fl oz[2] | 7 | 5 | 6 | 6 |
| 23 | EH1342 | 1.00 fl oz[2] | 8 | 5 | 6 | 6 |
| 24 | Super Trimec | 1.10 fl oz[2] | 6 | 2 | 2 | 3 |
| 25 | DCDA20 | 4.00 lb[3] | 7 | 4 | 4 | 5 |
| 26 | DTDA20 | 4.00 lb[3] | 7 | 5 | 6 | 6 |
| 27 | MCDA20 | 4.00 lb[3] | 8 | 4 | 4 | 5 |
| 28 | Turf Builder + 2 | 2.94 lb[3] | 8 | 5 | 4 | 6 |
| | $LSD_{0.05}$ | | NS | 2 | 2 | 2 |

[1]Damage ratings were assessed according to a 9 to 1 scale: 9 = no damage, 7 = little damage & will survive, 5 = damage & only a few dead, 3 = uniform severe damage & moderate mortality, 1 = most weeds dead.
[2]These rates are in fl oz product/1000 $ft^2$.
[3]These rates are in lb product/1000 $ft^2$.
[4]These rates are in grams product/A.
NS = means not significantly different at the 0.05 level.

**Table 5.** Percentage cover reductions[1] from June 10 (19 DAT), June 19 (28 DAT), and June 26 (35 DAT) for broadleaf weeds treated with herbicides in the 1997 Broadleaf Weed Control Study.

| | Materials | Rate lb a.i./A (unless noted) | June 10 | June 19 | June 26 | Mean |
|---|---|---|---|---|---|---|
| | | | % | | | |
| 1 | Untreated control | NA | 0 | 0 | 0 | 0 |
| 2 | Tri-Power [60.36%] | 1.19 fl oz[2] | 0 | 50 | 67 | 39 |
| 3 | Triplet [49.67%] | 1.19 fl oz[2] | 25 | 67 | 80 | 57 |
| 4 | Horsepower [59.40%] | 0.98 fl oz[2] | 0 | 55 | 63 | 39 |
| 5 | Millenium[55.80%] | 1.10 fl oz[2] | 42 | 63 | 68 | 58 |
| 6 | DCDA [47-.06%] | 0.98 fl oz[2] | 0 | 50 | 58 | 36 |
| 7 | DTDA [47.33%] | 0.98 fl oz[2] | 0 | 58 | 58 | 39 |
| 8 | MCDA [58.04%] | 0.98 fl oz[2] | 50 | 58 | 72 | 60 |
| 9 | DCDA20 (dry foliage) | 4.00 lb[3] | 0 | 42 | 58 | 33 |
| 10 | DTDA20 (dry foliage) | 4.00 lb[3] | 0 | 33 | 33 | 22 |
| 11 | MCDA20 (dry foliage) | 4.00 lb[3] | 0 | 58 | 58 | 39 |
| 12 | Turf Builder + 2 (dry foliage) | 2.94 lb[3] | 0 | 37 | 50 | 29 |
| | Gallery 75WG [FN-3133] | 0.75 lb | | | | |
| 13 | + Confront 3SL [XRM-5085] | + 0.75 lb | 25 | 42 | 72 | 46 |
| | Gallery 75WG [FN-3133] | 0.75 lb | | | | |
| 14 | + Trimec Classic 3.4SL | + 1.66 lb | 0 | 58 | 72 | 43 |
| 15 | Trimec Classic 3.4SL[3] | 1.66 lb | 0 | 72 | 77 | 49 |
| 16 | Confront 3SL [XRM-5085] | 0.75 lb | 30 | 55 | 72 | 52 |
| 17 | CGA #136872 (Beacon) + SCOIL MSO | 20.00 g[4] | 0 | 20 | 25 | 15 |
| 18 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 fb 10.0 g[4] | 0 | 25 | 25 | 17 |
| 19 | Trimec Classic 3.4SL | 1.00 fl oz[2] | 0 | 42 | 42 | 28 |
| 20 | EH1312 | 1.00 fl oz[2] | 25 | 58 | 58 | 47 |
| 21 | EH1312 | 1.20 fl oz[2] | 0 | 58 | 67 | 42 |
| 22 | EH1342 | 0.80 fl oz[2] | 0 | 25 | 25 | 17 |
| 23 | EH1342 | 1.00 fl oz[2] | 0 | 33 | 33 | 22 |
| 24 | Super Trimec | 1.10 fl oz[2] | 25 | 85 | 90 | 67 |
| 25 | DCDA20 (wet foliage) | 4.00 lb[3] | 0 | 42 | 58 | 33 |
| 26 | DTDA20 (wet foliage) | 4.00 lb[3] | 0 | 33 | 33 | 22 |
| 27 | MCDA20 (wet foliage) | 4.00 lb[3] | 0 | 58 | 58 | 39 |
| 28 | Turf Builder + 2 (wet foliage) | 2.94 lb[3] | 0 | 37 | 63 | 33 |
| | $LSD_{0.05}$ | | NS | 37 | 31 | 29 |

[1]Percentage reductions represent reductions in the area per plot covered by broadleaf weed species and are expressed as percent of the untreated controls.
[2]These rates are in fl oz product/1000 $ft^2$.
[3]These rates are in lb product/1000 $ft^2$.
[4]These rates are in grams product/A.
NS = means not significantly different at the 0.05 level.

**Table 6.** Weed counts[1] taken on July 3, 1997 from Kentucky bluegrass treated with herbicides in the 1997 Postemergence Broadleaf Weed Control Study.

| | Materials | Rate lb a.i./A (unless noted) | Number of plants | | Percent cover (%) | |
|---|---|---|---|---|---|---|
| | | | Dandelion | Oxalis | Clover | Black Medic |
| 1 | Untreated control | NA | 92 | 8 | 7 | 9 |
| 2 | Tri-Power [60.36%] | 1.19 fl oz[2] | 40 | 6 | 1 | 0 |
| 3 | Triplet [49.67%] | 1.19 fl oz[2] | 16 | 31 | 1 | 1 |
| 4 | Horsepower [59.40%] | 0.98 fl oz[2] | 44 | 10 | 1 | 0 |
| 5 | Millenium[55.80%] | 1.10 fl oz[2] | 24 | 31 | 0 | 0 |
| 6 | DCDA [47-.06%] | 0.98 fl oz[2] | 21 | 21 | 1 | 0 |
| 7 | DTDA [47.33%] | 0.98 fl oz[2] | 34 | 7 | 7 | 0 |
| 8 | MCDA [58.04%] | 0.98 fl oz[2] | 9 | 22 | 2 | 0 |
| 9 | DCDA20 [dry foliage] | 4.00 lb[3] | 47 | 21 | 1 | 0 |
| 10 | DTDA20 [dry foliage] | 4.00 lb[3] | 83 | 9 | 16 | 1 |
| 11 | MCDA20 [dry foliage] | 4.00 lb[3] | 54 | 16 | 2 | 1 |
| 12 | Turf Builder + 2 [dry foliage] | 2.94 lb[3] | 73 | 11 | 17 | 1 |
| | Gallery 75WG [FN-3133] | 0.75 lb | | | | |
| 13 | + Confront 3SL [XRM-5085] | + 0.75 lb | 12 | 23 | 0 | 1 |
| | Gallery 75WG [FN-3133] | 0.75 lb | | | | |
| 14 | + Trimec Classic 3.4SL | + 1.66 lb | 29 | 14 | 5 | 1 |
| 15 | Trimec Classic 3.4SL[3] | 1.66 lb | 16 | 30 | 10 | 1 |
| 16 | Confront 3SL [XRM-5085] | 0.75 lb | 17 | 7 | 0 | 0 |
| 17 | CGA #136872 (Beacon) + SCOIL MSO | 20.00 g[4] | 38 | 4 | 20 | 1 |
| 18 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 fb 10.0 g[4] | 22 | 7 | 1 | 5 |
| 19 | Trimec Classic 3.4SL | 1.00 fl oz[2] | 39 | 27 | 15 | 1 |
| 20 | EH1312 | 1.00 fl oz[2] | 24 | 10 | 2 | 1 |
| 21 | EH1312 | 1.20 fl oz[2] | 25 | 8 | 1 | 3 |
| 22 | EH1342 | 0.80 fl oz[2] | 69 | 12 | 20 | 2 |
| 23 | EH1342 | 1.00 fl oz[2] | 66 | 14 | 4 | 1 |
| 24 | Super Trimec | 1.10 fl oz[2] | 4 | 2 | 0 | 0 |
| 25 | DCDA20 [wet foliage] | 4.00 lb[3] | 27 | 11 | 1 | 0 |
| 26 | DTDA20 [wet foliage] | 4.00 lb[3] | 56 | 6 | 17 | 3 |
| 27 | MCDA20 [wet foliage] | 4.00 lb[3] | 10 | 16 | 1 | 0 |
| 28 | Turf Builder + 2 [wet foliage] | 2.94 lb[3] | 37 | 12 | 12 | 1 |
| | $LSD_{0.05}$ | | 40 | NS | 14 | [Pr > 0.06] 4 |

[1]These figures represent the number of dandelion and oxalis plants per plot and the percent of area per plot covered by clover and black medic.
[2]These rates are in fl oz product/1000 $ft^2$.
[3]These rates are in lb product/1000 $ft^2$.
[4]These rates are in grams product/A.
NS = means are not significantly different at the 0.05 level

**Table 7.** Percentage reductions in broadleaf weed counts and weed cover[1] taken on July 3, 1997 from Kentucky bluegrass treated with herbicides in the 1997 Postemergence Broadleaf Weed Control Study.

| | Materials | | Percent reductions in number of plants | | Percent reductions in weed cover (%) | |
|---|---|---|---|---|---|---|
| | | | Dandelion | Oxalis | Clover | Black Medic |
| | | | ---------- % ---------- | | ---------- % ---------- | |
| 1 | Untreated control | NA | 0 | 0 | 0 | 0 |
| 2 | Tri-Power [60.36%] | 1.19 fl oz[2] | 57 | 25 | 95 | 100 |
| 3 | Triplet [49.67%] | 1.19 fl oz[2] | 83 | 0 | 90 | 93 |
| 4 | Horsepower [59.40%] | 0.98 fl oz[2] | 53 | 0 | 90 | 100 |
| 5 | Millenium[55.80%] | 1.10 fl oz[2] | 74 | 0 | 100 | 100 |
| 6 | DCDA [47-.06%] | 0.98 fl oz[2] | 78 | 0 | 85 | 100 |
| 7 | DTDA [47.33%] | 0.98 fl oz[2] | 63 | 17 | 0 | 100 |
| 8 | MCDA [58.04%] | 0.98 fl oz[2] | 90 | 0 | 70 | 100 |
| 9 | DCDA20 [dry foliage] | 4.00 lb[3] | 49 | 0 | 85 | 100 |
| 10 | DTDA20 [dry foliage] | 4.00 lb[3] | 10 | 0 | 0 | 96 |
| 11 | MCDA20 [dry foliage] | 4.00 lb[3] | 41 | 0 | 70 | 96 |
| 12 | Turf Builder + 2 [dry foliage] | 2.94 lb[3] | 21 | 0 | 0 | 93 |
| 13 | Gallery 75WG [FN-3133]<br>+ Confront 3SL [XRM-5085] | 0.75 lb<br>+ 0.75 lb | 87 | 0 | 100 | 96 |
| 14 | Gallery 75WG [FN-3133]<br>+ Trimec Classic 3.4SL | 0.75 lb<br>+ 1.66 lb | 68 | 0 | 20 | 96 |
| 15 | Trimec Classic 3.4SL | 1.66 lb | 83 | 0 | 0 | 96 |
| 16 | Confront 3SL [XRM-5085] | 0.75 lb | 82 | 8 | 100 | 100 |
| 17 | CGA #136872 (Beacon) + SCOIL MSO | 20.00 g[4] | 59 | 46 | 0 | 96 |
| 18 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 fb 10.0 g[4] | 76 | 8 | 95 | 41 |
| 19 | Trimec Classic | 1.00 fl oz[2] | 58 | 0 | 0 | 89 |
| 20 | EH1312 | 1.00 fl oz[2] | 74 | 0 | 65 | 96 |
| 21 | EH1312 | 1.20 fl oz[2] | 73 | 0 | 80 | 63 |
| 22 | EH1342 | 0.80 fl oz[2] | 25 | 0 | 0 | 78 |
| 23 | EH1342 | 1.00 fl oz[2] | 28 | 0 | 40 | 96 |
| 24 | Super Trimec | 1.10 fl oz[2] | 95 | 80 | 100 | 100 |
| 25 | DCDA20 [wet foliage] | 4.00 lb[3] | 71 | 0 | 95 | 100 |
| 26 | DTDA20 [wet foliage] | 4.00 lb[3] | 39 | 25 | 0 | 67 |
| 27 | MCDA20 [wet foliage] | 4.00 lb[3] | 89 | 0 | 95 | 100 |
| 28 | Turf Builder + 2 [wet foliage] | 2.94 lb[3] | 60 | 0 | 0 | 96 |
| | $LSD_{0.05}$ | | 43 | NS | 50 | [Pr > 0.06]<br>49 |

[1]Percentage reductions represent reductions in the number of dandelion and oxalis plants per plot and reductions in the area per plot covered by clover and black medic. They are expressed as percent of the untreated controls.
[2]These rates are in fl oz product/1000 ft$^2$.
[3]These rates are in lb product/1000 ft$^2$.
[4]These rates are in grams product/A.
NS = means are not significantly different at the 0.05 level

# Effect of Beacon on Kentucky Bluegrass Cultivars

*Barbara R. Bingaman, Nick E. Christians, & Michael B. Faust*

The objective of this study was to evaluate CGA #136872 (Beacon) for phytotoxicity on four Kentucky bluegrass cultivars. This study was conducted at the ISU Horticulture Research Station north of Ames, IA. Identical studies were conducted in four Kentucky bluegrass cultivars: 'common', 'Glade', 'Park', and 'Ram I'. The soil in all four plots was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll). The 'common' plot had 3.65% organic matter, a pH of 5.42, 3 ppm P, and 93 ppm K and the 'Glade' plot had 4.0% organic matter, a pH of 6.85, 5 ppm P, and 76 ppm K. The 'Park' plot had 3.6% organic matter, a pH of 7.03, 17 ppm P, and 93 ppm K and the 'Ram I' plot had 3.9% organic matter, a pH of 7.00, 3 ppm P, and 76 ppm K.

Rainfall was sporadic during the study. Supplemental irrigation was used in all plots except the 'common' plot to keep the bluegrass in good growing condition.

These studies were designed as randomized complete blocks with three replications. There were four treatments including an untreated control. Novartis CGA #136872 (Beacon) was applied in single applications at 20 g and 40 g product/A. CGA #136872 (Beacon) also was applied in split applications at 10 g product/A. A methylated seed oil, SCOIL MSO, was added to all treatments at 0.25% V/V except the untreated control (Table 2). The treatments were applied at 30 psi using a $CO_2$ backpack sprayer equipped with TeeJet #8006 flat fan nozzles. Initial treatments were made on July 11. Sequential treatments were applied on July 24, 1997.

Phytotoxicity and visual quality data were taken weekly from July 15, 1997 through September 18. Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 7 = slight chlorosis, 5 = serious chlorosis, and 1 = dead turf (Tables 1-4). Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality (Tables 5-8). Data were analyzed with the Statistical Analysis System (SAS, version 6.10) and the Analysis of Variance (ANOVA) procedure. Means were compared using Fisher's Least Significant Difference (LSD) test. No phytotoxicity was detected on the 'common' bluegrass following the initial and sequential applications (Table 1). There was a slight chlorosis on 'Glade' bluegrass on July 30 following the sequential treatment of CGA #136872 (Beacon) at 10 g product/A on July 24 (Table 2). This discoloration was gone by August 6. On July 24, there was a general slight chlorosis on all treated 'Park' bluegrass (Table 3). By July 30, the quality of the treated 'Park' was the same as the untreated. The 'Ram I' bluegrass that received a sequential treatment on July 24 showed a moderate chlorotic effect on July 30. Bluegrass treated with an initial application of CGA #136872 (Beacon) at 40 g product/A had a slight chlorosis on this same date. By August 6, these symptoms were no longer present.

Turf quality was the same for treated and untreated 'common' bluegrass (Table 5). Because this plot was not irrigated, the sporadic rainfall can probably explain the poor quality in this plot during the summer. Turf quality of 'Glade' treated with CGA #136872 (Beacon) at 10 g product/A in split applications was lower than the other treated and untreated bluegrass on July 30 as a result of the sequential application on July 24 (Table 6). This difference was not evident on August 6. On July 24, 'Park' bluegrass treated with CGA #136872 (Beacon) had poorer quality than the untreated turf (Table 7). Turf quality was the same for treated and untreated 'Park' by July 30 and no other quality differences were noted throughout the season. Treatment with CGA #136872 (Beacon) resulted in lower turf quality of 'Ram I' bluegrass on July 24 (Table 8). On July 30, there also was a further quality decrease in 'Ram I' bluegrass that received a sequential treatment of CGA #136872 (Beacon) on July 24. The quality differences among the treated and untreated plots had disappeared by August 6.

In treated plots where decreases in quality occurred, they were not intensified by increases in the rate of CGA #136872 (Beacon). This would indicate that the phytotoxicity may have been due to the SCOIL rather than the CGA #136872 (Beacon). Future studies should include a SCOIL treatment with no CGA #136872 (Beacon) included.

**Table 1.** Phytotoxicity[1] of 'Common' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 7 = slight chlorosis, 5 = severe chlorosis, and 1 = dead turf.

**Table 2.** Phytotoxicity[1] of 'Glade' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 9 | 9 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 7 = slight chlorosis, 5 = severe chlorosis, and 1 = dead turf.

**Table 3**. Phytotoxicity[1] of 'Park' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 9 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 9 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 9 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 7 = slight chlorosis, 5 = severe chlorosis, and 1 = dead turf.

**Table 4.** Phytotoxicity[1] of 'Ram I' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 9 | 9 | 6 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 9 | 9 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | $LSD_{0.05}$ | | | NS | NS | 1 | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 7 = slight chlorosis, 5 = severe chlorosis, and 1 = dead turf.

**Table 5.** Visual quality[1] of 'Common' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 | Mean quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

**Table 6.** Visual quality[1] of 'Glade' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 | Mean quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 8 | 8 | 8 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 8 | 8 | 6 | 8 | 8 | 7 | 8 | 8 | 8 | 8 | 8 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 8 | 8 | 8 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 8 | 8 | 8 | 8 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

**Table 7.** Visual quality[1] of 'Park' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 | Mean quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 8 | 8 | 8 | 7 | 6 | 5 | 6 | 5 | 5 | 5 | 6 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 8 | 7 | 8 | 7 | 6 | 5 | 6 | 5 | 5 | 5 | 6 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 8 | 7 | 8 | 7 | 6 | 5 | 6 | 5 | 5 | 5 | 6 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 8 | 7 | 8 | 7 | 6 | 5 | 6 | 5 | 5 | 5 | 6 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

**Table 8.** Visual quality[1] of 'Ram I' Kentucky bluegrass treated in the 1997 Cultivar Phytotoxicity Study.

| | Material | Rate product/A. | Number of appl | July 15 | July 24 | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 | Mean quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 1 | 7 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7.5 |
| 2 | CGA #136872 (Beacon) + SCOIL MSO | 10.0 g + 0.25% V/V | 2 | 7 | 7 | 6 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7.2 |
| 3 | CGA #136872 (Beacon) + SCOIL MSO | 20.0 g + 0.25% V/V | 1 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7.3 |
| 4 | CGA #136872 (Beacon) + SCOIL MSO | 40.0 g + 0.25% V/V | 1 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 8 | 8 | 7.3 |
| | $LSD_{0.05}$ | | | NS | NS | 1 | NS | NS | NS | NS | NS | NS | NS | 0.1 |

Initial treatments were applied July 11 and sequentials were applied on July 24, 1997.
NS = means are not significantly different at the 0.05 level.
[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

# Effect of Primo on Kentucky Bluegrass Sod Establishment

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to determine the impact of the growth regulator, Trinexapac-ethyl (Primo), on the establishment of 'Majestic' Kentucky bluegrass sod. This study was conducted at the Iowa State University Horticulture Research Station north of Ames, Iowa. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 4.0% organic matter, a pH of 7.30, 2 ppm P, and 79 ppm K. This study was a repeat of a 1996 study. 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

The study was designed as a randomized complete block with four replications. Individual plots were 5 x 5 ft. Primo 1EC was applied at three treatment regimes. All Primo 1EC applications were made at 0.75 fl oz/1000 $ft^2$, the label rate for Kentucky bluegrass. The four treatments included an untreated control, applications of Primo 1EC two weeks prior to sod harvest, two weeks after sod establishment, and a combination treatment of two weeks prior plus two weeks after establishment (Table 1). Primo 1EC was applied at 30 psi with a $CO_2$ 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 $ft^2$. The two weeks before sod cutting treatments were made on June 11. The two weeks after sod cutting treatments were applied on July 10.

The bluegrass on the entire experimental plot was cut on June 26 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 with 18 mesh bottom screens. The pieces were trimmed and transplanted into the frames. 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. One frame per plot was sampled on each of four collection dates beginning July 10, two weeks after establishment. The other frames were harvested at two week intervals on July 21, August 6, and August 20 (Table 1).

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).

Visual quality data were taken on June 18, June 25, July 2, July 9, July 15, July 21, July 30, August 6, and August 20 (Table 2). Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

Data were analyzed using the Statistical Analysis System (SAS, Version 6.10) and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

There were no differences in turf quality between the treated and untreated plots (Table 2). No bluegrass phytotoxicity was detected during the study. There were no tensile strength differences in sod harvested on either July 10, July 21, or August 6 (Table 1). On August 20, the sod treated with Primo 1EC two weeks before cutting had significantly more root development than sod receiving the other Primo treatment regimes and the untreated control.

**Table 1.** Root tensile strength and knitting of Kentucky bluegrass sod growing in frames in the 1997 sod production study measured by the number of pounds per square inch (PSI) required to pull 1 $ft^2$ frames.

| | Material | Rate oz product/ 1000 $ft^2$ | Timing of application | July 9 | July 21 | August 6 | August 20 | Mean strength |
|---|---|---|---|---|---|---|---|---|
| | | | | psi | | | | |
| 1 | Untreated control | NA | NA | 104 | 159 | 214 | 213 | 172 |
| 2 | Primo 1EC | 0.75 | 2 wks before | 116 | 213 | 244 | 321 | 223 |
| 3 | Primo 1EC | 0.75 | 2 wks after | 125 | 180 | 193 | 225 | 181 |
| 4 | Primo 1EC | 0.75 | 2 wks before | 100 | 194 | 241 | 226 | 190 |
| | | 0.75 | + 2 wks after | | | | | |
| | $LSD_{0.05}$ | | | NS | NS | NS | 57 | 32 |

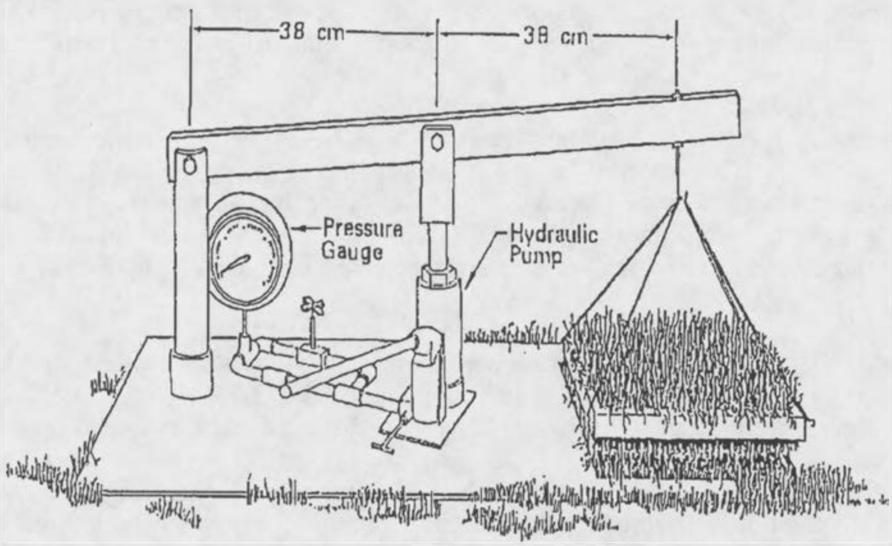
Two weeks prior to cutting sod treatments were applied on June 11. Sod was cut and put into frames on June 26. Two weeks after sod establishment treatments were made on July 10. Sod frames were pulled on July 10, July 22, August 6, and August 20.
NS = means are not significantly different at the 0.05 level.

**Table 2.** Visual quality[1] of Kentucky bluegrass sod growing in frames in the 1997 sod production study.

| | Material | Rate oz product/ 1000 $ft^2$ | Timing of applications | June 18 | June 25 | July 2 | July 9 | July 15 | July 30 | Aug 6 | Aug 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | NA | 9 | 9 | 7 | 6 | 7 | 6 | 6 | 6 |
| 2 | Primo 1EC | 0.75 | 2 wks before | 9 | 9 | 7 | 6 | 7 | 6 | 6 | 6 |
| 3 | Primo 1EC | 0.75 | 2 wks after | 9 | 9 | 7 | 6 | 7 | 6 | 6 | 6 |
| 4 | Primo 1EC | 0.75 | 2 wks before | 9 | 9 | 7 | 6 | 7 | 6 | 6 | 6 |
| | | 0.75 | + 2 wks after | | | | | | | | |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS |

Two weeks prior to cutting sod treatments were applied on June 11. Sod was cut and put into frames on June 26. Two weeks after sod establishment treatments were made on July 10.
[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

Figure 1. The hydraulic sod pulling apparatus used in the 1997 sod production study.



# Effects of Primo and Beacon on *Poa annua* Populations in Creeping Bentgrass Maintained at Green Height

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this control study was to evaluate CGA #136872 (Beacon) and the growth regulator, Trinexapac-ethyl (Primo) as *Poa annua* controls in green height creeping bentgrass.

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 33 to 65% through the season.

The study was a randomized complete block design with three replications. Individual plot size was 5 x 5 ft. There were five treatments including an untreated control, CGA #136872 (Beacon), and Primo. CGA #136872 (Beacon) was applied in single applications at 10 and 20 g product/A and at 10 g product/A in split applications. A methylated seed oil surfactant, SCOIL MSO, was added to CGA #136872 (Beacon) at 0.25% V/V for all applications. Primo 1EC was applied at 0.3 fl oz/1000 $ft^2$ monthly from June through September.

Initial applications of all materials were made on June 5. The sequential application of CGA #136872 (Beacon) was made on June 26. Additional Primo 1EC applications were made on July 10, August 13, and September 4. The materials were mixed with 283 ml of water (3 gal/1000 $ft^2$) and were applied at 30 psi with a $CO_2$ 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.

Phytotoxicity data were taken on June 10, June 19, June 26, and July 2. Phytotoxicity was assessed using a 9 to 1 scale: 9 = no damage, 6 = moderate tip burn (browning) and 4 = severe tip burn (Table 1). Visual turf quality data were taken weekly beginning June 10 and ending September 16 (Table 2). Visual turf quality was assessed with a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. *Poa annua* control was represented by estimating the percentage of area per plot covered by *Poa annua*. Percentage cover data were taken on June 19, June 26, July 15, July 21, and August 21 (Table 3). The presence of *Poa annua* seedheads also was recorded on July 2, July 15, July 21, and August 21 (Table 4). Seedhead numbers were estimated using many = a large number of uniformly distributed seedheads, moderate = a moderate number with a uniform distribution, few = a small number with a sporadic distribution, and none = no seedheads within the plot. Additional percentage cover data will be taken spring 1998 beginning at greenup. Winter damage also will be assessed in early spring.

There was severe phytotoxicity on bentgrass treated with CGA #136872 (Beacon) on June 10 through July 2 (Table 1). This material caused significant levels of phytotoxicity when compared with Primo 1EC-treated and untreated bentgrass. In addition, this phytotoxicity translated into significant brown areas in bentgrass treated with CGA #136872 (Beacon) on June 19, June 26, and July 2 when compared with Primo 1EC-treated and untreated bentgrass. There was no phytotoxicity detected after July 2.

There were no significant visual quality differences from July 21 through September 11 (Table 2). Primo 1EC-treated bentgrass had a darker green color than the CGA #136872 (Beacon)-treated and the untreated bentgrass from August 7 through September 11 but the difference was not significant.

Bentgrass treated with CGA #136872 (Beacon) showed reductions in percentage *Poa annua* cover for July 15 and July 21 but the percentages were not different from the Primo-treated and the untreated bentgrass (Table 3). On August 21, there were significantly lower *Poa annua* populations in bentgrass treated with CGA #136872 (Beacon) at 10 g and 20 g product/A and with Primo 1EC when compared with the other treated and untreated bentgrass.

Seedhead formation on *Poa annua* was suppressed by treatment with CGA #136872 (Beacon) and Primo 1EC. There were fewer seedheads in treated bentgrass than in untreated on July 2, July 15, July 21, and August 21.

**Table 1.** Phytotoxicity[1] and percent brown area[2] in plots of creeping bentgrass in the 1997 *Poa annua* control study.

| | Material | Rate product/A. (initial) | Rate product/A. (sequential) | Phytotoxicity[1] June 10 | June 19 | July 2 | Percent brown area[2] June 19 | June 26 | July 2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | NA | 9 | 9 | 9 | 0 | 0 | 0 |
| 2 | 136872 + SCOIL MSO | 10.0 g + 0.25% V/V | none | 7 | 4 | 9 | 17 | 8 | 0 |
| 3 | 136872 + SCOIL MSO | 20.0 g + 0.25% V/V | none | 7 | 3 | 9 | 32 | 20 | 0 |
| 4 | 136872 + SCOIL MSO | 10.0 g + 0.25% V/V | 10.0 g + 0.25% V/V | 7 | 4 | 3 | 10 | 7 | 28 |
| 5 | Primo 1EC | 0.3 fl oz/ 1000 $ft^2$ | 0.3 fl oz/ 1000 $ft^2$ | 9 | 9 | 9 | 0 | 0 | 0 |
| | $LSD_{0.05}$ | | | 1 | 1 | 1 | 13 | 9 | 6 |

[1]Phytotoxicity was assessed with a 9 to 1 scale: 9 = no damage, 6 = moderate tip burn (browning) and 4 = severe tip burn.
[2]Percent brown area per plot represents the total area with dying *Poa annua* and bentgrass with tip burn.
Initial applications were made on June 5 and sequentials on June 26, 1997. Primo was applied June 5, July 10, August 13, and September 4.

**Table 2.** Visual quality[1] in plots of creeping bentgrass in the 1997 *Poa annua* control study.

| | Material | Rate product/A. (initial) | Rate product/A. (sequential) | July 21 | July 31 | Aug 7 | Aug 14 | Aug 21 | Aug 28 | Sept 4 | Sept 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | NA | 7 | 9 | 8 | 8 | 8 | 8 | 9 | 9 |
| 2 | 136872 + SCOIL MSO | 10.0 g + 0.25% V/V | none | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 9 |
| 3 | 136872 + SCOIL MSO | 20.0 g + 0.25% V/V | none | 7 | 9 | 8 | 8 | 8 | 8 | 9 | 9 |
| 4 | 136872 + SCOIL MSO | 10.0 g + 0.25% V/V | 10.0 g + 0.25% V/V | 8 | 9 | 8 | 8 | 8 | 8 | 9 | 9 |
| 5 | Primo 1EC | 0.3 fl oz/ 1000 $ft^2$ | 0.3 fl oz/ 1000 $ft^2$ | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS | NS |

[1]Visual quality was assessed with a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
Initial applications were made on June 5 and sequentials on June 26, 1997. Primo was applied June 5, July 10, August 13, and September 4.
NS = means are not significantly different at the 0.05 level.

**Table 3.** Percentage *Poa annua* cover[1] in plots of creeping bentgrass in the 1997 *Poa annua* control study.

| | Material | Rate product/A. (initial) | Rate product/A. (sequential) | July 15 | July 21 | August 21 | Mean |
|---|---|---|---|---|---|---|---|
| | | | | % | | | |
| 1 | Untreated control | NA | NA | 45.0 | 33.3 | 65.0 | 47.8 |
| 2 | 136872<br>+ SCOIL MSO | 10.0 g<br>+ 0.25% V/V | none | 31.7 | 28.3 | 56.7 | 38.9 |
| 3 | 136872<br>+ SCOIL MSO | 20.0 g<br>+ 0.25% V/V | none | 33.3 | 23.3 | 53.3 | 36.7 |
| 4 | 136872<br>+ SCOIL MSO | 10.0 g<br>+ 0.25% V/V | 10.0 g<br>+ 0.25% V/V | 35.0 | 23.3 | 58.3 | 38.9 |
| 5 | Primo 1EC[2] | 0.3 fl oz/1000 ft[2] | 0.3 fl oz/1000 ft[2] | 53.3 | 30.0 | 35.0 | 39.4 |
| | $LSD_{0.05}$ | | | NS | NS | 8.6 | NS |

[1]Percent *Poa annua* cover represents the area per plot covered by *Poa annua*.
Initial applications were made on June 5 and sequentials on June 26, 1997. Primo was applied June 5, July 10, August 13, and September 4.
NS = means are not significantly different at the 0.05 level.

**Table 4.** Presence of *Poa annua* seedheads[1] in plots of creeping bentgrass in the 1997 *Poa annua* control study.

| | Material | Rate product/A. (initial) | Rate product/A. (sequential) | Seedhead numbers July 2 | July 15 | July 21 | August 21 |
|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | NA | moderate | moderate | moderate | many |
| 2 | 136872<br>+ SCOIL MSO | 10.0 g<br>+ 0.25% V/V | none | few | moderate | few | few |
| 3 | 136872<br>+ SCOIL MSO | 20.0 g<br>+ 0.25% V/V | none | none | none | none | few |
| 4 | 136872<br>+ SCOIL MSO | 10.0 g<br>+ 0.25% V/V | 10.0 g<br>+ 0.25% V/V | none | few | none | none |
| 5 | Primo 1EC | 0.3 fl oz/1000 ft[2] | 0.3 fl oz/1000 ft[2] | moderate | few | moderate | none |

[1]The presence of *Poa annua* seedheads was estimated as: many = a large number uniformly distributed, moderate = a moderate number with a uniform distribution, few = small number with a sporadic distribution, and none = no seedheads within the plot.
Initial applications were made on June 5 and sequentials on June 26, 1997. Primo was applied June 5, July 10, August 13, and September 4.
NS = means are not significantly different at the 0.05 level.

# Effects of Primo on *Poa annua* Populations in Creeping Bentgrass Maintained at Fairway Height

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to monitor *Poa annua* populations through the season in fairway height turf following a routine application program with the growth regulator, Trinexapac-ethyl (Primo).

This study was conducted in a turf area maintained at 1/2-inch mowing height surrounding a practice green at Veenker Golf Course in Ames, IA. The turf in this area consists of Perennial ryegrass and Kentucky bluegrass with a uniform infestation of *Poa annua*.

The experiment was a completely randomized design. Individual plot size was 5 x 5 ft with three replications. Untreated plots and Primo treated plots were randomly placed in a single row. Primo was applied at 0.5 fl oz/1000 $ft^2$.

Monthly applications were made on June 5, July 10, August 13, and September 4. The liquid was applied at 30-35 psi with a $CO_2$ backpack sprayer equipped with TeeJet™ #8006 flat fan nozzles. All applications were made between 6:30 and 7:00 a.m. The plot was watered with the normal watering schedule in the late afternoon.

Visual turf quality data were taken weekly beginning June 10 and ending September 16, 1997 (Table 1 and 2). Visual quality was assessed on a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality. *Poa annua* control was measured by estimating the percentage cover per plot. Percentage cover data were assessed by estimating the percent area per plot covered by *Poa annua* (Table 3). Percentage cover data were taken on June 5 and September 11. Additional percentage cover data will be taken in spring, 1998 beginning at greenup. Winter damage also will be assessed in early spring.

The plot and the surrounding area were overseeded with perennial ryegrass twice between late August and early September. By September 11, germinating ryegrass plants were quite numerous throughout the plot.

Throughout the season no *Poa annua* seedheads were visible in the plot or in the surrounding turf area. Beginning on August 20, the Primo treated plots had a darker blue-green color when compared with the untreated plots and the surrounding area. This color difference was detected through September 11. On September 16, no color differences were detected.

Percentage *Poa annua* cover data were taken on June 5 and September 11. There was a uniform *Poa annua* population among the treated and untreated plots on June 5. There were significantly smaller *Poa annua* populations in Primo treated plots on September 11 when compared with the untreated controls (Table 3). There was a large population of young ryegrass plants in all of the plots.

**Table 1.** Visual quality of fairway height Perennial ryegrass in the 1997-98 Postemergence *Poa annua* Conversion Study (June 10 through July 31, 1997).

| | Material | Rate fl oz/1000 ft$^2$ | June 10 | June 19 | June 26 | July 2 | July 15 | July 21 | July 31 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 9 | 9 | 9 | 9 | 9 | 8 | 9 |
| 2 | Primo | 0.5 | 9 | 9 | 9 | 9 | 9 | 8 | 9 |
| | $LSD_{0.05}$ | | NS | NS | NS | NS | NS | NS | NS |

Applications were made on June 5, July 10, August 13, and September 4.
NS = means are not significantly different at the 0.05 level.

**Table 2.** Visual quality of fairway height Perennial ryegrass in the 1997-98 Postemergence *Poa annua* Conversion Study (August 6 through September 16, 1997).

| | Material | Rate fl oz/1000 ft$^2$ | Aug 6 | Aug 12 | Aug 20 | Aug 28 | Sept 4 | Sept 11 | Sept 16 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 9 | 9 | 8 | 8 | 8 | 8 | 8 |
| 2 | Primo | 0.5 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| | $LSD_{0.05}$ | | NS | NS | NS | NS | NS | NS | NS |

Applications were made on June 5, July 10, August 13, and September 4.
NS = means are not significantly different at the 0.05 level.

**Table 3.** Percentage *Poa annua* cover in fairway height Perennial ryegrass in the 1997 Postemergence *Poa annua* Conversion Study.

| | Material | Rate fl oz/1000 ft$^2$ | June 5 | September 11 |
|---|---|---|---|---|
| 1 | Untreated control | NA | 35 | 30 |
| 2 | Primo | 0.5 | 35 | 3 |
| | $LSD_{0.05}$ | | NS | 9 |

Applications were made on June 5, July 10, August 13, and September 4.
NS = means are not significantly different at the 0.05 level.

# Effect of Primo on the Establishment of Kentucky Bluegrass in a Mature Grass Stand

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to determine if application of the growth regulator, Trinexapac-ethyl (Primo), would enhance the incorporation of new cultivars into existing stands of turf. This study was conducted at the Iowa State University Horticulture Research Station. The study was in an established area of 'Park' Kentucky bluegrass that was not fertilized in 1997. The soil in this plot was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.2%, a pH of 7.8, 3 ppm P, and 75 ppm K. It was overseeded with 'Baron' Kentucky bluegrass, a cultivar that has dark green seedlings. The color difference between 'Baron' and 'Park' should enable percentage cover estimations to be made for each cultivar..

Individual plot size was 5 x 5 ft with three replications and 3 ft barrier rows between replications. There were four treatments including an untreated and unseeded control and an untreated and seeded control. Primo was applied at 0.5 fl oz/1000 ft$^2$ to overseeded and unseeded plots. Primo applications were made two weeks before overseeding (Table 1). The Primo was mixed with 283 ml of water per plot and was applied at 30 psi using a $CO_2$ backpack sprayer equipped with TeeJet™ #8006 flat fan nozzles. This rate translates to 3 gal/1000 ft$^2$.

Rainfall was quite sporadic following overseeding. Irrigation was used to keep the bluegrass in good growing condition and to enhance germination.

Visual turf quality data were taken weekly beginning on August 21 when the Primo was applied. Data were taken on September 5, September 12, September 18, September 26, October 2, October 9, and October 14 (Table 1). Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

Overseeding was performed on September 12. At the time of overseeding, the entire plot was sliced with a vertical mower in three directions. The plot was raked to remove thatch and debris. 'Baron' Kentucky bluegrass was seeded by hand into individual plots at 1.5 lb/1000 ft$^2$ and raked into the slits.

On September 12, the plots treated with Primo had less growth and were not as green when compared with the untreated plots. By September 18, the quality differences were gone and there were no further quality differences through October 14 (Table 1).

The plots were monitored weekly for germination after September 12. Seedlings were first observed on September 26 in the overseeded plots. The seedlings were still too small to take % cover data by October 14. On October 9 and October 14, we confirmed that there were young seedlings in both the Primo treated and untreated, overseeded plots. The seedlings were so small that estimations of populations could not be made at this time. The plot was monitored weekly through November 12. At this time, the temperatures were prohibitive for further seedling growth so we ceased monitoring the plot. Percent cover data will be taken for both cultivars in the early spring. The color differences between the 'Baron' and 'Park' should be quite visible at spring greenup.

**Table 1.** Visual quality of 'Park' Kentucky bluegrass.

| | Materials | Rate (fl oz product/1000 ft$^2$) | Overseeded | Sept 5 | Sept 12 | Sept 18 | Sept 26 | Oct 2 | Oct 9 | Oct 14 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | no | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 2 | Primo | 0.5 | no | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 3 | Primo | 0.5 | yes | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| 4 | Seeded control | NA | yes | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| | $LSD_{0.05}$ | | | NS | NS | NS | NS | NS | NS | NS |

Primo treatments were made on August 21 and the plots were overseeded on September 12, 1997.
NS = means are not significantly different at the 0.05 level.

# 1997 Postemergence Ground Ivy Control Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The purpose of this study was to evaluate herbicide formulations for their efficacy on ground ivy in turfgrass. The study was conducted on the Iowa State University campus in 'common' Kentucky bluegrass heavily infested with ground ivy. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 5.3% organic matter, a pH of 7.5, 12 ppm P, and 165 ppm K.

The study was designed as a randomized complete block. Individual plot size was 5 x 5 ft with three replications. There were five treatments plus an untreated control (Table 1). Experimental formulations EH1312 and EH1342 were applied at two different rates. EH1312 was applied at 1.0 and 1.2 fl oz product/1000 $ft^2$ and EH1342 at 0.8 and 1.0 fl oz/1000 $ft^2$. Trimec Classic was applied at 1.5 fl oz/1000 $ft^2$.

Applications were made postemergently on June 5 after the ground ivy was well established. The materials were diluted in 189 ml water and applied at 30 psi using a $CO_2$ backpack sprayer equipped with #8006 nozzles. This rate translates to 2 gal/1000 $ft^2$.

Damage to ground ivy plants was evaluated using a 9 to 1 scale: 9 = no damage, 7 = slight curling and discoloration, 5 = moderate curling and discoloration, 3 = severe discoloration & curling, 1 = all plants dead. Ground ivy control was assessed using a 9 to 1 scale: 9 = healthy plants, 3 = most plants dead, 1 = all ground ivy plants dead.

Data were analyzed with the Statistical Analysis System (SAS, version 6.10) and the Analysis of Variance (ANOVA) procedure. Means were compared with Fisher's Least Significant Difference (LSD) test.

There was no bluegrass phytotoxicity. Ground ivy damage data were taken on June 10 and June 19 (Table 1). On June 10, all herbicide treated ground ivy had some damage. On June 19, the most severe damage was on ground ivy treated with EH1312 at 1.0 fl oz product/1000 $ft^2$ and EH1342 at 0.8 fl oz product/1000 $ft^2$. Mean damage for these two dates showed that all herbicides produced significant damage when compared with the untreated control.

By June 26, there was high ground ivy mortality in all treated bluegrass. Most of the treated ground ivy plants were dead by July 2. All treated ground ivy plants treated with EH1342 at 0.8 fl oz product/1000 $ft^2$ were dead on July 2. The plot was monitored through September and there was no regrowth of ground ivy in the treated turf.

**Table 1.** Ground ivy control with various herbicides used in the 1997 Postemergence Ground Ivy Control Study.

| | | | Degree of damage[1] | | | Ground ivy control[2] | | |
|---|---|---|---|---|---|---|---|---|
| | Materials | Rate (fl oz product /1000 $ft^2$ | June 10 | June 19 | Mean damage | June 26 | July 2 | Mean control |
| 1 | Untreated control | NA | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| 2 | Trimec Classic | 1.0 | 6.5 | 5.0 | 5.8 | 3.5 | 1.5 | 2.5 |
| 3 | EH1312 | 1.0 | 6.0 | 3.0 | 4.5 | 4.0 | 2.0 | 3.0 |
| 4 | EH1312 | 1.2 | 6.5 | 4.0 | 5.3 | 4.0 | 2.0 | 3.0 |
| 5 | EH1342 | 0.8 | 6.0 | 2.5 | 4.3 | 2.0 | 1.0 | 1.5 |
| 6 | EH1342 | 1.0 | 6.5 | 5.0 | 5.8 | 4.5 | 2.0 | 3.3 |
| | $LSD_{0.05}$ | | NS | NS | 2.5 | NS | 2.9 | NS |

[1]Degree of damage was evaluated using a 9 to 1 scale: 9 = no damage, 7 = slight curling and discoloration, 5 = moderate curling and discoloration, 3 = severe discoloration & curling, 1 = all plants dead.
[2]Ground ivy control was assessed using a 9 to 1 scale: 9 = healthy plants, 3 = most plants dead, 1 = all plants dead.
Materials were applied on June 5, 1997
NS = means are not significantly different at the 0.05 level.

# Effect of Beacon on the Germination of Kentucky Bluegrass and Creeping Bentgrass

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to evaluate the effect of CGA #136872 (Beacon) on seed germination and establishment of Kentucky bluegrass and creeping bentgrass. This study was conducted 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 $CO_2$ 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 $ft^2$.

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.

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 $ft^2$ and the other with 'Award' Kentucky bluegrass at 1.5 lb/1000 $ft^2$. 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. 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 on October 9, October 14, and November 11 (Tables 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.

Data were analyzed with the Statistical Analysis System (SAS, version 6.10) 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 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, 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 two weeks before seeding at 40 g product/A (Table 2). These were unusual results for the Kentucky bluegrass and observations will be made in the spring to confirm these results.

**Table 1.** Percentage cover[1] of 'Penneagle' creeping bentgrass in the 1997 carryover seedling study.

| | Material | Rate product/A. | Timing of application (before seeding) | Oct 9 | Oct 14 | Nov 11 | Mean cover |
|---|---|---|---|---|---|---|---|
| | | | | % | | | |
| 1 | Untreated Control | NA | NA | 32 | 35 | 55 | 41 |
| 2 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 8 weeks | 40 | 45 | 73 | 53 |
| 3 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 4 weeks | 43 | 43 | 75 | 54 |
| 4 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 2 weeks | 30 | 32 | 72 | 44 |
| 5 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 1 day | 22 | 27 | 40 | 29 |
| 6 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 8 weeks | 33 | 35 | 65 | 44 |
| 7 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 4 weeks | 20 | 20 | 45 | 28 |
| 8 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 2 weeks | 20 | 23 | 53 | 32 |
| 9 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 1 day | 5 | 5 | 12 | 7 |
| | $LSD_{0.05}$ | | | NS | NS | 38 | NS |

[1]Percentage cover was estimated as the area per plot covered by creeping bentgrass.
'Eight weeks before seeding' materials were applied on July 14, 'four weeks' on August 15, 'two weeks' on August 28, and one day on September 11. Seeding took place on September 12.
NS = means are not significantly different at the 0.05 level.

**Table 2.** Percentage cover[1] of 'Award' Kentucky bluegrass in the 1997 carryover seedling study.

| | Material | Rate product/A. | Timing of application (before seeding) | Oct 9 | Oct 14 | Nov 11 | Mean cover |
|---|---|---|---|---|---|---|---|
| | | | | % | | | |
| 1 | Untreated Control | NA | NA | 13 | 15 | 53 | 27 |
| 2 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 8 weeks | 12 | 17 | 32 | 20 |
| 3 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 4 weeks | 17 | 18 | 48 | 28 |
| 4 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 2 weeks | 12 | 15 | 25 | 17 |
| 5 | CGA #136872 + SCOIL MSO | 20.0 g + 0.25% V/V | 1 day | 12 | 12 | 35 | 19 |
| 6 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 8 weeks | 15 | 17 | 50 | 27 |
| 7 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 4 weeks | 12 | 15 | 40 | 22 |
| 8 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 2 weeks | 12 | 15 | 35 | 21 |
| 9 | CGA #136872 + SCOIL MSO | 40.0 g + 0.25% V/V | 1 day | 10 | 10 | 40 | 20 |
| | | | | | | ($p \geq 0.06$) | |
| | $LSD_{0.05}$ | | | NS | NS | 18 | NS |

[1]Percentage cover was estimated as the area per plot covered by Kentucky bluegrass.
'Eight weeks before seeding' materials were applied on July 14, 'four weeks' on August 15, 'two weeks' on August 28, and one day on September 11. Seeding took place on September 12.
NS = means are not significantly different at the 0.05 level.

# 1997 Non-selective Herbicide Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The objective of this study was to demonstrate trim and edging of cool season turfgrasses with non-selective herbicides. This study was designed as a demonstration plot for the 1997 Iowa State University Turfgrass Field Day on August 14 at the Horticulture Research Station north of Ames, IA. The plot was in an area of 'common' Kentucky bluegrass adjacent to an ornamental grass bed.

The study was designed with the treated plots in a single row. Each plot was a 0.5 x 8.0 ft. (4 $ft^2$) strip with 0.5 x 1.0 ft. barrier strips between plots. This study was not replicated and the treatments were applied once. There were seven treatments including an untreated control (Table 1). Reward was applied alone at 2.0 pt. product/A and at 0.5, 1.0 and 1.5 pt. product/A in combination with Roundup Pro at 2 qt. product/A. Fusilade II at 4, 8, and 16 oz. product/A was combined with Reward at 1.0 pt. product/A. LESCO spreader/sticker was added to all treatments at 0.25% V/V.

The herbicides were mixed in 60 ml of water and applied at 30 psi using a $CO_2$ backpack sprayer equipped with one TeeJet™ #8006 flat fan nozzle. Applications were made to ensure that there was no herbicide drift. Water was withheld from the plot for at least 24 hours post-treatment.

Plots were rated for plant damage using a 9 to 1 scale: 9 = 100% brown, 5 = 35-50% brown, and 1 = 100% green. Ratings were taken on August 1, August 4, August 6, August 14, August 21, August 28, September 5, September 12, September 18, and September 26 (Table 1). The percentage of damaged and dead plants per plot was also recorded on these dates. These data were recorded as the percent brown area per plot (Table 2). In addition, notes on species affected, species regrowth, and spreading of the herbicide affected areas were made on each collection day.

On August 1, broadleaf plants were slightly discolored (bleached) in turf treated with Reward alone at 2.0 pt. product/A and at 0.5 and 1.0 pt product/A in combination with Roundup Pro (Table 1). There was no discoloration of any treated turfgrass.

Turfgrass and broadleaves were damaged and turning brown in all treated plots by August 4. There were a few redroot pigweed plants treated with Reward at 1.0 pt product/A plus Fusilade II at 16 oz. product/A that were undamaged. There was still 25 - 40% green cover in plots treated with Reward alone, Reward at 0.5 pt. plus Roundup Pro at 2 qt. product/A, and Reward at 1.0 pt. product/A plus Fusilade II at 4 oz. product/A. In the other treated plots, 80 - 90% of the grass was brown (Table 2).

On August 6, 40% of the cover was still green within the plot treated with Reward at 0.5 pt. product/A plus Roundup Pro at 2 qt. product/A and 30% of the cover was green in the plot treated with Reward at 1.0 pt. product/A plus Fusilade II at 4 oz product/A. In other treated plots there was ≤ 20% green cover.

By August 14, in those plots treated with Reward + Roundup Pro the herbicide affected area had begun to widen. There was ≥ 70% dead plants in all treated plots. In addition, there was 100% brown cover in plots treated with Reward at 1.0 and 1.5 pt. product/A plus Roundup Pro at 2 qt. product/A.

On August 21, all herbicides had produced at least 80% brown plants except Reward alone at 2.0 pt. product/A. The pigweeds treated with Reward at 1.0 pt. product/A plus Fusilade II at 16 oz. product/A were still undamaged.

By August 28, the grass had begun to spread back into some of the treated plots. The plot treated with Reward at 2.0 pt. product/A was 50% overgrown with grass and the Reward + Fusilade II plots were beginning to fill in with grass. The plots treated with Reward at 0.5, 1.0, and 1.5 pt. product/A plus Roundup Pro at 2.0 qt. product/A were completely brown.

By September 5 (5 WAT), there was 75% green cover in the plot treated with Reward at 1.0 pt. product/A plus Fusilade II at 4 oz. product/A. Regrowth of 50% was recorded in plots treated with either Reward at 20 pt. product/A or Reward at 1.0 pt. product/A plus Fusilade II at 8.0 oz. product/A. There was < 5% grass regrowth in plots receiving Reward at 0.5, 1.0, and 1.5 pt. product/A plus Roundup Pro at 2 qt. product/A.

The turf plots treated with Reward at 0.5, 1.0, and 1.5 pt. product/A plus Roundup Pro at 2 qt. product/A still had very little regrowth on September 12 (6 WAT). There was 90% regrowth in the plot treated with Reward at 1.0 pt. product/A plus Fusilade II at 4 oz. product/A.

**Table 1.** Damage ratings[1] for grass and broadleaf species in Kentucky bluegrass treated for the 1997 Nonselective Herbicide Study.

| Treatments | Rate product/A | Aug 1 | Aug 4 | Aug 6 | Aug 14 | Aug 21 | Aug 28 | Sept 5 | Sept 12 |
|---|---|---|---|---|---|---|---|---|---|
| 1 Reward | 2.0 pt | 2 | 7 | 7 | 7 | 6 | 5 | 5 | 5 |
| 2 Reward | 0.5 pt | | | | | | | | |
| + Roundup Pro | 2.0 qt. | 2 | 6 | 6 | 7 | 8 | 9 | 8 | 8 |
| 3 Reward | 1.0 pt | | | | | | | | |
| + Roundup Pro | 2.0 qt. | 2 | 7 | 8 | 9 | 9 | 9 | 8 | 8 |
| 4 Reward | 1.5 pt | | | | | | | | |
| + Roundup Pro | 2.0 qt. | 1 | 8 | 8 | 9 | 9 | 9 | 9 | 8 |
| 5 Reward | 1.0 pt | | | | | | | | |
| + Fusilade II | 4.0 oz | 1 | 6 | 6 | 6 | 7 | 6 | 3 | 2 |
| 6 Reward | 1.0 pt | | | | | | | | |
| + Fusilade II | 8.0 oz | 1 | 8 | 7 | 8 | 8 | 8 | 5 | 4 |
| 7 Reward | 1.0 pt | | | | | | | | |
| + Fusilade II | 16.0 oz | 1 | 8 | 7 | 8 | 8 | 8 | 8 | 7 |

LESCO Spreader/Sticker was added to all treatments at 0.25% v/v = 0.15 ml/plot.
[1]Damage was assessed using a 9 to 1 scale: 9 = 100% brown, 5 = 50% brown and 1 = 100% green.

**Table 2.** Percentage brown plant cover per plot[1] in Kentucky bluegrass treated for the 1997 Nonselective Herbicide Study.

| Treatments | Rate product/A | Aug 1 | Aug 4 | Aug 6 | Aug 14 | Aug 21 | Aug 28 | Sept 5 | Sept 12 |
|---|---|---|---|---|---|---|---|---|---|
| | | % | | | | | | | |
| 1 Reward | 2.0 pt | 5 | 75 | 80 | 80 | 60 | 50 | 50 | 40 |
| 2 Reward | 0.5 pt | | | | | | | | |
| + Roundup Pro | 2.0 qt. | 5 | 60 | 60 | 75 | 90 | 100 | 95 | 90 |
| 3 Reward | 1.0 pt | | | | | | | | |
| + Roundup Pro | 2.0 qt. | 5 | 80 | 90 | 100 | 100 | 100 | 95 | 95 |
| 4 Reward | 1.5 pt | | | | | | | | |
| + Roundup Pro | 2.0 qt. | 0 | 90 | 90 | 100 | 100 | 100 | 100 | 95 |
| 5 Reward | 1.0 pt | | | | | | | | |
| + Fusilade II | 4.0 oz | 0 | 70 | 70 | 70 | 80 | 70 | 25 | 10 |
| 6 Reward | 1.0 pt | | | | | | | | |
| + Fusilade II | 8.0 oz | 0 | 90 | 80 | 85 | 90 | 90 | 50 | 30 |
| 7 Reward | 1.0 pt | | | | | | | | |
| + Fusilade II | 16.0 oz | 0 | 90 | 80 | 85 | 95 | 95 | 90 | 80 |

LESCO Spreader/Sticker was added to all treatments at 0.25% v/v = 0.15 ml/plot.
[1]Percentage brown cover represents the area covered by brown damaged and dead plants per plot.

# Growth of *Agrostis palustris* in Response to Adventitious Root Infection by Species of *Acremonium*

*Clinton. F. Hodges and Douglas A. Campbell*

The form genus *Acremonium* is recognized primarily for its endophytic associations with numerous grass species (11, 13, 14) that range from mutualistic to pathogenic (16). The economic consequences of endophyte-infected grasses are both positive and negative. Negative effects include Fescue toxicosis and ryegrass staggers in livestock (2,6). Positive effects include increased insect, nematode, and pathogen tolerance (3, 11, 13, 14). Other positive effects include enhanced seed germination, growth, and drought resistance (1, 4, 5). Naturally occurring endophytes have not been reported in association with *Agrostis palustris,* but inoculations of *A. palustris* with a group of *Acremonium* isolates suggest that stolons can be infected (15). In recent years, research has focused primarily on the potential benefits afforded turfgrasses infected by *Acremoniun* endophytes.

Over the last 10 to 12 years isolation of *Acremonium rutilum* and *A. alternatum* from the roots and leaves of diseased *A. palustris* growing on high-sand-content golf greens has increased. Symptoms are expressed differently depending on whether the plants are on the closely mowed greens or on the collar of the green at higher mowing levels. Closely mowed greens show irregular areas of unthrifty, thinning turf due to mild undercover chlorosis and tanning of the older leaves. The higher mowed grasses of the collars show distinct brown, irregular patches of turf with living plants interspersed through the patches. The affected areas in the collar enlarge very slowly during the growing season and seem to be perennial in that they recur in the same location from season to season. Isolation of *Acremonium* species from *A. palustris* with these symptoms is most common during cool, wet periods of the spring and fall. The expression of symptoms, however, is most prevalent in the warmer periods of the summer.

## Shoot and Root Growth

Inoculation of adventitious roots of *A. palustris* with three isolates of *A. rutilum* and one isolate of *A. alternatum* under high (95° day/75° night) and low (75° day/60° night) temperature regimes decreased the growth of the plants, but no plants were killed. Under high temperatures, the various isolates of *A. rutilum* examined decreased shoot growth 13 to 58%; root growth was decreased 23 to 47%. *A. alternatum* induced a 68% decreased in shoot growth and a 56% decrease in root growth under the high temperatures. Under low temperatures, the isolates of *A. rutilum* decreased shoot growth 60 to 69% and root growth 51 to 62%. *A. alternatum* decreased shoot growth by 71% and root growth by 58% under the low temperatures. The observations show that growth of plants infected by *A. rutilum* is inhibited more under low temperatures than under high temperatures, and that the negative effect on growth by *A. alternatum* is temperature neutral.

## Stolon Numbers

The number of stolons produced by *A. palustris* infected by the *Acremonium* species decreased in response to high and low temperatures. Under high temperatures, stolon numbers per plant were reduced 21 to 35% in response to the isolates of *A. rutilum* and 36% in response to *A. alternatum.* The decrease in stolon numbers was more severe under the low temperatures; isolates of *A. rutilum* decreased stolon numbers in a range of 48 to 54% and *A. alternatum* decreased stolons by 60%.

## *Acremonium* Development on Roots

Inoculated roots from both the high and low temperature regimes were typically tan colored without any evidence of lesions or rot and no visible signs of hyphae or spores. Vascular cylinders of some inoculated roots were cream colored, and some root tips were swollen. Some roots that were cleared and stained showed fine hyphal growth on and within the cortex from the low temperature study; visible hyphae on the surface of roots from the high temperature regime were rare. Among plants subjected to the high temperature regime, reisolation of the isolates of *A. rutilum* from roots ranged from 63 to 77%; *A. alternatum* was reisolated from 81% of the inoculated roots. Reisolation of *A. rutilum* isolates from inoculated roots of plants subjected to the low temperature regime ranged from 73 to 83%; *A. alternatum* was reisolated from 73% of the inoculated roots.

### Significance of *Acremonium* Species as Root-Borne Pathogens

Decreases in shoot and root growth in response to isolates of *A. rutilum* and *A. alternatum* and their reisolation from inoculated roots establishes a degree of pathogenicity. Inoculated roots, however, showed only slight tanning, some yellowing of the vascular cylinder and scant hyphal development in the cortex. Also, reisolation of the *Acremonium* isolates from inoculated roots ranged only from 63 to 83%. These characteristics coupled with the inability of the *Acremonium* isolates to induce shoot symptoms suggest that they do not function as strong primary pathogens.

The developmental characteristics of *A. rutilum* and *A. alternatum* on roots of *A. palustris* suggest that these species may be emerging pathogens and/or constituents of root disease complexes. The modern high-sand-content green and the management practices applied to it are especially stressful and may predispose *A. palustris* roots to infection by weak pathogens and/or minor root pathogens (12). Evidence is growing that close moving and abrasion of roots by sand particles are predisposing roots to infection by relatively weak pathogens like *A. rutilum* and *A. aternatum*. Other weak and minor root pathogens showing similar characteristics on *A. palustris* roots include *Idriella bolleyi*, *Curvularia lunata*, and various species of *Pythium* (7, 8, 9, 10). All of these organisms, including the *Acremonium* species, are commonly isolated from the adventitious roots of the same plant. Each organism alone can induce some symptoms when they infect adventitious roots, but individually they cannot reproduce the field symptoms. These responses suggest that organisms like *A. rutilum*, *A. alternatum*, *I. bolleyi*, *C. lunata*, and some *Pythium* species are responding to the stressful conditions applied to *A. palustris* as a root-disease complex. It is also possible that the stressful management conditions are contributing to the emergence of pathogens from organisms that are typically benign under less stressful growing conditions.

### Acknowledgments

The research presented was funded in part by grants from the Iowa Turfgrass Institute and the Iowa Golf Course Superintendents Association.

### References

1. Arachevaleta, M., C. W. Bacon, C. S. Hoveland, D. E. Radcliffe. 1989. Effect of the tall fescue endophyte on plant response to environmental stress. Agron. J. 81: 83-90.
2. Bacon, C. W., J. K. Porter, J. D. Robins, E. S. Luttrell. 1977. *Epichloe typhina* from toxic tall fescue grasses. Appl. Environ. Microbiol. 34: 576-581.
3. Clay, K. 1991. Endophytes as antagonists of plant pests. In: Andrews, J. H., S. S. Hirano (eds.), Microbial Ecology of Leaves, pp. 331-357. Springer-Verlag, New York.
4. Clay, K. 1988. Fungal endophytes of grasses: a defensive mutualism between plants and fungi. Ecology 69: 10-16.
5. Clay, K. 1987. Effects of fungal endophytes on the seed and seedling biology of *Lolium perenne* and *Festuca arundinacea*. Oecologia 73: 358-362.
6. Fletcher, L. R., I. C. Harvey. 1981. An association of a *Lolium* endophyte with ryegrass staggers. N. Z. Vet. J. 29: 185-186.
7. Hodges, C. F., D. A. Campbell. 1996. Infection of adventitious roots of *Agrostis palustris* by *Idriella bolleyi*. J. Phytopathol. 144: 265-271.

8. Hodges, C. F., D. A. Campbell. 1995. Growth of *Agrostis palustris* in response to adventitious root infection by *Curvularia lunata*. J. Phytopathol. 143: 639-642.
9. Hodges, C. F., D. A. Campbell. 1994. Infection of adventitious roots of *Agrostis palustris* by *Pythium* species at different temperature regimes. Can. J. Bot. 72: 378- 383.
10. Hodges, C. F., L. W. Coleman. 1985. *Pythium*-induced root dysfunction of secondary roots of *Agrostis palustris*. Plant Dis. 69: 336-340.
11. Latch, G. C. M. 1993. Physiological interactions of endophytic fungi and their hosts. Biotic stress tolerance imparted to grasses by endophytes. Agric., Ecosystems, Environ. 44: 143-156.
12. Salt, G. A. 1979. The increasing interest in 'minor pathogens'. In: Schippers, B., W. Gams (eds.), Soil-Borne Plant Pathogens, pp. 289-312. Academic Press, New York.
13. Siegel, M. R., C. L. Schardl. 1991. Fungal endophytes of grasses: Detrimental and beneficial associations. In: Andrews, J. H., S. S. Hirano (eds.), Microbial Ecology of Leaves, pp. 198-221. Springer-Verlag, New York.
14. Siegel, M. R., G. C. M. Latch, M. C. Johnson. 1987. Fungal endophytes of grasses. Ann. Rev. Phytopathol. 25: 293-315.
15. Sun, S., A. D. Brede. 1997. Inoculation of creeping bent with *Acremonium* endophyte. Int. Turfgrass Soc. Res. J. 8: 925-929.
16. White, J. F., Jr. 1988. Endophyte-host associations in forage grasses. XI. A proposal concerning the origin and evolution. Mycologia 80: 442-446.

# Evaluation of Fungicides for Control of Dollar Spot in Penncross Creeping Bentgrass - 1997

*Mark L. Gleason*

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

Initial inoculation with the dollar spot pathogen was not fully successful, so fungicide applications were suspended July 2. After inoculation of the entire plot with pathogen-infested rye grain on August 4, spray applications began on August 8. Subsequent applications were made at specified intervals on August 27, August 29, September 5, and September 10.

Dollar spot symptoms appeared in the plot by August 18. Disease development was severe during late August and early September. Most, but not all, treatments exhibited significantly better dollar spot control than the untreated check on all three rating dates (see Table 1). No phytotoxicity symptoms were observed during the trial.

**Table 1.** 1997 Dollar Spot Trial at ISU Horticulture Station. Plot size 20 $ft^2$, 4 plots/trt; 80 $ft^2$ per treatment.

| Trt. | Product | Rate/1000 $ft^2$ | Interval (days) | % plot infected[1] Aug 29 | Sept 7 | Sept 14 |
|---|---|---|---|---|---|---|
| 1 | Check | ----- | ---- | 42.5 | 42.5 | 40.0 |
| 2 | Lynx 25 DF | 0.5 oz | 14 | 2.8 | 1.1 | 1.9 |
| | + chlorothalonil 4 F | 3.0 fl oz | | | | |
| 3 | Lynx 25 DF | 0.5 oz | 21 | 19.3 | 4.5 | 11.8 |
| | + Heritage 50 DF | 0.2 oz | | | | |
| 4 | Lynx 1% G | 24.0 oz | 28 | 18.0 | 13.0 | 8.3 |
| 5 | Bayleton 25 DF | 0.5 oz | 14 | 8.0 | 2.8 | 9.5 |
| | + Chlorothalonil 4 F | 3.0 fl oz | | | | |
| 6 | Bayleton 25 DF | 0.5 oz | 21 | 16.8 | 8.3 | 22.5 |
| | + Heritage 50 DF | 0.2 oz | | | | |
| 7 | Bayleton 25 DF | 0.5 oz | 14 | 25.0 | 8.3 | 19.3 |
| 8 | Thalonil 4 L | 4.0 fl oz | 14 | 37.5 | 23.8 | 26.3 |
| | + Heritage 50 WG | 0.2 oz | | | | |
| 9 | Thalonil 4 L | 6.0 fl oz | 14 | 9.8 | 4.3 | 10.0 |
| | + Heritage 50 WG | 0.2 oz | | | | |
| 10 | Thalonil 4 L | 4.0 fl oz | 14 | 40.0 | 31.8 | 41.3 |
| 11 | Thalonil 4 L | 6.0 fl oz | 14 | 22.0 | 7.3 | 13.8 |
| 12 | CONFIDENTIAL | ----- | --- | 20.0 | 23.8 | 30.0 |
| 13 | CONFIDENTIAL | ----- | --- | 16.3 | 9.0 | 18.8 |
| 14 | CONFIDENTIAL | ----- | --- | 30.3 | 16.3 | 24.0 |
| 15 | CONFIDENTIAL | ----- | --- | 1.0 | 0.0 | 0.1 |
| 16 | CONFIDENTIAL | ----- | --- | 11.3 | 3.5 | 9.5 |
| 17 | CONFIDENTIAL | ----- | --- | 3.5 | 0.5 | 1.1 |
| 18 | CONFIDENTIAL | ----- | --- | 1.5 | 0.1 | 0.1 |
| 19 | Daconil Ultrex 82.5 WDG | 3.8 oz | 14 | 6.5 | 2.5 | 5.5 |
| 20 | IB 11522 | 4.1 oz | 14 | 18.3 | 8.3 | 14.5 |

| Trt. | Product | Rate/1000 ft² | Interval (days) | % plot infected[1] Aug 29 | Sept 7 | Sept 14 |
|---|---|---|---|---|---|---|
| 21 | Daconil Ultrex 82.5 WDG | 3.0 oz | 14 | 7.8 | 4.4 | 10.8 |
| | + Heritage 50 WG | 0.2 oz | | | | |
| 22 | Heritage 50 WG | 0.2 oz | 28 | 31.3 | 36.3 | 41.3 |
| 23 | EXP 10790 (26 GT) 2 SC | 3.0 fl oz | 14 | 33.3 | 22.8 | 23.0 |
| | ALTERNATE WITH | | | | | |
| | Heritage 50 WG | 0.2 oz | 28 | | | |
| | +EXP 10790(26 GT) 2 SC | 3.0 fl oz | | | | |
| 24 | Daconil Ultrex 82.5 WDG | 3.1 oz | 14 | 12.3 | 5.0 | 11.8 |
| | ALTERNATE WITH | | | | | |
| | Heritage 50 WG | 0.2 oz | 28 | | | |
| | + Daconil Ultrex 82.5 WDG | 3.1 oz | | | | |
| 25 | Chipco Aliette Signature 80 WG | 4.0 oz | 14 | 37.5 | 25.0 | 37.5 |
| | + EXP 10790 (26 GT) 2 SC | 3.0 fl oz | | | | |
| | ALTERNATE WITH | | | | | |
| | Heritage 50 WG | 0.2 oz | 28 | | | |
| | + Chipco Aliette Signature 80 WC | 4.0 oz | | | | |
| | + EXP 10790 (26 GT) 2 SC | 3.0 fl oz | | | | |
| 26 | Chipco Aliette Signature 80 WC | 4.0 oz | 14 | 31.3 | 21.5 | 20.0 |
| | + EXP 10790 (26 GT) 2 SC | 3.0 fl oz | | | | |
| | 3336 F | 2.0 fl oz | 14 | 2.0 | 0.0 | 0.0 |
| | + Chipco 26019 FLO | 2.0 fl oz | | | | |
| 28 | CTM 90 WDG | 4.0 oz | 14 | 0.9 | 0.0 | 0.0 |
| 29 | CTM 90 WDG | 8.0 oz | 14 | 0.03 | 0.0 | 0.0 |
| 30 | Turfcide 400 | 4.5 fl oz | 14 | 45.0 | 23.8 | 21.3 |
| 31 | Turfcide 75 WC | 3.0 oz | 14 | 30.0 | 22.0 | 25.0 |
| 32 | Turfcide 75 WC | 3.0 oz | 14 | 13.8 | 9.0 | 11.3 |
| | + Daconil Ultrex 82.5 WDG | 2.0 oz | | | | |
| 33 | Daconil Ultrex 82.5 WDG | 2.0 oz | 14 | 27.5 | 21.8 | 28.8 |
| 34 | Turfcide 75 WG | 3.0 oz | 14 | 23.8 | 14.0 | 21.8 |
| | + Spotrete 75 WDC | 3.0 oz | | | | |
| 35 | Spotrete 75 WDG | 3.0 oz | 14 | 30.0 | 31.3 | 37.5 |
| 36 | Turfcide 75 WG | 3.0 oz | 14 | 18.8 | 5.3 | 20.0 |
| | + Terraguard 50 W | 2.0 oz | | | | |
| 37 | Terraguard 50 W | 2.0 oz | 14 | 6.9 | 3.5 | 9.3 |
| 38 | Eagle 40 W | 0.6 oz | 21 | 4.0 | 1.4 | 5.3 |
| 39 | Eagle 40 W | 0.6 oz | 14 | 1.8 | 0.3 | 2.0 |
| | ALTERNATE WITH | | | | | |
| | Fore 75 DG | 6.0 oz | 14 | | | |
| | LSD[2] | | | 1637 | 10.5 | 11.9 |

[1]n = 4

[2]Least Significant Difference, P=0.05.

# Radiometric Assessment of Dollar Spot Severity on a Creeping Bentgrass Green

*Mark L. Gleason, Forrest W. Nutter, Jr., and Nick E. Christians*

## Introduction

Few guidelines are available to help researchers, consultants, and agrichemical industry personnel to select a "best" method for assessing the severity of turfgrass diseases. The "best" method should be easy to use, offer reproducible results, and provide a fast and accurate measure of disease severity.

Rating systems for turfgrass diseases - usually based on visual assessment of test plots - are highly subjective and vary greatly from person to person. This crazy quilt of methods slows the development of new disease control products because assessment errors and variability can mask or distort differences between treatments.

Radiometers have shown promise for improving assessment of some turf diseases. Research in the early 1990's by our group (Nutter et al., *Phytopathology* 83:806-812, 1993) showed that assessments of dollar spot severity using a commercially available radiometer (Crop Scan Inc.) were not only more accurate than visual assessments but also faster to make.

This report summarizes a 1997 project to test radiometric assessment against visual assessment in the "real world" context of fungicide trials. The purpose of the trial was to evaluate radiometry's potential to improve the quality of research in new product evaluation.

## Procedures

A field trial was conducted in September 1997 on green-height Penncross creeping bentgrass at the ISU Horticulture Research Farm. Plot design was a randomized complete block with 39 fungicide treatments (38 treatments selected by agrichemical companies plus one untreated check treatment) and four replications per treatment. The entire plot was inoculated with rye grain infested with the dollar spot pathogen, *Sclerotinia homeocarpa*, approximately one month before plot ratings were made, and fungicide treatments began five days after inoculation. Applications of fungicides were made with a bicycle sprayer using flat fan nozzles at 30 psi, using 5 gal water/1000 $ft^2$.

By the first week of September, plots displayed a wide range of dollar spot severity, from disease-free to severely infected. On 9 September, all plots were rated visually and radiometrically by four individuals. Radiometric readings, using a CropScan radiometer at 610 and 810 nm wavelengths, were made in full sun between 11 am and 2 pm. Both visual and radiometric assessments were made on the central 1 $m^2$ of each plot.

## Results

Statistical analysis of the data showed that:

1. There was a significant interaction between the fungicide treatment and the person doing the visual assessment, but not the radiometric assessment.
2. The coefficient of variation (a measure of the precision of the measurements; the lower the number, the more precise the measurements) was 31.5 for visual ratings and 1.4 for radiometric ratings.
3. For visual ratings, the slope of the graphs comparing one rater's ratings to that of another rater - an indicator of systematic bias (varies with disease severity) among the raters - was significant for 10 of the 12 combinations of four raters; for radiometric ratings, none of the 12 combinations was significant.
4. The intercept of the graphs comparing one rater's ratings with another's - an indicator of a constant bias (does not vary with disease severity) was significant for 8 of the 12 comparisons for visual assessment but for none of the radiometric assessment comparisons.

5. Rank correlation of treatments between visual and radiometric assessments was relatively high (91%). However, preliminary analysis of the data suggested that the rank order of several treatments was significantly different between visual and radiometric methods. This means that the rating of the relative success of at least some of the fungicide treatments at controlling dollar spot would have been different with the two methods.

**Interpretation**

1. Radiometric assessment of dollar spot severity was more precise and less subject to bias by individual raters than visual assessment.
2. Although the rankings of treatments were fairly similar by the two methods, some treatments were ranked significantly different by these methods.
3. An earlier study (Nutter et al., 1993) showed that radiometric ratings of dollar spot severity were also more accurate (i.e., closer to the true level of disease) than visual ratings, and required only 2/3 the time to complete.

**Bottom line**

The study demonstrated that radiometric assessment has excellent potential for improving the accuracy, precision, and speed of dollar spot ratings. The method may also have potential to improve ratings of other turfgrass diseases.

# Evaluation of Fungicides for Control of Pythium Blight in Perennial Ryegrass - 1997

*Mark L. Gleason*

Trials were conducted on a perennial ryegrass fairway at Veenker Memorial Golf Course in Ames, IA. Fungicides were applied with a modified bicycle sprayer at 30 psi and a dilution rate of 5 gal/1,000 $ft^2$. Experimental design was a randomized complete block with 4- x 5-ft subplots and 4 replications per treatment. All treatments began on June 13, when active Pythium mycelium was noted in the grass. Additional applications were made on June 20 and 27 and July 4, 11, 18, and 25.

Weather during late June, and again in late July, was moderately conducive to Pythium blight (daytime temperatures 80-95° F, nights 70-80° F, prolonged periods of high relative humidity). Disease development in the untreated check plots was light on both rating dates (July 24 and 31). Most treatments showed no symptoms, and had significantly less disease than the check treatment.

No symptoms of phytoptoxicity were observed during the course of the study.

**Table 1.** 1997 Pythium Blight Trial. Perennial ryegrass fairway at Iowa State University's Veenker Memorial Golf Course, Ames, Iowa. Plot size = 20 $ft^2$, 4 plots/trt; 80 $ft^2$ per treatment

| | | | Interval | Number of infection centers per plot[1] | |
|---|---|---|---|---|---|
| Trt. | Product | Rate/1000 $ft^2$ | (days) | July 24 | July 31 |
| 1 | Check | ----- | ---- | 2.0 | 1.8 |
| 2 | Heritage 50 WG | 0.4 oz | 14 | 0.0 | 0.0 |
| 3 | Heritage 50 WG | 0.3 oz | 14 | 0.0 | 0.0 |
| 4 | Heritage 50 WG | 0.2 oz | 14 | 0.0 | 0.3 |
| 5 | Terrazole 35 W | 2.0 oz | 7 | 0.0 | 0.0 |
| 6 | Terrazole 35 W | 4.0 oz | 7 | 0.0 | 0.8 |
| 7 | Terrazole 35 W | 6.0 oz | 7 | 0.0 | 0.0 |
| 8 | Confidential 1 | ----- | ---- | 0.3 | 0.0 |
| 9 | Confidential 2 | ----- | ---- | 1.0 | 0.0 |
| 10 | Confidential 3 | ----- | ---- | 1.3 | 2.5 |
| 11 | Confidential 4 | ----- | ---- | 0.0 | 1.0 |
| 12 | Confidential 5 | ----- | ---- | 0.0 | 0.0 |
| 13 | Heritage 50 WG | 600 g ai/ha | 10 | 0.0 | 0.0 |
| 14 | Aliette 80 WP | 9,765 g ai/ha | 10 | 0.0 | 0.0 |
| | LSD[2] | | | 1.01 | 1.60 |

[1]n = 3.

[2]Least significant difference (P = 0.05).

# Evaluation of Fungicides for Control of Brown Patch in Creeping Bentgrass - 1997

*Mark L. Gleason*

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

Fungicide applications began on June 11. Subsequent applications were made at specified intervals on June 18 and 25 and July 2, 9, 16, 23, and 30.

**Brown patch** symptoms were first observed on July 1. 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% diseased area per plot), was moderately severe on July 4, 10, and 24, and severe on July 18. Many, but not all, fungicide treatments exhibited significantly (LSD, $P \leq 0.05$) less disease than the untreated check.

Severe **dollar spot** developed during the brown patch trial. Dollar spot was rated as the number of infection centers per plot. **NOTE: The trial was organized with brown patch as the target disease.**

No phytotoxicity symptoms were observed during the trial.

**Table 1.** 1997 Brown Patch Trial. WOI Greens - ISU Campus. Plot Size=20 ft$^2$, 3 plots/trt; 60 ft$^2$ per treatment

| | | | Interval | July 4 | | July 10 | | July 18 | | July 24 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trt. | Product | Rate/1000 ft$^2$ | (days) | bp[1] | ds[2] | bp | ds | bp | ds | bp | ds |
| 1 | Check | ---- | ---- | 3.3 | 138 | 3.3 | 150.3 | 4.0 | 175.3 | 3.3 | 187.3 |
| 2 | Banner MAXX 1.24 MC | 1.0 fl oz | 21 | 0.7 | 13.7 | 2.0 | 26.7 | 2.0 | 36.3 | 3.0 | 13.3 |
| 3 | Banner MAXX 1.24 MC | 1.0 fl oz | 21 | 0.0 | 38.0 | 0.0 | 0.3 | 0.0 | 1.0 | 0.0 | 0.0 |
| | + Heritage 50 WG | 0.2 fl oz | | | | | | | | | |
| 4 | Banner MAXX 1.24 MC | 1.0 fl oz | 21 | 1.0 | 10.7 | 0.7 | 0.3 | 0.3 | 0.0 | 1.7 | 0.0 |
| | +Daconil Ultrex 82.5 WDG | 3.8 oz | | | | | | | | | |
| 5 | Sentinel 40 WG | 0.167 oz | 21 | 1.0 | 54.0 | 1.0 | 3.7 | 0.0 | 0.0 | 0.3 | 0.0 |
| 6 | Sentinel 40 WG | 0.167 oz | 21 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 3.0 | 0.0 | 0.0 |
| | + Heritage 50 WG | 0.2 oz | | | | | | | | | |
| 7 | Sentinel 40 WG | 0.167 oz | 21 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| | Daconil Ultrex 82.5 WDG | 3.8 oz | 21 | | | | | | | | |
| 8 | Heritage 50 WG | 0.2 oz | 21 | 0.0 | 74.7 | 0.3 | 111.0 | 0.3 | 146.0 | 1.00 | 118.0 |
| 9 | Daconil Ultrex 82.5 WDG | 3.8 oz | 21 | 0.3 | 18.7 | 0.0 | 2.0 | 1.7 | 21.0 | 1.3 | 4.0 |
| 10 | CGA-BMP | 0.5 oz | 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11 | CGA-BMP | 0.5 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 12 | CGA-BMP | 1.0 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13 | CGA-BMP | 0.5 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| | + Primo L | 0.10 fl oz | | | | | | | | | |
| 14 | Heritage 50 WG | 0.2 oz | 14 | 0.0 | 23.3 | 0.3 | 17.3 | 1.0 | 78.0 | 0.7 | 20.0 |
| 15 | Heritage 50 WG | 0.2 oz | 28 | 0.3 | 180.3 | 0.3 | 112.0 | 0.3 | 135.0 | 1.0 | 108.7 |
| 16 | Heritage 50 WG | 0.3 oz | 21 | 0.0 | 94.0 | 0.3 | 135.0 | 0.3 | 171.7 | 1.0 | 105.7 |
| 17 | Heritage 50 WG | 0.4 oz | 28 | 0.0 | 168.3 | 0.0 | 160.7 | 1.0 | 250.7 | 1.7 | 175.0 |
| 18 | Thalonil 4 L | 4.0 fl oz | 14 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 |
| | + Heritage 50 WG | 0.2 oz | | | | | | | | | |
| 19 | Thalonil 4L | 6.0 fl oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 |
| | + Heritage 50 WG | 0.2 oz | | | | | | | | | |
| 20 | Thalonil 4 L | 4.0 fl oz | 14 | 0.3 | 0.7 | 0.3 | 0.0 | 1.0 | 16.7 | 0.7 | 0.0 |
| 21 | Thalonil 4 L | 6.0 fl oz | 14 | 0.0 | 9.0 | 0.0 | 0.0 | 0.3 | 21.0 | 1.0 | 0.0 |
| 22 | CONFIDENTIAL | ---- | ---- | 1.3 | 73.0 | 1.0 | 92.7 | 2.0 | 119.0 | 4.0 | 89.7 |
| 23 | CONFIDENTIAL | ---- | ---- | 0.7 | 109.7 | 0.3 | 90.7 | 2.7 | 39.7 | 3.3 | 117.3 |
| 24 | CONFIDENTIAL | ---- | ---- | 0.3 | 11.0 | 0.7 | 16.0 | 1.0 | 23.7 | 1.0 | 6.0 |
| 25 | CONFIDENTIAL | ---- | ---- | 0.1 | 8.5 | 0.3 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 |

| Trt. | Product | Rate/1000 $ft^2$ | Interval (days) | July 4 bp[1] | July 4 ds[2] | July 10 bp | July 10 ds | July 18 bp | July 18 ds | July 24 bp | July 24 ds |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | CONFIDENTIAL | ---- | ---- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 |
| 27 | CONFIDENTIAL | ---- | ---- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 |
| 28 | CONFIDENTIAL | ---- | ---- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 29 | Daconil Ultrex 82.5 WDG | 3.8 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.3 | 0.3 | 0.0 |
| 30 | IB 11522 | 4.1 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 1.0 | 0.0 |
| 31 | Daconil Ultrex 82.5 WDG | 3.0 oz | 14 | 0.0 | 1.0 | 0.0 | 0.0 | 0.3 | 6.0 | 0.0 | 0.0 |
| | + Heritage 50 WG | 0.2 oz | | | | | | | | | |
| 32 | Chipco Aliette Signature 80 WG | 4.0 oz | 14 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 |
| | +Chipco 26019 FLO 2 SC | 4 fl oz. | | | | | | | | | |
| 33 | Chipco Aliette Signature 80 WG | 4 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.0 |
| | + EXP 10790A (26 GT) 2 SC | 4 fl oz | | | | | | | | | |
| 34 | Chipco Aliette Signature 80 WG | 4 oz | 14 | 0.0 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 |
| | + EXP 10702B (EXP 26 GT) 2 SC | 4 fl oz | | | | | | | | | |
| 35 | Chipco Aliette Signature 80 WG | 4 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | + Daconil Ultrex 82.5 WDG | 3.8 oz | | | | | | | | | |
| 36 | EXP 10790A (26 GT) 2 SC | 2.0 fl oz | 14 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.7 | 5.7 |
| | + Cleary's 3336 F | 2.0 fl oz | | | | | | | | | |
| 37 | Chipco Aliette Signature 80 WG | 4.0 oz | 14 | 0.7 | 86.7 | 2.0 | 24.7 | 2.7 | 102.7 | 2.0 | 99.3 |
| 38 | Chipco Aliette 80 WG | 4.0 oz | 14 | 1.7 | 38.7 | 1.0 | 36.0 | 4.0 | 54.0 | 2.7 | 27.3 |
| 39 | Chipco 26019 FLO 2 SC | 4.0 fl oz | 14 | 0.0 | 0.3 | 0.0 | 0.0 | 1.0 | 0.0 | 1.3 | 0.0 |
| 40 | 3336 F | 2.0 fl oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.7 | 0.0 |
| | + Chipco 6019 FLO | 2.0 fl oz | | | | | | | | | |
| 41 | 3336 50 WP | 4.0 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.3 |
| 42 | 3336 50 WP | 8.0 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 43 | Spotrete 75 WDG | 5.0 oz | 7 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| 44 | CTM 90 WDG | 4.0 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| 45 | CTM 90 WDG | 8.0 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 46 | CONFIDENTIAL | ----- | --- | 2.0 | 6.3 | 3.0 | 3.3 | 2.7 | 6.3 | 2.3 | 0.0 |
| 47 | CONFIDENTIAL | ----- | --- | 1.7 | 3.3 | 2.0 | 1.3 | 1.7 | 2.0 | 2.0 | 0.0 |
| 48 | CONFIDENTIAL | ----- | --- | 1.0 | 0.0 | 0.7 | 0.0 | 2.3 | 0.0 | 3.3 | 0.0 |
| 49 | CONFIDENTIAL | ----- | --- | 0.7 | 1.7 | 0.0 | 0.0 | 0.3 | 0.0 | 1.0 | 0.0 |
| 50 | CONFIDENTIAL | ----- | --- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 51 | Heritage 50 WG | 400 g ai/ha | 21 | 0.0 | 97.7 | 1.0 | 99.0 | 3.0 | 133.7 | 2.7 | 109.3 |

| Trt. | Product | Rate/1000 $ft^2$ | Interval (days) | July 4 bp[1] | July 4 ds[2] | July 10 bp | July 10 ds | July 18 bp | July 18 ds | July 24 bp | July 24 ds |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | Sentinel 40 WG | 300 g ai/ha | 21 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 53 | Eagle 40 W | 1.2 oz | 21 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 54 | Eagle 40 W | 1.2 oz | 21 | 0.7 | 25.0 | 0.3 | 25.0 | 0.0 | 44.0 | 0.0 | 0.7 |
| | ALTERNATED WITH | | | | | | | | | | |
| | Heritage 50 WG | 0.2 oz | 21 | | | | | | | | |
| 55 | S-7247 | 2 fl oz | 14 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 56 | S-7247 | 4 fl oz | 14 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 57 | S-7221 | 0.6 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | + S-7222 | 3.7 oz | | | | | | | | | |
| 58 | S-7221 | 1.2 oz | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | + S-7222 | 7.35 oz | | | | | | | | | |
| | LSD[3] | | | 1.12 | 76 | 1.11 | 78 | 1.40 | 82 | 2.03 | 97.3 |

[1]0 = no disease, 1 = 1-5%, 2 = 5-10%, 3 = 10-25%, 4 = 25-50%, 5 = >50% of plot symptomatic.
[2]Number of infection centers per plot.
[3]Least significant difference (P = 0.05).

# 1997 Kentucky Bluegrass Fertility Study

*Barbara R. Bingaman, Nick E. Christians, & Michael B. Faust*

The purpose of this study was to evaluate the response of Kentucky bluegrass to various natural organic and commercial fertilizers. The experimental plot was an established area of 'Park' Kentucky bluegrass at the Iowa State University Horticulture Station north of Ames, Iowa. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.3% organic matter, a pH of 6.5, 3 ppm P, and 80 ppm K. Irrigation was used to supplement rainfall and maintain the turf in good growing condition.

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

All fertilizers were applied in the spring and late summer at a yearly rate of 4 lb N/1000 $ft^2$ (Table 1). There were 11 treatments including eight different fertilizers and an untreated control. Two soybean-based natural products from Renaissance Fertilizer Co. (6-0-6 and 8-2-6) were applied at 2 lbs N/1000 $ft^2$ followed by 2 lbs N/1000 $ft^2$, and at 3 lbs N/1000 $ft^2$ followed by 1 lb N/1000 $ft^2$. Corn gluten meal from Grain Processing Inc., Safe & Simple (a different particle configuration of corn gluten meal) from Blue Seal Feeds, Milorganite (processed sewage sludge), Poly Plus™ sulfur coated urea (39-0-0) from LESCO Inc., and Proturf (32-3-10) from The Scotts Company also were included. These products were applied in split applications at 2 lbs N/1000 $ft^2$. In addition, a liquid product, Green Lawn, was applied monthly May through September (5 applications) at 0.8 lb N/1000 $ft^2$.

Prior to treatment the plot was mowed to a uniform height of 2 inches A survey of the area was made before application and turf quality was uniform. Granular fertilizers were applied using 'shaker dispensers'. Green Lawn was applied at 30 psi using a $CO_2$ backpack sprayer equipped with TeeJet #8006 flat fan nozzles. It was mixed in 283 ml of water which translates to an application rate of 3 gal/1000 $ft^2$.

Initial applications were made on May 15. Late summer sequential applications were made on July 31. Green Lawn was applied on May 15, June 11, July 10, July 31, and September 5.

It was a very cool and dry spring. In April, there was only one substantial rainfall with total rainfall for the month under 1.5 inches. In May and June, the rainfall events were sporadic. This trend continued in July and August. Because of this, irrigation was heavily relied on to keep the bluegrass in good growing condition.

Visual turf quality and fresh clipping weight data were taken weekly from May 21 through October 2. Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst turf quality (Tables 2 and 3). Mowing height for taking clippings was 2 inches (Tables 3 and 4).

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

There was no phytotoxicity on the treated bluegrass. The visual quality of all fertilized bluegrass was significantly better than the untreated control from May 30 through October 2 (Table 2 and 3). The quality of all fertilized turf did not fall below the acceptable quality level (a rating of 6) for the entire season. Sulfur coated urea, Proturf, and Renaissance (6-0-6) at 3 lb N followed by 1 lb N/1000 $ft^2$

(treatment 4) produced the best mean quality. The effects of these treatments were not different from those of corn gluten meal, Renaissance (6-0-6) at 2 lb N followed by 2 lb N/1000 $ft^2$ (treatment 3), Renaissance (8-2-6) at 3 lb N followed by 1 lb N/1000 $ft^2$ (treatment 6), and Safe & Simple.

Two commercial fertilizers, Proturf and sulfur coated urea, caused rapid bluegrass quality improvements following initial and sequential applications. The response to the natural product fertilizers, corn gluten meal, Renaissance (6-0-6 and 8-2-6), and Safe & Simple, generally was slower but was maintained longer. After the initial treatments, the best quality through May 30 was found in bluegrass treated with Proturf and sulfur coated urea. By June 4, the visual quality of bluegrass treated with the soybean products (Renaissance 6-0-6 and 8-2-6) applied at 3 lb N followed by 1 lb N/1000 $ft^2$ was similar to bluegrass treated with Poly-Plus (Table 2 and 3).

Untreated bluegrass produced the least fresh clippings from June 4 through the end of the study. For the period from June 4 through July 30, the most clippings were from bluegrass treated with Renaissance (8-2-6) at 3 lb N followed by 1 lb N/1000 $ft^2$ (treatment 6). During this period, similar weights were produced by Poly-Plus on June 4, June 10, July 9, July 22, and July 30; by Proturf on June 4; and by Renaissance (6-0-6) at 3 lb N followed by 1 lb N/1000 $ft^2$ (treatment 4) on June 18, June 25, July 9, July 15, July 22, and July 30. On July 2, corn gluten meal had comparable clipping weights. On July 22 and July 30, the clipping weights in bluegrass treated with Green Lawn and Safe & Simple were similarly high.

Mean and total clipping weights from untreated bluegrass were significantly less than clippings from treated bluegrass (Table 4). The largest mean and total clipping weights were from bluegrass treated with Renaissance (8-2-6) at 3 lb N followed by 1 lb N1000 $ft^2$ (treatment 6) but they were similar to those weights from all other fertilizers except Milorganite.

**Table 1.** Application rates for fertilizer materials used in the 1997 Kentucky Bluegrass Fertility Study.

| | Materials | yearly lbs N/1000 $ft^2$ | Initial application[1] Rate lbs N /1000 $ft^2$ | Sequential application[2] Rate lbs N /1000 $ft^2$ |
|---|---|---|---|---|
| 1 | Untreated control | NA | NA | NA |
| 2 | Corn gluten meal (10% N) | 4 | 2.0 | 2.0 |
| 3 | Renaissance (6-0-6)[3] | 4 | 2.0 | 2.0 |
| 4 | Renaissance (6-0-6)[3] | 4 | 3.0 | 1.0 |
| 5 | Renaissance (8-2-6)[3] | 4 | 2.0 | 2.0 |
| 6 | Renaissance (8-2-6)[3] | 4 | 3.0 | 1.0 |
| 7 | Milorganite (6-2-0) | 4 | 2.0 | 2.0 |
| 8 | Proturf (32-3-10)[4] | 4 | 2.0 | 2.0 |
| 9 | Safe & Simple (10% N) | 4 | 2.0 | 2.0 |
| 10 | Sulfur coated urea (39-0-0)[5] | 4 | 2.0 | 2.0 |
| 11 | Green Lawn (26-4-2)[6] | 4 | 0.8 | 0.8 |

[1]Initial applications were made on May 15, 1997.
[2]Sequential applications were made on July 30, 1997. Green Lawn fertilizer was applied 5 times (May 15, June 11, July 10, July 30, and September 5.
These products are being screened for [3] Renaissance Fertilizer Company, [4]The Scotts Company, [5]LESCO,and [6]Green Lawn (applied monthly for a total yearly rate of 4.0 lb N/1000 $ft^2$).

**Table 2.** Visual quality of Kentucky bluegrass for May 21 through July 22 for the 1997 Kentucky Bluegrass Fertility Study.

| | Materials | Amount of N/1000 ft² | May 21 | May 30 | June 4 | June 10 | June 18 | June 25 | July 2 | July 9 | July 15 | July 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 7 | 6 | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 6 |
| 2 | Corn gluten meal (10% N)[1] | 2 fb 2 | 7 | 6 | 7 | 8 | 8 | 9 | 9 | 8 | 7 | 7 |
| 3 | Renaissance (6-0-6)[1&3] | 2 fb 2 | 6 | 7 | 7 | 9 | 8 | 9 | 8 | 7 | 7 | 8 |
| 4 | Renaissance (6-0-6)[2&3] | 3 fb 1 | 7 | 8 | 9 | 9 | 9 | 9 | 9 | 8 | 8 | 8 |
| 5 | Renaissance (8-2-6)[1&3] | 2 fb 2 | 7 | 7 | 7 | 8 | 7 | 8 | 7 | 7 | 7 | 7 |
| 6 | Renaissance (8-2-6)[2&3] | 3 fb 1 | 7 | 7 | 9 | 9 | 9 | 9 | 9 | 7 | 8 | 8 |
| 7 | Milorganite (6-2-0)[1] | 2 fb 2 | 7 | 7 | 7 | 8 | 6 | 7 | 8 | 7 | 7 | 7 |
| 8 | Proturf (32-3-10)[1&4] | 2 fb 2 | 8 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 |
| 9 | Safe & Simple (10% N)[1] | 2 fb 2 | 7 | 6 | 6 | 7 | 7 | 8 | 8 | 7 | 7 | 8 |
| 10 | Sulfur coated urea (39-0-0)[1&5] | 2 fb 2 | 8 | 9 | 9 | 9 | 8 | 8 | 8 | 7 | 8 | 8 |
| 11 | Green Lawn (26-4-2)[6] | 0.8 x 5 | 8 | 8 | 7 | 7 | 7 | 8 | 7 | 6 | 7 | 8 |
| | $LSD_{0.05}$ | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

[1]These materials were applied in split spring and late summer applications at 2 lbs N/1000 ft².
[2]These products were applied in spring and late summer applications at 3 lbs N/1000 ft² and 1 lb N/1000 ft², respectively.
[3]These products were screened for Renaissance Fertilizer Company, [4]The Scotts Company, [5]LESCO, and [6]Green Lawn (applied monthly for a total yearly rate of 4.0 lb N/1000 ft²).
Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
Initial applications were made on May 15, 1997 and sequentials on July 30, 1997. Green Lawn applications were made on May 15, June 11, July 10, July 31, and September 5.

**Table 3.** Visual quality of Kentucky bluegrass for July 30 through October 2 for the 1997 Kentucky Bluegrass Fertility Study.

| | Materials | Amount of N/1000 ft² | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 | Sept 26 | Oct 2 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 7 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 5 | 5.5 |
| 2 | Corn gluten meal (10% N)[1] | 2 fb 2 | 8 | 7 | 8 | 8 | 8 | 8 | 9 | 7 | 7 | 7 | 7.6 |
| 3 | Renaissance (6-0-6)[1&3] | 2 fb 2 | 9 | 8 | 9 | 8 | 8 | 7 | 8 | 7 | 6 | 7 | 7.6 |
| 4 | Renaissance (6-0-6)[2&3] | 3 fb 1 | 9 | 8 | 8 | 7 | 7 | 7 | 6 | 7 | 7 | 6 | 7.8 |
| 5 | Renaissance (8-2-6)[1&3] | 2 fb 2 | 8 | 7 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 7 | 7.2 |
| 6 | Renaissance (8-2-6)[2&3] | 3 fb 1 | 8 | 7 | 7 | 7 | 7 | 6 | 7 | 7 | 7 | 6 | 7.5 |
| 7 | Milorganite (6-2-0)[1] | 2 fb 2 | 8 | 7 | 8 | 7 | 7 | 6 | 7 | 7 | 7 | 7 | 7.0 |
| 8 | Proturf (32-3-10)[1&4] | 2 fb 2 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 6 | 7.8 |
| 9 | Safe & Simple (10% N)[1] | 2 fb 2 | 9 | 7 | 8 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 7.6 |
| 10 | Sulfur coated urea (39-0-0)[1&5] | 2 fb 2 | 8 | 9 | 9 | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 8.0 |
| 11 | Green Lawn (26-4-2)[6] | 0.8 x 5 | 8 | 8 | 7 | 7 | 7 | 7 | 7 | 9 | 8 | 7 | 7.3 |
| | $LSD_{0.05}$ | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0.4 |

[1]These materials were applied in split spring and late summer applications at 2 lbs N/1000 ft².
[2]These products were applied in spring and late summer applications at 3 lbs N/1000 ft² and 1 lb N/1000 ft², respectively.
[3]These products were screened for Renaissance Fertilizer Company, [4]The Scotts Company, [5]LESCO, and [6]Green Lawn (applied monthly for a total yearly rate of 4.0 lb N/1000 ft²).
Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
Initial applications were made on May 15, 1997 and sequentials on July 30, 1997. Green Lawn applications were made on May 15, June 11, July 10, July 31, and September 5.

**Table 4.** Fresh clipping weights of Kentucky bluegrass for May 21 through July 22 for the 1997 Kentucky Bluegrass Fertility Study.

| | Materials | Amount of N/1000 $ft^2$ | May 21 | June 4 | June 10 | June 18 | June 25 | July 2 | July 9 | July 15 | July 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 400 | 120 | 55 | 63 | 76 | 81 | 100 | 73 | 105 |
| 2 | Corn gluten meal (10% N)[1] | 2 fb 2 | 397 | 147 | 85 | 135 | 175 | 177 | 164 | 111 | 139 |
| 3 | Renaissance (6-0-6)[1&3] | 2 fb 2 | 380 | 176 | 92 | 126 | 161 | 146 | 157 | 110 | 144 |
| 4 | Renaissance (6-0-6)[2&3] | 3 fb 1 | 350 | 207 | 106 | 174 | 207 | 190 | 206 | 128 | 176 |
| 5 | Renaissance (8-2-6)[1&3] | 2 fb 2 | 360 | 181 | 92 | 135 | 158 | 158 | 165 | 100 | 141 |
| 6 | Renaissance (8-2-6)[2&3] | 3 fb 1 | 390 | 240 | 148 | 199 | 218 | 204 | 207 | 153 | 241 |
| 7 | Milorganite (6-2-0)[1] | 2 fb 2 | 365 | 158 | 81 | 120 | 137 | 147 | 150 | 103 | 143 |
| 8 | Proturf (32-3-10)[1&4] | 2 fb 2 | 407 | 216 | 109 | 134 | 148 | 144 | 151 | 96 | 122 |
| 9 | Safe & Simple (10% N)[1] | 2 fb 2 | 363 | 145 | 79 | 119 | 159 | 167 | 173 | 111 | 176 |
| 10 | Sulfur coated urea (39-0-0)[1&5] | 2 fb 2 | 391 | 234 | 115 | 140 | 154 | 154 | 176 | 113 | 164 |
| 11 | Green Lawn (26-4-2)[6] | 0.8 x 5 | 418 | 157 | 85 | 122 | 158 | 142 | 143 | 122 | 206 |
| | $LSD_{0.05}$ | | NS | 62 | NS | 33 | 33 | 34 | 31 | NS | NS |

[1]These materials were applied in split spring and late summer applications at 2 lbs N/1000 $ft^2$.
[2]These products were applied in spring and late summer applications at 3 lbs N/1000 $ft^2$ and 1 lb N/1000 $ft^2$, respectively.
[3]These products were screened for Renaissance Fertilizer Company, [4]The Scotts Company, [5]LESCO, and [6]Green Lawn (applied monthly for a total yearly rate of 4.0 lb N/1000 $ft^2$).
Fresh clipping weights are reported in grams fresh tissue.
Initial applications were made on May 15, 1997 and sequentials on July 30, 1997. Green Lawn applications were made on May 15, June 11, July 10, July 31, and September 5.

**Table 5.** Fresh clipping weights of Kentucky bluegrass for July 30 through October 2 for the 1997 Kentucky Bluegrass Fertility Study.

| | Materials | Amount of N/1000 $ft^2$ | July 30 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 11 | Oct 2 | Mean weight | Total clipping weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 158 | 114 | 105 | 82 | 58 | 80 | 51 | 108 | 1722 |
| 2 | Corn gluten meal (10% N)[1] | 2 fb 2 | 196 | 142 | 258 | 230 | 152 | 225 | 151 | 180 | 2882 |
| 3 | Renaissance (6-0-6)[1&3] | 2 fb 2 | 213 | 161 | 370 | 283 | 156 | 192 | 113 | 186 | 2980 |
| 4 | Renaissance (6-0-6)[2&3] | 3 fb 1 | 228 | 165 | 281 | 211 | 113 | 130 | 93 | 185 | 2966 |
| 5 | Renaissance (8-2-6)[1&3] | 2 fb 2 | 198 | 157 | 368 | 279 | 140 | 166 | 110 | 182 | 2907 |
| 6 | Renaissance (8-2-6)[2&3] | 3 fb 1 | 303 | 189 | 291 | 226 | 132 | 153 | 99 | 212 | 3391 |
| 7 | Milorganite (6-2-0)[1] | 2 fb 2 | 208 | 148 | 275 | 215 | 123 | 150 | 106 | 164 | 2629 |
| 8 | Proturf (32-3-10)[1&4] | 2 fb 2 | 191 | 191 | 399 | 265 | 135 | 169 | 100 | 186 | 2978 |
| 9 | Safe & Simple (10% N)[1] | 2 fb 2 | 243 | 156 | 256 | 230 | 142 | 196 | 110 | 176 | 2824 |
| 10 | Sulfur coated urea (39-0-0)[1&5] | 2 fb 2 | 244 | 231 | 400 | 263 | 143 | 185 | 116 | 201 | 3221 |
| 11 | Green Lawn (26-4-2)[6] | 0.8 x 5 | 239 | 206 | 255 | 178 | 98 | 152 | 140 | 176 | 2819 |
| | $LSD_{0.05}$ | | NS | 61 | 79 | 35 | 31 | 37 | 29 | 41 | 657 |

[1]These materials were applied in split spring and late summer applications at 2 lbs N/1000 $ft^2$.
[2]These products were applied in spring and late summer applications at 3 lbs N/1000 $ft^2$ and 1 lb N/1000 $ft^2$, respectively.
[3]These products were screened for Renaissance Fertilizer Company, [4]The Scotts Company, [5]LESCO, and [6]Green Lawn (applied monthly for a total yearly rate of 4.0 lb N/1000 ft2).
Fresh clipping weights are reported in grams fresh tissue.
Initial applications were made on May 15, 1997 and sequentials on July 30, 1997. Green Lawn applications were made on May 15, June 11, July 10, July 31, and September 5.

# 1996-97 Aquatrols Creeping Bentgrass Fertilizer Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The purpose of this study was to compare several different fertilizers in a fall fertilization program on creeping bentgrass maintained at fairway height. The experimental plot was in an established fairway height area of 'Penneagle' Creeping Bentgrass grown on native soil at the Iowa State University Horticulture Research Station north of Ames, Iowa. The pH of the soil was 8.0, the P level was 14 lb/A and the K level was 140 lb/A.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft with three replications. Three-foot barrier rows were placed between replications to facilitate taking clippings. Fertilizers were applied in the fall of 1996 shortly before the bentgrass ceased actively growing for the season (15-30 days).

The reason for the timing of application was that in the fall photosynthesis was still occurring and the plants would use the nutrients to increase root growth and carbohydrate levels. The resulting turf stand, therefore, should have better winter hardiness and an improved response (earlier greenup and higher quality) in the spring.

Single applications of five fertilizer formulations were made on October 24, 1996. Untreated Urea (46-0-0), Fertilizer Plus 0.5% (46-0-0), and Fertilizer Plus 1.0% (46-0-0) were applied at 0.5 and 1.0 lb N/1000 $ft^2$. Fertilizer A (17-10-12) and Fertilizer B (22-4-14) were applied at 0.6 lb N/1000 $ft^2$. An untreated control will be included for a total of 10 treatments (Table 1). The fertilizers were applied using plastic coated containers as 'shaker dispensers'.

Post treatment observations were made in the fall of 1996. The plots were checked on October 28 and periodically throughout the fall for phytotoxicity and quality differences. Greenup began on March 13 and all plots were green by April 18, 1997. Greenup data were recorded using a 9 to 1 scale: 9 = 100% green, 6 = 50% green, 1 = 100% brown turf (Table 1). Visual quality data were taken on April 18, May 22, and May 30 (Table 1). Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.

On May 22, the plots were mowed to 3/8" and clippings were collected. Fresh clipping weights were taken (Table 1). The clippings were dried for 96 hours at 67° C and dry weights were measured (Table 1). The dry tissue was ground to 40 mesh using a Wiley Laboratory Mill and submitted for tissue nutrient and carbohydrate analysis.

Tissue nutrient analyses were conducted by the Plant Nutrition Lab in the Department of Horticulture at Iowa State University using an IRIS - AP - Duo, Inductively Coupled Argon Plasma Analyzer (ICAP). Nitrogen was determined as percent N on a dry weight basis. Tissue content of boron, copper, manganese, molybdenum, nickel, and zinc were determined in ppm. The percent content in leaf tissue levels of calcium, potassium, magnesium, and phosphorus also were evaluated (Tables 2 and 3).

Total non-structural carbohydrate content (TNC) analyses was conducted by the Agronomy Forage Lab in the Department of Agronomy at Iowa State University. The acid extraction procedure for removing total non-structural carbohydrate and the phenol-sulfuric acid calorimetric method for total carbohydrate analysis were used. This methodology followed the guidelines in Chemical & Biological Methods for Grain & Forage Sorghum, Department of Agronomy, International Programs in Agriculture, Purdue University. The carbohydrate levels were determined as percent by weight on a dry matter basis (Table 3).

Root cores were taken on May 29. Five cores were taken from each plot. The cores were split into three sections by depth (0-5, 5-10, and 10-15 cm). The roots were extracted from the soil using water and a series of screens with various mesh sizes. The roots were dried at 100° C and dry weights were taken. The roots were 'ashed' in a muffle furnace at 500° C to burn off the root tissue. The residue was weighed and root weights were calculated by subtracting the ashed remnants from the dry root weights (Table 4).

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

There was a difference in spring greenup between the grass in the control and all other treatments. The grass treated with the fertilizer plus 1% treatment at 1 lb N/1000 ft$^2$ had the highest rating (Table 1). The fresh clipping and dry clipping weights were also highest for that treatment.

There were significant differences in tissue N content (Table 2). The grass in the control had the lowest N content as would be expected. The grass treated with the fertilizer plus 1% treatment at 1 lb N/1000 ft$^2$ contained the highest N content.

Phosphorus tissue content was highest in the grass treated with the 17-10-12 fertilizer (Table 3). This again would be expected because of the lack of P in most of the other treatments. There were no differences in carbohydrate content among the treatments.

Root weight of the grass varied among the treatments at the 0-5 cm depth only (Table 4). It was generally the grass treated with the 0.5 lb N/1000 ft$^2$ treatment levels that had the highest rooting. The exception was treatment 6, the 1 lb N/1000 ft$^2$ treatment with the 0.5% fertilizer plus treatment.

**Table 1.** Spring 1997 greenup[1], visual quality[2] and clipping weight[3] data for creeping bentgrass in the 1996-97 Bentgrass Fertilizer Study.

| | Materials | Rate lb N/1000 ft$^2$ | Greenup March 13 | Visual quality May 22 | Visual quality May 30 | Clipping weights from May 22 Fresh weights | Clipping weights from May 22 Dry weights |
|---|---|---|---|---|---|---|---|
| 1. | Untreated control | NA | 5 | 6 | 9 | 278.5 | 95.1 |
| 2. | Untreated urea (46-0-0) | 0.5 | 6 | 6 | 9 | 341.3 | 113.4 |
| 3. | Untreated urea (46-0-0) | 1.0 | 7 | 7 | 9 | 355.4 | 115.5 |
| 4. | Fertilizer Plus 0.5 (46-0-0) | 0.5 | 6 | 7 | 9 | 302.2 | 99.1 |
| 5. | Fertilizer Plus 1.0 (46-0-0) | 0.5 | 6 | 7 | 9 | 333.6 | 108.1 |
| 6. | Fertilizer Plus 0.5 (46-0-0) | 1.0 | 7 | 7 | 9 | 341.5 | 111.8 |
| 7. | Fertilizer Plus 1.0 (46-0-0) | 1.0 | 7 | 7 | 9 | 412.9 | 134.5 |
| 8. | Fertilizer A (17-10-12) | 0.6 | 6 | 6 | 9 | 351.4 | 114.0 |
| 9. | Fertilizer B (22-4-14) | 0.6 | 6 | 7 | 9 | 341.5 | 110.8 |
| | $LSD_{0.05}$ | | 1 | NS | NS | 74.6 ($p>0.08$) | 22.9 ($p>.10$) |

Fertilizers applied on October 24, 1996.
NS = means not significantly different at the 0.05 level.
[1]Greenup was assessed using a 9 to 1 scale: 9 = 100% green, 6 = 50% green, and 1 = 100% brown turf.
[2]Visual quality ratings were based on a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
[3]Height for clippings was 3/8".

**Table 2.** Tissue nutrient data for creeping bentgrass clippings[1] taken May 22, 1997 for the 1996-97 Aquatrols Bentgrass Fertilizer Study.

| | Materials | lb N/ 1000 $ft^2$ | % dry weight N | Tissue content (ppm) B | Cu | Mn | Mo | Ni[2] | Z |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Untreated control | NA | 2.11 | 7.96 | 5.43 | 46.07 | 2.42 | 0.700 | 21.23 |
| 2. | Untreated urea (46-0-0) | 0.5 | 2.18 | 7.09 | 4.71 | 45.47 | 2.15 | 0.700 | 21.20 |
| 3. | Untreated urea (46-0-0) | 1.0 | 2.35 | 6.99 | 4.52 | 44.00 | 2.26 | 0.700 | 21.23 |
| 4. | Fertilizer Plus 0.5 (46-0-0) | 0.5 | 2.17 | 6.97 | 5.22 | 43.43 | 2.24 | 0.700 | 20.80 |
| 5. | Fertilizer Plus 1.0 (46-0-0) | 0.5 | 2.30 | 7.18 | 5.27 | 45.20 | 2.28 | 0.823 | 22.47 |
| 6. | Fertilizer Plus 0.5 (46-0-0) | 1.0 | 2.30 | 7.39 | 6.11 | 52.30 | 2.03 | 0.700 | 21.13 |
| 7. | Fertilizer Plus 1.0 (46-0-0) | 1.0 | 2.37 | 7.11 | 5.41 | 48.87 | 1.96 | 0.700 | 21.60 |
| 8. | Fertilizer A (17-10-12) | 0.6 | 2.27 | 7.37 | 5.31 | 48.50 | 2.43 | 0.700 | 21.67 |
| 9. | Fertilizer B (22-4-14) | 0.6 | 2.24 | 6.90 | 6.15 | 43.67 | 1.89 | 0.700 | 21.73 |
| | $LSD_{0.05}$ | | 0.10 | NS | 1.00 | 5.25 | NS | NS | 0.87 |

Fertilizers applied on October 24, 1996.
NS = means not significantly different at the 0.05 level.
[1]Mowing height for clippings was 3/8".
[2]Nickel tissue concentrations were < 0.700 ppm.

**Table 3.** Tissue nutrient and tissue total carbohydrate data for creeping bentgrass clippings[1] taken May 22, 1997 for the 1996-97 Aquatrols Bentgrass Fertilizer Study.

| | Materials | lb N/ 1000 $ft^2$ | Percent Tissue content (%) Ca | K | Mg | P | Percent by weight on dry matter basis: Total carbohydrates |
|---|---|---|---|---|---|---|---|
| 1. | Untreated control | NA | 1.00 | 1.18 | 0.34 | 0.249 | 29.25 |
| 2. | Untreated urea (46-0-0) | 0.5 | 0.98 | 1.19 | 0.35 | 0.247 | 28.99 |
| 3. | Untreated urea (46-0-0) | 1.0 | 0.96 | 1.15 | 0.35 | 0.243 | 29.00 |
| 4. | Fertilizer Plus 0.5 (46-0-0) | 0.5 | 0.94 | 1.20 | 0.33 | 0.243 | 29.87 |
| 5. | Fertilizer Plus 1.0 (46-0-0) | 0.5 | 0.96 | 1.14 | 0.36 | 0.261 | 29.92 |
| 6. | Fertilizer Plus 0.5 (46-0-0) | 1.0 | 0.99 | 1.17 | 0.35 | 0.237 | 29.76 |
| 7. | Fertilizer Plus 1.0 (46-0-0) | 1.0 | 0.99 | 1.20 | 0.36 | 0.249 | 29.19 |
| 8. | Fertilizer A (17-10-12) | 0.6 | 0.98 | 1.22 | 0.35 | 0.275 | 29.16 |
| 9. | Fertilizer B (22-4-14) | 0.6 | 0.96 | 1.25 | 0.34 | 0.252 | 29.43 |
| | $LSD_{0.05}$ | | NS | NS | NS | 0.020 | NS |

Fertilizers applied on October 24, 1996.
NS = means not significantly different at the 0.05 level.
[1]Mowing height for clippings was 3/8".

**Table 4.** Root weights[1] for creeping bentgrass in the 1996-97 Aquatrols Bentgrass Fertilizer Study.

| | Materials | Rate lb N/1000 $ft^2$ | Root weight (g) 0 - 5 cm | 5 - 10 cm | 10 - 15 cm |
|---|---|---|---|---|---|
| 1. | Untreated control | NA | 0.37 | 0.08 | 0.02 |
| 2. | Untreated urea (46-0-0) | 0.5 | 0.48 | 0.11 | 0.06 |
| 3. | Untreated urea (46-0-0) | 1.0 | 0.37 | 0.09 | 0.03 |
| 4. | Fertilizer Plus 0.5 (46-0-0) | 0.5 | 0.36 | 0.09 | 0.03 |
| 5. | Fertilizer Plus 1.0 (46-0-0) | 0.5 | 0.52 | 0.23 | 0.05 |
| 6. | Fertilizer Plus 0.5 (46-0-0) | 1.0 | 0.51 | 0.12 | 0.05 |
| 7. | Fertilizer Plus 1.0 (46-0-0) | 1.0 | 0.43 | 0.08 | 0.04 |
| 8. | Fertilizer A (17-10-12) | 0.6 | 0.33 | 0.10 | 0.04 |
| 9. | Fertilizer B (22-4-14) | 0.6 | 0.36 | 0.10 | 0.03 |
| | $LSD_{0.05}$ | | 0.12 | NS | NS |

Fertilizers applied on October 24, 1996.
NS = means not significantly different at the 0.05 level.
[1]Root cores were taken on May 30, 1997.

# Creeping Bentgrass Fertility Trial Results - 1997

*James R. Dickson and Nick E. Christians*

### Introduction

Two liquid products and one granular product from the Ringer Corp. were tested against Plant Marvel (20-5-30) and a control of urea. All treatments were applied at the rate of 4 lbs N per 1000 sq. ft. per year. The applications were made at two-week intervals over a period of 20 weeks (ten applications) between May 26 and September 29, 1997. They were applied on Penncross creeping bentgrass growing on a sand-based golf green which was constructed to USGA specifications.

This report summarizes information on turf visual quality, shoot clipping yield, and root growth. The clipping yield data were collected once per month beginning July 29th. These clippings were collected one week after treatment application. Visual quality data were collected, beginning July 7th, during the weeks when no treatments were applied. Roots samples were collected September 17, 1997.

### Methods and Materials

The treatments in this trial were applied in a randomized complete block design with 3 replications on 5 x 5 ft plots (Figure 1). All treatments were diluted in deionized water to yield a volume of 560 ml. They were then applied to the plots through a $CO_2$ pressurized 3-nozzle wand with TeeJet XR 8005 nozzles.

Visual quality ratings were based on turf color and density. A 9 to 1 scale was employed with 9 being the best possible quality and 1 representing dead turf.

A non-motorized, Ransom greens mower was used for obtaining clippings. The clippings were placed in paper sacks and dried at 70° C for at least 48-hours. Their weights were then measured to the nearest 0.01-g.

Six 2 x 15 cm cores were collected from each plot for root weight measurements. These cores were divided into three 5 cm increments and all six cores within a 5 cm depth interval were combined. The roots were washed by hand and collected on a No. 40 U.S.A. standard sieve. They were then dried at 70° C for at least 48 hours. The oven-dry weights were measured to the nearest 0.0001-g prior to ashing at 500° C for at least 24 hours. The ash weights were then measured to the nearest 0.0001-g, and subtracted from the oven-dry weight.

A statistical analysis of the treatment results for visual quality, the shoot weights (by event and cumulative) and root weights (by treatment and depth) was conducted using the Statistical Analysis System (SAS) to determine treatment effects.

### Results and Discussion

Significant treatment differences in clipping weight (Table 1) were observed in September data only. There were no treatment differences for the annual average clipping weights.

There were no treatment differences observed in the data from the root samples (Table 2).

There were no apparent visual quality differences between the treatments until late-September (Table 3). At that date, it became apparent that the grass receiving the Ringer “C2” treatment and the urea (control) treatment were producing a darker green color.

**Table 1.** 1997 mean clipping yields (g)

| Treatment | Date 7/29 | 8/27 | 9/24 | 10/9 | Average |
|---|---|---|---|---|---|
| Ringer[C-1] | 31.1 | 32.4 | 5.22 | 9.9 | 19.6 |
| C-1 +Ringer (5-2-10) | 37.3 | 40.7 | 6.6 | 14.5 | 24.8 |
| Ringer[C-2] | 35.3 | 33.6 | 5.1 | 11.6 | 21.4 |
| Plant Marvel (20-5-30) | 35.4 | 32.6 | 6.5 | 13.0 | 21.9 |
| Control (urea) | 32.6 | 33.0 | 5.0 | 12.2 | 20.7 |
| $LSD_{0.05}$ | NS | NS | NS | 2.50 | NS |

**Table 2.** 1997 mean root yields (g) at three depth intervals

| Treatment | Depth (cm) 0-5 | 5-10 | 10-15 | Average |
|---|---|---|---|---|
| Ringer[C-1] | 1.112 | 0.481 | 0.179 | 0.591 |
| C-1 +Ringer (5-2-10) | 1.125 | 0.411 | 0.230 | 0.588 |
| Ringer[C-2] | 1.240 | 0.401 | 0.240 | 0.627 |
| Plant Marvel (20-5-30) | 1.152 | 0.448 | 0.370 | 0.657 |
| Control (urea) | 1.089 | 0.218 | 0.193 | 0.592 |
| $LSD_{0.05}$ | NS | NS | NS | NS |

**Table 3.** 1997 mean visual quality ratings

| Treatment | Date 7/07 | 7/16 | 7/30 | 8/13 | 8/27 | 9/10 | 9/24 | 10/9 | Average |
|---|---|---|---|---|---|---|---|---|---|
| Ringer[C-1] | 5.7 | 6.7 | 6.7 | 6.7 | 6.7 | 7.0 | 6.3 | 6.0 | 6.45 |
| C-1 +Ringer (5-2-10) | 6.0 | 7.0 | 7.0 | 7.3 | 7.0 | 7.3 | 7.0 | 7.0 | 6.96 |
| Ringer[C-2] | 6.0 | 7.0 | 7.0 | 7.3 | 7.0 | 7.7 | 7.7 | 7.7 | 7.17 |
| Plant Marvel (20-5-30) | 6.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.3 | 7.0 | 6.92 |
| Control (urea) | 6.0 | 7.0 | 7.0 | 7.7 | 7.0 | 7.7 | 8.0 | 8.0 | 7.29 |
| $LSD_{0.05}$ | NS | NS | NS | NS | NS | NS | 0.69 | 0.49 | 0.31 |

# 1997 Kentucky Bluegrass Slow Release Fertilizer Study

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

The purpose of this study was to evaluate the response of Kentucky bluegrass to various commercial fertilizers. The experimental plot was an established area of 'Park' Kentucky bluegrass at the Iowa State University Horticulture Station north of Ames, Iowa. The soil in this area was a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with 3.0% organic matter, a pH of 6.75, 4.5 ppm P, and 107 ppm K. Irrigation was used to supplement rainfall and maintain the turf in good growing condition.

The experiment was arranged in a randomized complete block design. Individual plots were 5 x 5 ft and three replications were conducted. All fertilizers were applied in a single application at 2 lb. N/1000 $ft^2$ (Table 1). There were nine treatments including eight different fertilizers and an untreated control. Three experimental formulations (44-0-0), sulfur coated urea (39-0-0), Polyon (42-0-0). ESN (41-0-0), and Nutralene (40-0-0) were supplied by LESCO. In addition, IBDU (31-0-0) was included.

The fertilizers were applied on May 29, 1997. A pre-treatment survey of the plot showed that the bluegrass was uniform throughout. The materials were applied using 'shaker dispensers'. The materials were 'watered in' with the irrigation system. There was no substantial rainfall until mid-June so irrigation was used to maintain the plot.

Visual turf quality data were taken weekly beginning on June 4. Quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. Subsequent data were taken weekly through September 26.

Data were analyzed using the Statistical Analysis System (SAS, version 6.10) and the Analysis of Variance (ANOVA) procedure. Means comparisons were made with Fisher's Least Significant Difference (LSD) test.

Differences in turf quality were detected among the treated and untreated plots from June 4 through June 25 (Table 1). On June 10, bluegrass treated with either sulfur coated urea or Nutralene had significantly better quality than the other treated and untreated turf. The quality of bluegrass treated with the other fertilizers was the same as the untreated turf. By June 18, the quality of all treated bluegrass, except turf treated with Exp. 1, was better than the untreated control. The quality of bluegrass fertilized with sulfur coated urea, ESN, and Nutralene was better than the other treated and untreated turf. On June 25, all fertilized turf had significantly better quality than the untreated turf. Sulfur coated urea, Exp. 3, ESN, Nutralene, Polyon, and IBDU produced the best quality. From July 2 through September 5, there were generally no quality differences among the fertilized bluegrass but all fertilized turf had better quality than the untreated control. After September 5, the fertilizer effects were no longer detected.

**Table 1**. Visual quality[1] of Kentucky bluegrass treated for the 1997 Kentucky Bluegrass Slow Release Fertilizer Study.

| | Materials | June 4 | June 10 | June 18 | June 25 | July 2 | July 9 | July 15 | July 21 | Aug 6 | Aug 15 | Aug 21 | Aug 28 | Sept 5 | Sept 11 | Sept 18 | Sept 26 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | 6.0 | 6.3 | 5.0 | 5.0 | 6.0 | 5.0 | 6.0 | 7.0 | 6.0 | 7.0 | 7.0 | 7.0 | 7.0 | 5.0 | 9.0 | 6.0 | 6.4 |
| 2 | Exp. 1 (44-0-0) | 6.3 | 6.7 | 5.3 | 7.3 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 8.7 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.3 |
| 3 | Exp. 2 (44-0-0) | 6.0 | 7.0 | 6.0 | 7.3 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 8.7 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.3 |
| 4 | Exp. 3 (44-0-0) | 6.0 | 7.0 | 6.0 | 8.3 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 9.0 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.4 |
| 5 | Sulfur coated urea (39-0-0) | 6.3 | 8.7 | 7.3 | 8.7 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 9.0 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.6 |
| 6 | Polyon (42-0-0) | 6.0 | 6.3 | 6.0 | 7.7 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 9.0 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.3 |
| 7 | ESN (41-0-0) | 6.3 | 7.3 | 7.0 | 8.3 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 9.0 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.5 |
| 8 | IBDU (31-0-0) | 6.3 | 6.7 | 6.0 | 7.7 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 8.7 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.3 |
| 9 | Nutralene [MU (40-0-0)] | 6.7 | 8.3 | 7.3 | 8.0 | 8.0 | 7.0 | 7.0 | 8.0 | 7.0 | 8.0 | 8.3 | 8.0 | 7.0 | 5.0 | 9.0 | 6.0 | 7.5 |
| | $LSD_{0.05}$ | NS | 1.0 | 0.6 | 1.1 | NS | NS | NS | NS | NS | NS | 0.6 | NS | NS | NS | NS | NS | 0.1 |

Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
Fertilizer applications were made on May 29, 1997.
NS = means are not significantly different at the 0.05 level.

# Creeping Bentgrass Establishment on Sand Greens

*Michael B. Faust, Nick E. Christians, and Barbara R. Bingaman*

## Introduction

This creeping bentgrass establishment trial was initiated 1 Sept. 1996 at the Iowa State University Horticulture Research Station. The study was conducted to observe the development of creeping bentgrass from seed grown in a sand-based golf course green.

Sand has become a popular growing medium for golf course greens. The popularity of sand is due to its physical characteristics. Sand-based greens are more resistant to heavy compaction and provide increased water infiltration through the subsurface of the green. However, high sand content greens have drawbacks. Greens constructed of high sand mixes are inefficient recyclers of nutrients due to low levels of organic matter which results in reduced microbial activity. Nutrient and water retention is minimal because of low quantities of humus and clay. Essential elements required by turfgrass are easily leached through the sand medium.

Organic-based nutrient products containing humic substances and soluble carbohydrates were tested to increase the stability and efficiency of sand-based greens. The sand medium is enhanced through increased microbial activity, and by growth stimulating compounds supplied by the organic products.

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 development of 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. A 900 $ft^2$ area was used to conduct the research. The research was conducted as a randomized complete block design using six treatments in three replications. Each experimental plot had an area of 50 $ft^2$.

The list of treatments and application sequences can be found in the treatment protocol section. Five of the treatments used in the study were liquid fertilizer products, and the sixth treatment was a granular fertilizer material. Four of the liquid treatments, excluding the control, were general use soil conditioners designed to stimulate microbial activity and to provide overall improved soil fertility. The granular treatment was a ground feather meal product containing 56% WIN. All of the liquid treatments were applied to the turf using a $CO_2$ tank and hand-held spray boom. The granular treatment was applied with a hand-held shaker.

Application of the treatments followed a four-week cycle in September and October of 1996. Week one was a 1:1:1 (N,P,K) application with 0.5 lb N, P, and K/1000 $ft^2$ being applied to the turf. Weeks 2-4 used a 2:0:1 (N,P,K) application with 0.5 lb N, and 0.25 lb K/1000 $ft^2$. The treatments were irrigated after application. A single four-week cycle was completed in 1996. The study was covered by a tarp in November to protect the newly emerged seedlings during the winter months.

Treatments were resumed in the spring of 1997. Changes were made to the research at this time. The plots were split into two 25 $ft^2$ sections, doubling the number of individual plots in the trial. A randomized split block design was used for the 1997 growing season.

The first application in the spring of 1997 was a 1:1:1 starter fertilizer containing 0.5 lb N, P, and K/1000 $ft^2$. This starter fertilizer application occurred on 1 May 1997. It was applied to both sections of the split 50 $ft^2$ plot. Application frequency and product quantity changes were initiated two weeks following the 1:1:1 application. At that time, a switch was made to 2:0:1 treatments. These treatments were applied for the remainder of the season.

Half of the experimental plots received one 0.5 lb N/1000 $ft^2$ application every two weeks (2 applications per month). The other half of the plot received two 0.125 lb N/1000 $ft^2$ applications per week (8 applications per month). The high frequency of applications was designed to imitate fertigation treatments. A total of 1 lb N/1000 $ft^2$ and 0.5 lb K/1000 $ft^2$ was applied each month from 15 May through 18 July. On 18 July, another change was made concerning the rates of N and K that were applied through the treatment applications. The N and K rates were reduced by one-half. This change resulted in 0.5 lb N/1000 $ft^2$ and 0.25 lb K/1000 $ft^2$ being applied to each experimental plot in a one-month period. The new rates were used for the remainder of the season. All treatments were irrigated following application.

Clipping tissue samples were removed and collected seven times throughout the 1997 season following improved maturity of the plots. Individual collection dates were 25 July, 8 and 22 August, 5 and 19 September, 3 October, and 3 November. Clippings were taken 3 to 4 days following the fourth and eighth 0.0625 lb N/1000 $ft^2$ 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).

Root samples were taken twice during the 1997 growing season. Five one-inch diameter cores were removed from random locations on each plot at a depth of 6 inches. The roots were washed from the sand media using a screening technique. The extracted root material was dried at 78 °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.

Percentage cover data were taken throughout the duration of the research. One set of data was taken in the fall of 1996 and the remainder occurred in 1997. Ratings for percentage cover of grass were between 1 and 100%; where 1% = no grass and 100% = total grass coverage. Visual quality data rating density and color of each plot was taken in the fall of 1997. Quality was rated on a 1 to 9 scale: 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 tissue concentration between treatments were shown for phosphorus (P) and sulfur (S) (Table 1). The granular product (Treatment 6) provided significantly higher tissue P and S concentrations compared to the five liquid treatments. Tissue concentrations of the plants grown with the granular treatment were on average 18% and 10% higher for P and S, respectively, 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). P was not supplied to plots receiving the liquid treatments throughout the 1997 growing season.

Application frequency differences occurred for the macronutrients nitrogen (N), Phosphorus (P), and Sulfur (S) (Table 1). Tissue concentrations were 5%, 7%, and 5% higher for N, P, and S, respectively, in plots receiving 8 applications/month compared to those receiving 2 applications/month.

Treatment differences were shown for the following micronutrients: molybdenum (Mo), nickel (Ni), and zinc (Zn) (Table 2). The molasses product (Treatment 4) provided plants with the highest tissue Mo and Ni concentrations. Turfgrass grown on the granular treated plots had the lowest tissue Mo and Ni concentrations. Highest Zn concentrations for plants grown with the granular treatment were on average 20% higher than plants supplied with the liquid treatments.

The micronutrients Mo and Zn showed differences in application frequency (Table 2). Tissue concentrations were 8% and 7% higher for Mo and Zn, respectively in plots receiving 8 applications/month compared to the plots that received 2 applications/month.

A treatment effect developed between treatments for percentage turf cover (Table 3). Data taken 4 and 18 June 1997 showed a 28% average lower percentage turf cover value for grass grown on the plots treated with the granular material compared to the grass grown on plots receiving the liquid treatments. Turf coverage was initially slow because nutrients were not immediately available for plant uptake. The granular treatment was a slow release fertilizer containing 56% water insoluble nitrogen for sustained plant response. As nutrients were released for plant uptake, differences in percentage turf cover disappeared. A mean significant difference in percentage turf cover between treatments was shown for the 1997 growing season because of the slow development of grass plants supplied by the granular treatment early in the season. Application frequency did not have an effect on how quickly the grass developed on each plot (Table 3).

Visual quality data taken on 17 Oct. 1997 showed no differences among fertilizer treatments (Table 3). However, plots receiving 8 applications per month had an 8% better quality rating than plots receiving 2 applications/month. The average quality of turfgrass was highest on granular treated plots and lowest on plots receiving the 22% humic acid treatment.

No differences occurred between treatments or application frequency for root development of the grass plants (Table 3). A trend was shown where plants grown on plots treated with molasses had the highest dry root mass, but this was not a significant difference. Plots treated with the 6-0-0, with compost derived organic acids, had the lowest dry root mass.

## Conclusions

Consistent differences between the organic-based fertilizer products and the control, which contained no organic material, were not observed in the study. For quicker establishment of 'Crenshaw' creeping bentgrass, liquid fertilizers tended to work better than the granular fertilizer. However, quality was highest at the end of the growing season for plants treated with the granular product. Plants grown on plots treated with lighter, more frequent applications provided higher visual quality ratings. This could be attributed to the higher N, P, S, Mo, and Zn concentrations in tissue of plants grown on plots treated eight times per month compared to those treated only twice. Significant differences in root growth as affected by the treatments or application frequency did not occur in this study. Treatments and application frequency schedules will be resumed in the spring of 1998 to attain second year results.

## Treatment Protocol for the Bentgrass Establishment Trial 1996-1997

- **Objectives**

  -Compare the effects of five different combinations of soil conditioner fertilizers and control on the establishment of creeping bentgrass.

  -Compare the effects of two different application frequency schedules on the growth and development of creeping bentgrass.

- **Post Germination Treatments (1996)**

  -Weekly applications at a rate of 0.5lb N/1000 $ft^2$

  -Week 1- 1:1:1 N, P, & K

  -Weeks 2, 3, & 4- 2:0:1 N, P, & K

  -One 4-week cycle was completed in the fall of 1996

- **Post Germination Treatments (1997)**

  -Initial 1:1:1 treatment application with 0.5 lb N, 0.5 lb P, and 0.5 lb K/1000 $ft^2$

  -2:0:1 treatment applications were used for the remainder of the season

  -Half of the plots received one 0.5 lb N/1000 $ft^2$ application every two weeks (2 applications/month), the other half of the experimental plots received two 0.125 lb N/1000 $ft^2$ applications per week (8 applications/month)-These rates were used May 15 through July 18. On July 18 the application rates were reduced by one-half.

  -All experimental plots received 1.0 lb N/1000 $ft^2$ and 0.5 lb K/1000 $ft^2$ per month from May 15 to July 18.

  -Experimental plots received 0.5 lb N/1000 $ft^2$ and 0.25 lb K/1000 $ft^2$ per month from July 18 to end of the 1997 growing season.

- **1:1:1 Treatments (N,P,K)**

  *1:1:1 treatment applications were made on 15 September 1996, and 15 May 1997. These treatments contained phosphorus and were applied as a starter fertilizer.

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

- **2:0:1 Treatments (N,P,K)**

  *2:0:1 treatment applications were made 22 September through 6 October completing a four-week application cycle in 1996. The 2:0:1 treatments were resumed 15 May 1997 and were continued the entire 1997 growing season.

1. 22% *humic acid* ; $KNO_3$ as K source; remaining N from $NH_4NO_3$
2. 6-0-0 *w/compost derived organic acids* ; $KNO_3$ as K source; remaining N from $NH_4NO_3$
3. 15% *humic acid* ; $KNO_3$ as K source; remaining N from $NH_4NO_3$
4. 5-3-2 *w/molasses* ; $KNO_3$ as primary K source; remaining N from $NH_4NO_3$
5. (Control) $KNO_3$ as K source; remaining N from $NH_4NO_3$
6. 12-3-9 *granular* ground feather meal product

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

| Treatment[y] | Nitrogen (N) | Phosphorus (P) | Potassium (K) | Calcium (Ca) | Magnesium (Mg) | Sulfur (S) |
|---|---|---|---|---|---|---|
| | Macronutrients[z] | | | | | |
| | % of dry tissue | | | | | |
| 1 | 3.07 | 0.27b[w] | 1.64 | 0.86 | 0.40 | 0.22b |
| 2 | 3.02 | 0.26b | 1.61 | 0.93 | 0.42 | 0.21b |
| 3 | 3.16 | 0.28b | 1.70 | 0.82 | 0.39 | 0.22b |
| 4 | 3.09 | 0.28b | 1.66 | 0.84 | 0.39 | 0.22b |
| 5 | 3.06 | 0.27b | 1.65 | 0.86 | 0.40 | 0.21b |
| 6 | 3.18 | 0.33a | 1.71 | 0.92 | 0.42 | 0.24a |
| **Application Frequency** | | | | | | |
| 2 apps/month | 3.02b | 0.27b | 1.64 | 0.89 | 0.41 | 0.22b |
| 8 apps/month | 3.17a | 0.29a | 1.69 | 0.85 | 0.40 | 0.23a |
| **Anova[x] Prob > F** | | | | | | |
| Treatment | 0.2920 | 0.0002 | 0.4337 | 0.5202 | 0.4920 | 0.0054 |
| App. Freq. | 0.0022 | 0.0253 | 0.1210 | 0.3034 | 0.2215 | 0.0337 |
| Trt*App. Freq | 0.2540 | 0.2883 | 0.4189 | 0.5964 | 0.7605 | 0.0762 |

[z]Data shown are the mean of seven tissue collection dates during the 1997 growing season. Individual collection dates were 25 July, 8 and 22 August, 5 and 19 September, 3 October, and 3 November.
[y]2:0:1 (N,P,K) treatments are described on the Treatment Protocol page in this report.
[x]Significant differences occur at the $P \leq 0.05$ level.
[w]Mean separation within columns and parameters by Fisher's LSD, $P \leq 0.05$

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

| Treatment[y] | Boron (B) | Copper (Cu) | Iron (Fe) | Manganese (Mn) | Molybdenum (Mo) | Nickel (Ni) | Zinc (Zn) |
|---|---|---|---|---|---|---|---|
| | Micronutrients[z] | | | | | | |
| | $mg \cdot kg^{-1}$ | | | | | | |
| 1 | 7.20 | 8.99 | 220 | 138 | 2.84a[w] | 7.52a | 40.07b |
| 2 | 7.39 | 9.18 | 255 | 135 | 2.70b | 7.12b | 40.20b |
| 3 | 7.45 | 9.15 | 192 | 132 | 2.89a | 7.63a | 41.11b |
| 4 | 7.38 | 8.90 | 197 | 138 | 3.01a | 7.68a | 41.90b |
| 5 | 7.25 | 8.85 | 212 | 133 | 2.73b | 7.66a | 39.09b |
| 6 | 6.73 | 8.40 | 283 | 127 | 2.26c | 6.84b | 49.67a |
| **Application Frequency** | | | | | | | |
| 2 apps/month | 7.32 | 8.80 | 229 | 134 | 2.63b | 7.38 | 40.40b |
| 8 apps/month | 7.15 | 9.01 | 224 | 134 | 2.85a | 7.44 | 43.62a |
| **Anova[x] Prob > F** | | | | | | | |
| Treatment | 0.2465 | 0.2884 | 0.1795 | 0.5162 | 0.0001 | 0.0098 | 0.0001 |
| App. Freq. | 0.3445 | 0.3048 | 0.8316 | 0.9001 | 0.0012 | 0.6595 | 0.0009 |
| Trt*App. Freq | 0.9292 | 0.5393 | 0.2355 | 0.7057 | 0.1250 | 0.7526 | 0.0327 |

[z]Data shown are the mean of seven tissue collection dates during the 1997 growing season. Individual collection dates were 25 July, 8 and 22 August, 5 and 19 September, 3 October, and 3 November.
[y]2:0:1 (N,P,K) treatments are described on the Treatment Protocol page in this report.
[x]Significant differences occur at the $P \leq 0.05$ level.
[w]Mean separation within columns and parameters by Fisher's LSD, $P \leq 0.05$

**Table 3.** Percentage cover, quality, rooting data, and analysis of variance.

| Treatment[w] | % Cover[z] June 4 | June 18 | June 25 | July 11 | July 18 | July 24 | July 31 | Aug 15 | Sept 2 | Sept 9 | Mean | Quality[y] Oct 17 | Root 1[x] Aug 6 | Root 2[x] Nov 11 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 63.3a[u] | 73.3a | 75.0 | 69.2 | 71.7 | 81.7 | 85.0 | 87.5 | 91.5 | 94.5 | 79.3a | 5.5 | 0.3762 | 0.2852 | 0.3307 |
| 2 | 53.3b | 64.2a | 69.2 | 69.2 | 68.3 | 78.3 | 80.3 | 87.5 | 91.5 | 94.6 | 75.7a | 6.3 | 0.3458 | 0.2825 | 0.3142 |
| 3 | 65.0a | 72.5a | 75.8 | 71.7 | 74.2 | 79.2 | 84.2 | 85.8 | 93.7 | 94.5 | 79.7a | 5.7 | 0.4044 | 0.3038 | 0.3541 |
| 4 | 65.0a | 76.7a | 80.0 | 77.5 | 71.7 | 80.8 | 85.0 | 90.0 | 94.5 | 96.8 | 81.8a | 5.7 | 0.4330 | 0.3332 | 0.3831 |
| 5 | 56.6b | 65.8a | 70.0 | 71.7 | 68.3 | 75.8 | 82.5 | 86.5 | 92.1 | 93.0 | 76.3a | 6.0 | 0.3834 | 0.3148 | 0.3491 |
| 6 | 40.0c | 55.0b | 60.0 | 64.2 | 62.5 | 73.3 | 81.7 | 84.2 | 93.3 | 95.5 | 70.9b | 6.5 | 0.3184 | 0.3354 | 0.3253 |
| **Application Frequency** | | | | | | | | | | | | | | | |
| 2 apps/mo. | 56.1 | 65.3 | 70.6 | 69.2 | 68.3 | 76.9 | 80.8b | 85.3b | 91.5 | 94.1 | 75.8 | 5.7b | 0.3839 | 0.2989 | 0.3414 |
| 8 apps/mo. | 58.3 | 70.6 | 72.8 | 71.9 | 70.6 | 79.4 | 85.6a | 88.6a | 94.1 | 95.6 | 78.7 | 6.2a | 0.3698 | 0.3184 | 0.3441 |
| **Anova[v] Prob > F** | | | | | | | | | | | | | | | |
| Treatment | 0.0001 | 0.0247 | 0.1439 | 0.0717 | 0.1270 | 0.2036 | 0.5938 | 0.4421 | 0.9027 | 0.7354 | 0.0521 | 0.0955 | 0.1113 | 0.1224 | 0.1443 |
| App. Freq. | 0.3400 | 0.1559 | 0.6005 | 0.2420 | 0.3610 | 0.2309 | 0.0101 | 0.0523 | 0.1755 | 0.2770 | 0.1421 | 0.0213 | 0.5525 | 0.1438 | 0.8559 |
| Trt*App. Freq. | 0.2702 | 0.1667 | 0.4453 | 0.2714 | 0.9352 | 0.2388 | 0.5087 | 0.2272 | 0.5220 | 0.5556 | 0.2823 | 0.2090 | 0.9924 | 0.0544 | 0.9235 |

[z]Percentage cover ratings are between 1% and 100%: 1% = No grass; 100% = Total grass coverage.
[y]Quality (Density and Color) was rated on a 9 to 1 scale: 9 = highest quality, 1 = poorest quality.
[x]Root 1 and Root 2 represent two different root collection dates. The root masses are expressed in grams (g).
[w]2:0:1 (N,P,K) treatments are shown on the Treatment Protocol page in this report.
[v]Significance occurs at the $P \leq 0.05$ level.
[u]Mean separation within columns and parameters by Fisher's LSD, $P \leq 0.05$.

# 1991 Corn Gluten Meal Crabgrass Control Study - Year 7

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

A study screening corn gluten meal (CGM) for efficacy as a natural product herbicide and fertilizer in turf was begun in 1991 and has been continued on the same plot for seven consecutive years. It is being conducted at the Iowa State University Research Station north of Ames, IA. The experiment is located in an area of 'Parade' Kentucky bluegrass. The soil in this experimental area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.6% a pH of 7.1, 4.5 ppm P, and 101 ppm K.

The experimental design is a randomized complete block. Individual experimental plots are 5 x 5 ft with three replications. There are seven treatments including CGM at 20, 40, 60, 80, 100, and 120 lbs/1000 $ft^2$ and an untreated control (Table 1). Because corn gluten meal is 10% N, these rates are equivalent to 2, 4, 6, 8, 10, and 12 lb N/1000 $ft^2$. All treatments were made to the same plots as in previous years. The CGM was applied in a single, early spring preemergence application on April 18, 1997 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, and weed control. Visual turf quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst turf quality. Quality data were taken on June 5, June 25, July 21, July 30, and August 20 (Table 1).

Weed control was measured by either counting the number of plants or estimating the percentage cover per individual plot. Broadleaf species (dandelion and clover) and annual grasses (crabgrass) were surveyed. Data were taken for dandelion and clover on June 5, July 30, and August 20. Crabgrass data were taken on July 30 and August 20. Crabgrass germination was noted on June 6.

Data were analyzed with the Statistical Analysis System version 6.10 (SAS Institute, 1989) 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. Weed control data were converted to percentage reductions as compared with the untreated controls.

It was an unusually cool, dry, and windy spring. The usual greenup was more subtle this year. Bluegrass did not respond to CGM treatments as dramatically as in the past. The nitrogen response was slower and was not uniform within individual plots.

There was no phytotoxicity observed in the Kentucky bluegrass treated with CGM. Turf quality was significantly better in CGM treated bluegrass than the untreated control for the entire season (Table 1). The best quality was in turf receiving the highest level of CGM.

Crabgrass populations were low in the untreated controls because the dandelion and clover infestations were large and well established before crabgrass germination. Corn gluten meal at 40, 60, 80, 100, and 120 lb resulted in numerical reductions in the number of crabgrass plants as compared with the untreated control on August 2 (Table 2). Crabgrass reductions were lower in 1997 when compared with data over the previous six years (Table 5).

Percentage reductions of dandelion numbers and clover cover were similar to those found in previous years (Table 6). Treatment with CGM at all levels in 1997 except at 20 lb significantly reduced dandelion populations (Table 3). Clover cover was significantly reduced by all levels of CGM as compared with the untreated control (Table 4).

**Table 1.** Visual quality[1] of Kentucky bluegrass treated in the 1991 Corn Gluten Meal Weed Control Study.

| | Material | lbs CGM /1000 ft$^2$ | lbs N /1000 ft$^2$ | June 5 | June 25 | July 21 | July 30 | August 20 | Mean quality |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | 0 | 0 | 5 | 5 | 5 | 6 | 5 | 5 |
| 2 | Corn gluten meal | 20 | 2 | 6 | 6 | 6 | 7 | 6 | 6 |
| 3 | Corn gluten meal | 40 | 4 | 7 | 7 | 7 | 7 | 7 | 7 |
| 4 | Corn gluten meal | 60 | 6 | 8 | 7 | 8 | 7 | 7 | 8 |
| 5 | Corn gluten meal | 80 | 8 | 8 | 8 | 9 | 8 | 8 | 8 |
| 6 | Corn gluten meal | 100 | 10 | 8 | 8 | 9 | 8 | 8 | 8 |
| 7 | Corn gluten meal | 120 | 12 | 9 | 8 | 9 | 8 | 9 | 9 |
| | $LSD_{0.05}$ | | | 1 | 1 | 1 | NS | 1 | 1 |

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

**Table 2.** Number of crabgrass plants[1] in Kentucky bluegrass plots treated in the 1991 Corn Gluten Meal Weed Control Study.

| | | | Crabgrass counts | | | Percentage Reduction[2] | | |
|---|---|---|---|---|---|---|---|---|
| | Material | lbs CGM /1000 ft$^2$ | July 30 | Aug 20 | Mean | July 30 | Aug 20 | Mean |
| 1 | Untreated control | 0 | 2 | 7 | 5 | 0 | 0 | 0 |
| 2 | Corn gluten meal | 20 | 8 | 11 | 10 | 0 | 0 | 0 |
| 3 | Corn gluten meal | 40 | 1 | 1 | 1 | 67 | 82 | 79 |
| 4 | Corn gluten meal | 60 | 1 | 1 | 1 | 83 | 82 | 82 |
| 5 | Corn gluten meal | 80 | 2 | 2 | 2 | 0 | 73 | 54 |
| 6 | Corn gluten meal | 100 | 1 | 1 | 1 | 67 | 82 | 79 |
| 7 | Corn gluten meal | 120 | 1 | 1 | 1 | 67 | 86 | 82 |
| | $LSD_{0.05}$ | | NS | 6 | (P > 0.06) 6 | NS | NS | NS |

[1]These values represent the number of crabgrass plants per plot.
[2]These values represent percentage reductions in crabgrass plants per plot as compared with the untreated controls.
NS = means are not significantly different at the 0.05 level.

**Table 3.** Dandelion counts[1] in Kentucky bluegrass treated with corn gluten meal in the 1991 Corn Gluten Meal Weed Control Study.

| | Material | lbs N /1000 ft$^2$ | Dandelion numbers | | | | Percentage reduction[2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | June 5 | July 30 | Aug 20 | Mean | June 5 | July 30 | Aug 20 | Mean |
| 1. | Untreated control | 0 | 12 | 21 | 29 | 21 | 0 | 0 | 0 | 0 |
| 2. | Corn gluten meal | 2 | 8 | 10 | 29 | 16 | 31 | 51 | 2 | 24 |
| 3. | Corn gluten meal | 4 | 3 | 5 | 7 | 5 | 71 | 78 | 77 | 76 |
| 4. | Corn gluten meal | 6 | 2 | 2 | 6 | 3 | 80 | 91 | 81 | 84 |
| 5. | Corn gluten meal | 8 | 0 | 1 | 4 | 1 | 100 | 97 | 88 | 93 |
| 6. | Corn gluten meal | 10 | 1 | 1 | 6 | 2 | 94 | 98 | 78 | 88 |
| 7. | Corn gluten meal | 12 | 1 | 0 | 1 | 1 | 94 | 100 | 97 | 97 |
| | $LSD_{0.05}$ | | 8 | 12 | 20 | 13 | 68 | 56 | 68 | 61 |

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

**Table 4.** Percentage clover cover[1] and percentage reductions per plot[2] in Kentucky bluegrass in the 1991 Corn Gluten Meal Weed Control Study.

| | Material | lbs N /1000 ft$^2$ | Percentage clover cover (%)[1] | | | | Percentage cover reduction (%)[2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | June 5 | July 30 | Aug 20 | Mean | June 5 | July 30 | Aug 20 | Mean |
| 1 | Untreated control | 0 | 57 | 47 | 53 | 52 | 0 | 0 | 0 | 0 |
| 2 | Corn gluten meal | 2 | 25 | 22 | 12 | 19 | 56 | 54 | 78 | 63 |
| 3 | Corn gluten meal | 4 | 13 | 2 | 5 | 7 | 77 | 95 | 91 | 87 |
| 4 | Corn gluten meal | 6 | 2 | 3 | 2 | 3 | 96 | 93 | 96 | 95 |
| 5 | Corn gluten meal | 8 | 2 | 3 | 2 | 3 | 96 | 93 | 96 | 95 |
| 6 | Corn gluten meal | 10 | 10 | 14 | 14 | 13 | 82 | 70 | 74 | 76 |
| 7 | Corn gluten meal | 12 | 3 | 2 | 5 | 4 | 94 | 95 | 90 | 93 |
| | $LSD_{(0.05)}$ | | 12 | 20 | 15 | 14 | 21 | 42 | 28 | 27 |

[1]Percentage clover cover represents the area per plot covered by clover.
[2]These values represent the percentage reductions in clover cover per plot as compared with the untreated controls.

**Table 5.** Comparisons of the mean percentage crabgrass reductions[1] in Kentucky bluegrass in the 1991 Corn Gluten Meal Weed Control Study through 1997.

| | Material | lbs N /1000 ft² | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|---|---|
| | | | Percentage crabgrass reduction (%) | | | | | | |
| | | | % | | | | | | |
| 1 | Untreated control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Corn gluten meal | 2 | 58 | 85 | 91 | 70 | 36 | 15 | 0 |
| 3 | Corn gluten meal | 4 | 86 | 98 | 98 | 97 | 88 | 97 | 79 |
| 4 | Corn gluten meal | 6 | 97 | 98 | 93 | 98 | 93 | 85 | 82 |
| 5 | Corn gluten meal | 8 | 87 | 93 | 93 | 87 | 75 | 69 | 54 |
| 6 | Corn gluten meal | 10 | 79 | 94 | 95 | 86 | 75 | 87 | 79 |
| 7 | Corn gluten meal | 12 | 97 | 100 | 100 | 98 | 84 | 97 | 82 |
| | $LSD_{0.05}$ | | 26 | 44 | 31 | 39 | 40 | 60 | NS |

[1]These values represent the percentage reductions in crabgrass plants per plot as compared with the untreated controls.
NS = means are not significantly different at the 0.05 level.

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

| | Material | lbs N /1000 ft² | Percentage clover cover reduction (%)[3] | | | | Reduction in dandelion numbers[3] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1994 | 1995 | 1996 | 1997 | 1994 | 1995 | 1996 | 1997 |
| | | | % | | | | % | | | |
| 1 | Untreated control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Corn gluten meal | 2 | 81 | 56 | 71 | 63 | 71 | 49 | 33 | 24 |
| 3 | Corn gluten meal | 4 | 90 | 64 | 82 | 87 | 100 | 77 | 75 | 76 |
| 4 | Corn gluten meal | 6 | 98 | 93 | 93 | 95 | 100 | 89 | 79 | 84 |
| 5 | Corn gluten meal | 8 | 100 | 76 | 90 | 95 | 98 | 96 | 95 | 93 |
| 6 | Corn gluten meal | 10 | 94 | 84 | 92 | 76 | 100 | 98 | 96 | 88 |
| 7 | Corn gluten meal | 12 | 90 | 93 | 93 | 93 | 100 | 100 | 100 | 97 |
| | $LSD_{(0.05)}$ | | NS | 48 | 29 | 26 | 50 | 65 | 60 | 61 |

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

# 1995 Corn Gluten Meal Rate Weed Control Study - Year 3

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

Corn gluten meal (CGM) was screened for efficacy as a natural product herbicide in turf. This trial is a long-term study begun in 1995 that will be continued on the same area for several years. It is being conducted at the Iowa State University Horticulture Research Station north of Ames, IA. The experiment is in an area of '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 7.0, 3 ppm P, and 110 ppm K. The initial broadleaf weed population exceeded 50% cover on most of the test area.

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

Initial applications were made on April 18. The second application for treatment 2 was made on June 3, the third on July 30, and the final on September 5. Sequential application of treatment 3 was made on August 6.

The experimental plot was checked for phytotoxicity after applications. Visual quality was measured using a 9 to 1 scale: 9 = best and 6 = lowest acceptable, and 1 = worst quality (Table 1). Visual quality data were taken on May 21, June 5, June 10, June 18, July 2, July 21, July 30, and August 20. Crabgrass control was assessed by estimating the percentage crabgrass cover per individual plot on July 30 and by counting the number of plants per individual plot on August 20 (Table 2). Dandelion control was measured by estimating the percentage of area covered in each plot on June 5 and by counting the number of plants per plot on August 20 (Table 3). Clover control was recorded by estimating the percentage of area covered in each plot on June 5, July 30, and August 20 (Table 4). Weed control data were converted to express percentage reductions as compared with the untreated control (Tables 2, 3, and 4).

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

There were no phytotoxic symptoms detected on the treated bluegrass. Visual turf quality was significantly better in bluegrass treated with CGM than in the untreated control on each data collection date except July 21 (Table 1).

Broadleaf weed species were well established when the crabgrass was emerging especially in the untreated controls. Competition from the broadleaves and the mature turf probably prevented the establishment of large crabgrass populations within the untreated plots. Consequently crabgrass cover was low in the untreated turf. Corn gluten meal did cause numerical reduction in crabgrass cover as compared with the untreated control but the differences were not statistically different (Table 2).

Crabgrass numbers were decreased by CGM at 10 lb in four applications (treatment 2), by split applications at 20 lb (treatment 3), and by an initial 30 lb application followed by 10 lb (treatment 4) as compared with the untreated control (Table 3). There were more crabgrass plants in turf receiving an initial application of CGM at 40 lb (treatment 5) than in the untreated control. The level of control with CGM applied in split applications at 20 lb (treatment 3) was consistent for 1995, 1996, and 1997. In 1997, crabgrass control was better than 1995 and 1996 for CGM at 10 lb applied four times (treatment 2).

Percentage dandelion cover was reduced by all levels of CGM as compared with the untreated control (Table 4). In 1997, CGM at all levels except at 30 lb followed by 10 lb (treatment 4) provided ≥ 50% reductions in cover as compared with the untreated control. In 1996, the CGM at these rates provided ≥ 48% reductions.

Corn gluten meal at all levels reduced the number of dandelions as compared with the untreated control (Table 5). The best control was provided by CGM at 10 lb in four applications and CGM at 20 lb in split applications.

Percentage clover cover was significantly reduced by CGM at all levels as compared with the untreated control. Percentage reductions for 1997 were ≥ 64% in all treated turf. Clover control was better in 1997 than 1996 in turf treated with CGM at 10 lb in four applications and CGM at 20 lb in split applications (Table 7).

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

| Material | Rate (lb product/1000 $ft^2$) | May 21 | June 5 | June 10 | June 18 | July 2 | July 21 | July 30 | Aug 20 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Untreated control | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 2. Corn gluten meal | 10 fb 10 fb 10 fb 10 | 7 | 7 | 7 | 7 | 9 | 7 | 8 | 8 | 8 |
| 3. Corn gluten meal | 20 fb 20 | 8 | 8 | 8 | 7 | 8 | 7 | 7 | 8 | 8 |
| 4. Corn gluten meal | 30 fb 10 | 7 | 9 | 9 | 8 | 9 | 8 | 8 | 8 | 8 |
| 5. Corn gluten meal | 40 | 7 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 |
| $LSD_{0.05}$ | | 1 | 1 | 1 | 1 | 1 | NS | 1 | 2 | 1 |

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

**Table 2.** Percentage crabgrass cover per plot[1] in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study.

| Material | Rate (lb product/1000 $ft^2$) | Percentage crabgrass cover | Percentage cover reductions |
|---|---|---|---|
| | | % | % |
| 1. Untreated control | NA | 22 | 0 |
| 2. Corn gluten meal | 10 fb 10 fb 10 fb 10 | 10 | 54 |
| 3. Corn gluten meal | 20 fb 20 | 7 | 66 |
| 4. Corn gluten meal | 30 fb 10 | 9 | 60 |
| 5. Corn gluten meal | 40 | 17 | 22 |
| $LSD_{0.05}$ | | NS | NS |

[1]Percentage crabgrass cover data represent the area per plot covered by crabgrass.
[2]These values represent the percentage reduction in crabgrass cover per plot as compared with the untreated controls.
All treatments were at an annual rate of 4 lb N/1000 $ft^2$. Initial applications were made on April 18. The second application of treatment 2 was made on June 3, the third on July 30, and the final on September 5. The sequential application of treatment 3 was made on August 6.
NS = means are not significantly different at the 0.05 level.

**Table 3.** Crabgrass counts per plot[1] and percentage crabgrass reductions[2] in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study for 1995, 1996, and 1997.

| | Material | Rate (lb product/1000 ft$^2$) | 1995 Crabgrass reduction[2] | 1996 Crabgrass counts[1] | 1996 Crabgrass reduction[2] | 1997 Crabgrass counts[1] | 1997 Crabgrass reduction[2] |
|---|---|---|---|---|---|---|---|
| | | | % | | % | | % |
| 1. | Untreated control | NA | 0 | 4 | 0 | 36 | 0 |
| 2. | Corn gluten meal | 10 fb 10 fb 10 fb 10 | 28 | 7 | 0 | 19 | 48 |
| 3. | Corn gluten meal | 20 fb 20 | 45 | 3 | 33 | 18 | 50 |
| 4. | Corn gluten meal | 30 fb 10 | 44 | 1 | 67 | 14 | 61 |
| 5. | Corn gluten meal | 40 | 54 | 5 | 0 | 37 | 0 |
| | $LSD_{0.05}$ | | NS | NS | NS | NS | NS |

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

**Table 4.** Percentage dandelion cover per plot[1] and percentage dandelion cover reductions[2] in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study for 1996 and 1997.

| | Material | Rate (lb product/1000 ft$^2$) | 1996 Mean percentage cover | 1996 Percentage cover reductions | 1997 Percentage dandelion cover | 1997 Percentage cover reductions |
|---|---|---|---|---|---|---|
| | | | % | | % | |
| 1. | Untreated control | NA | 23 | 0 | 17 | 0 |
| 2. | Corn gluten meal | 10 fb 10 fb 10 fb 10 | 12 | 48 | 8 | 50 |
| 3. | Corn gluten meal | 20 fb 20 | 12 | 50 | 7 | 60 |
| 4. | Corn gluten meal | 30 fb 10 | 17 | 28 | 12 | 28 |
| 5. | Corn gluten meal | 40 | 12 | 50 | 7 | 58 |
| | $LSD_{0.05}$ | | NS | NS | NS | NS |

[1]Percentage dandelion cover data represent the area per plot covered by dandelions.
[2]These values represent the percentage reductions in dandelion numbers per plot as compared with the untreated control.
All treatments were at an annual rate of 4 lb N/1000 ft$^2$. Initial applications were made on April 18. The second application of treatment 2 was made on June 3, the third on July 30, and the final on September 5. The sequential application of treatment 3 was made on August 6.
NS = means are not significantly different at the 0.05 level

**Table 5.** Dandelion counts[1] and percentage dandelion reductions[2] in Kentucky bluegrass treated the 1995 Corn Gluten Meal Rate Weed Control Study.

| | Material | Rate (lb product/1000 $ft^2$) | Dandelion counts July 30 | Dandelion counts Aug 20 | Dandelion counts Mean | Percentage reduction (%) July 30 | Percentage reduction (%) Aug 20 | Percentage reduction (%) Mean |
|---|---|---|---|---|---|---|---|---|
| 1. | Untreated control | NA | 90 | 152 | 121 | 0 | 0 | 0 |
| 2. | Corn gluten meal | 10 fb 10 fb 10 fb 10 | 49 | 79 | 64 | 45 | 48 | 47 |
| 3. | Corn gluten meal | 20 fb 20 | 45 | 66 | 56 | 50 | 56 | 54 |
| 4. | Corn gluten meal | 30 fb 10 | 53 | 117 | 85 | 41 | 23 | 30 |
| 5. | Corn gluten meal | 40 | 60 | 103 | 82 | 33 | 33 | 33 |
| | $LSD_{0.05}$ | | NS | NS | NS | NS | NS | NS |

[1]Dandelion counts represent the number of plants per plot.
[2]These values represent the percentage reductions in dandelion numbers per plot as compared with the untreated control.

**Table 6.** Percent clover cover[1] and percentage clover reductions[2] in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study.

| | Material | Rate (lb product/1000 $ft^2$) | Percentage clover cover (%) June 5 | July 30 | Aug 20 | Mean | Percentage reductions in clover cover (%) June 5 | July 30 | Aug 20 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | % | | | | % | | | |
| 1. | Untreated control | NA | 42 | 35 | 38 | 38 | 0 | 0 | 0 | 0 |
| 2. | Corn gluten meal | 10 fb 10 fb 10 fb 10 | 17 | 10 | 13 | 14 | 59 | 70 | 65 | 64 |
| 3. | Corn gluten meal | 20 fb 20 | 10 | 5 | 6 | 7 | 75 | 85 | 85 | 81 |
| 4. | Corn gluten meal | 30 fb 10 | 5 | 1 | 4 | 7 | 88 | 97 | 90 | 92 |
| 5. | Corn gluten meal | 40 | 2 | 2 | 16 | 3 | 94 | 94 | 59 | 83 |
| | $LSD_{0.05}$ | | 27 (p > 0.06) | 24 | NS | 22 | 27 (p > 0.06) | 67 | NS | 58 |

[1]Percentage cover represents the area per plot covered by clover.
[2]These figures represent the reductions in clover cover per plot as compared with the untreated control.
All treatments were at an annual rate of 4 lb N/1000 $ft^2$. Initial applications were made on April 18. The second application of treatment 2 was made on June 3, the third on July 30, and the final on September 5. The sequential application of treatment 3 was made on August 6.
NS = means are not significantly different at the 0.05 level.

**Table 7.** Comparisons of the percentage clover cover[1] and percentage clover reductions[2] in Kentucky bluegrass treated in the 1995 Corn Gluten Meal Rate Weed Control Study for 1996 and 1997.

| | Material | Rate (lb product/1000 $ft^2$) | 1996 Mean clover cover[1] | 1996 Percentage cover reduction[2] | 1997 Mean clover cover[1] | 1997 Percentage cover reduction[2] |
|---|---|---|---|---|---|---|
| | | | % | | % | |
| 1. | Untreated control | NA | 20 | 0 | 40 | 0 |
| 2. | Corn gluten meal | 10 fb 10 fb 10 fb 10 | 11 | 45 | 14 | 65 |
| 3. | Corn gluten meal | 20 fb 20 | 6 | 69 | 7 | 82 |
| 4. | Corn gluten meal | 30 fb 10 | 3 | 90 | 7 | 92 |
| 5. | Corn gluten meal | 40 | 2 | 92 | 3 | 83 |
| | $LSD_{0.05}$ | | NS | NS | 22 | 58 |

[1]Percentage clover cover data represent the area per plot covered by clover.
[2]These values represent the percentage reduction in clover cover per plot as compared with the untreated controls.

# 1995 Corn Gluten Hydrolysate Weed Control Study - Year 3

*Barbara R. Bingaman, Nick E. Christians, and Michael B. Faust*

Corn gluten hydrolysate (CGH) was screened for efficacy as a natural herbicide in turf. This trial is a long-term study started in 1995 that will be continued in the same experimental area for several years. It is being conducted at the Iowa State University Research Station north of Ames, IA. The experiment is located in an area of 'Ram 1' Kentucky bluegrass. The soil in this area is a Nicollet (fine-loamy, mixed, mesic Aquic Hapludoll) with an organic matter content of 3.7% a pH of 7.1, 5 ppm P, and 100 ppm K.

The experimental design is a randomized complete block. Individual experimental plots are 5 x 5 ft with three replications. There are 3-ft barrier rows between replications. Corn gluten hydrolysate was applied at 5, 10, 15, and 20 lbs product/1000 $ft^2$ (Table 1). These rates translate to 0.5, 1.0, 1.5, and 2.0 lbs N/1000 $ft^2$. The CGH was dissolved in water and the volumes applied were 700, 1400, 2100, and 2800 ml for the 5, 10, 15, and 20 lb rates, respectively. An untreated control was included for comparisons. A liquid seaweed foliar feeding product (0.2-0-1), RL-37, from International Ag Labs, Inc. was applied to the south half of the plots in replication 1 at 3 oz product/1000 $ft^2$. This product is supposed to stabilize the CGH and prolong the CGH effects. The CGH was applied at 20 psi using a carbon dioxide backpack sprayer equipped with TeeJet™ #8006 flat fan nozzles.

All treated plots received a single application on May 9. A wind barrier was used as a windbreak to prevent sprayer drift. The treatments were watered in with irrigation. Supplemental irrigation was used throughout the season to maintain the grass in good growing condition.

Visual quality data were taken on May 21, June 5, June 10, June 18, July 21, July 30, and August 20. Visual quality was measured using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality (Table 1). Weed populations were very high especially in the untreated controls. The percentage of area per plot covered by all weed species was estimated on May 12 and June 5 (Table 2). On July 30, the percentage of area per plot covered by broadleaf weed species was determined (Table 2). Crabgrass control was assessed by counting the number of crabgrass plants per plot on July 30 and August 20 (Table 3). In addition, weed control data were taken on August 20 for dandelion, clover, and black medic. The number of dandelion plants per plot were counted and the percentages of clover and black medic cover were estimated per plot (Table 4).

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

No phytotoxic symptoms were detected in any of the treated plots. Turf quality was improved by CGH as compared with the untreated control plots through July 30. By August 20, there were no differences in quality between the treated and untreated turf.

Total weed populations were not significantly reduced by CGH (Table 2). On some of the data collection dates, weed cover was higher in bluegrass treated with CGH than in the untreated control. The majority of the weed cover was dandelion and clover.

Crabgrass populations were reduced by CGH as compared with the untreated control (Table 3). The higher rates of CGH provided the best control.

Corn gluten hydrolysate at 10, 15, and 20 lb caused numerical reductions in the number of dandelions per plot but the reductions were not statistically significant (Table 4). There were more dandelions in turf treated with CGH at 5 lb than in the untreated control. Percentage clover cover was not reduced by CGH. The percentage cover in all CGH treated turf was equal to or greater than the cover in the untreated control. Black medic cover was numerically reduced by CGH at 15 and 20 lb but the differences as compared to the untreated control and the other treated turf were not statistically significant. There was more black medic in turf treated with CGH at 5 and 10 lb than in the untreated control.

**Table 1.** Visual quality[1] of Kentucky bluegrass in the 1995 Corn Gluten Hydrolysate Weed Control Study.

| | | Rate lb/1000 ft² | May 21 | June 5 | June 10 | June 18 | July 21[2] | July 30 | Aug 20 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Untreated control | NA | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 2 | CGH | 5 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 3 | CGH | 10 | 7 | 8 | 7 | 7 | 7 | 7 | 6 | 7 |
| 4 | CGH | 15 | 7 | 8 | 9 | 8 | 7 | 8 | 6 | 8 |
| 5 | CGH | 20 | 8 | 8 | 8 | 8 | 7 | 8 | 6 | 8 |
| | $LSD_{0.05}$ | | 1 | 1 | 1 | 1 | 1 | 1 | NS | 1 |

[1]Visual quality was assessed using a 9 to 1 scale: 9 = best, 6 = lowest acceptable, and 1 = worst quality.
[2]Means are significantly different at the 0.07 level.
NS = means are not significantly different at the 0.05 level.

**Table 2.** Percentage total weed cover[1] and percentage broadleaf weed cover[2] in Kentucky bluegrass in the 1995 Corn Gluten Hydrolysate Weed Control Study.

| | | Rate lb/1000 ft² | Percentage weed cover: May 12 | Percentage weed cover: June 5 | Percentage weed cover: Mean | Percentage broadleaf cover: July 30 |
|---|---|---|---|---|---|---|
| | | | % | % | % | % |
| 1 | Untreated control | NA | 62 | 70 | 66 | 23 |
| 2 | CGH | 5 | 60 | 75 | 68 | 37 |
| 3 | CGH | 10 | 47 | 62 | 54 | 32 |
| 4 | CGH | 15 | 43 | 62 | 53 | 15 |
| 5 | CGH | 20 | 60 | 62 | 61 | 38 |
| | $LSD_{0.05}$ | | NS | NS | NS | NS |

[1] These figures represent the total percentage area per plot covered by all weed species.
[2]These figures represent the percentage are per plot covered by broadleaf weed species.
NS = Means are not significantly different at the 0.05 level.

**Table 3.** Crabgrass counts[1] in Kentucky bluegrass in the 1995 Corn Gluten Hydrolysate Weed Control Study.

| | | Rate lb/1000 ft² | Crabgrass counts: July 30 | Crabgrass counts: August 20 | Crabgrass counts: Mean |
|---|---|---|---|---|---|
| 1 | Untreated control | NA | 20 | 27 | 24 |
| 2 | CGH | 5 | 12 | 20 | 16 |
| 3 | CGH | 10 | 4 | 10 | 8 |
| 4 | CGH | 15 | 2 | 13 | 7 |
| 5 | CGH | 20 | 4 | 4 | 4 |
| | $LSD_{0.05}$ | | 10 | 10 | 8 |

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

**Table 4.** Dandelion counts, percentage clover cover, and percentage black medic cover[1] in Kentucky bluegrass in the 1995 Corn Gluten Hydrolysate Weed Control Study.

| | | Rate lb/1000 ft² | Dandelion count | Clover cover | Black medic cover |
|---|---|---|---|---|---|
| | | | | % | % |
| 1 | Untreated control | NA | 76 | 13 | 7 |
| 2 | CGH | 5 | 96 | 15 | 12 |
| 3 | CGH | 10 | 64 | 15 | 12 |
| 4 | CGH | 15 | 60 | 13 | 1 |
| 5 | CGH | 20 | 61 | 17 | 4 |
| | $LSD_{0.05}$ | | NS | NS | NS |

[1]These figures represent the number of dandelions per plot and the percentage area per plot covered by clover and black medic.
NS = Means are not significantly different at the 0.05 level.

# Carriers for Corn Gluten Hydrolysate

*Melissa C. McDade and Nick E. Christians*

Corn gluten hydrolysate (CGH) is an effective natural preemergent control in growth chamber and greenhouse environments. The use of a carrier is being considered to stabilize the hydrolysate and improve its activity in a field situation. Two possible carriers for the 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). The humic acid is thought to bind with the CGH particles to slow degradation, while the oil is mixed with the solution of CGH and water to encapsulate droplets of the solution, slowing its dispersal and degradation in the soil.

This study is taking place at the Iowa State University Horticulture Research Station north of Ames, Iowa. It is located in an area which has a mature stand of Kentucky bluegrass.

Three rates of CGH, three rates of humic acid, and three rates of oil are being used along with an untreated control for each factor. The experiment is set up in a factorial design with the treatments randomized in each of three replications. Each individual plot measures 5'x 5'. The rates used in this experiment are based on previously effective rates of the CGH and suggested rates for both the humic acid and the oil. The rates being used are:

| CGH | Humic Acid | SprayTech Oil |
|---|---|---|
| 0 lbs/1000ft$^2$ | 0 gal/acre | 0 pts/acre |
| 10 lbs/1000ft$^2$ | 1 gal/acre | 0.5 pts/acre |
| 20 lbs/1000ft$^2$ | 2 gal/acre | 1 pts/acre |
| 40 lbs/1000ft$^2$ | 4 gal/acre | 2 pts/acre |

Treatments were sprayed onto the plots in May. The study area is irrigated as needed to provide a good growing condition for the turf.

Weed control will be determined by collecting data on percent cover of broadleaf and grass weeds during the season. Visual quality will also be assessed during the season using a 9 to 1 scale: 9 = best quality, 6 = lowest acceptable quality, 1 = poorest quality.

Analysis of data will utilize the Statistical Analysis System version 6.12 (SAS Institute, 1989-1996).

This study is ongoing and full data will be available in the 1999 Turfgrass Report.

# Evaluating Turfgrass Species for Use Over Buried Steam Lines 1996-98

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

This two-year study was initiated in the summer of 1996 to evaluate the performance of various grass species planted in an area with elevated soil temperatures above a steam line. The 16-inch diameter steam line has 3.5 inches of 400° F insulation and is buried 3.5 ft below the surface. The 400° F steam temperature has produced summer soil temperatures of 120° F at the 12-inch depth. The performance of both warm and cool season grasses was monitored over a two-year period. Kentucky bluegrass, perennial ryegrass, tall fescue, and combinations of these species represent the cool season species. Three warm season species; zoysiagrass, bermudagrass, and buffalograss, were used alone and in combination with cool season species. A total of 18 different grass combinations were planted in the summer of 1996 from either seed or sod. In addition three cultivars, J-554, J-36, and J-37, were added in nonreplicated plots.

The design of this trial was a randomized complete block with three replications. The experiment was situated in a 320 x 10 ft area above a buried steam tunnel on the intramural recreational facility of the ISU campus. Individual plot size was 5 x 10 ft and three replications were included. The individual plots were placed perpendicular to the length of the steam line so that the middle of each plot was directly over the steam line and received higher temperatures than either the east or west section of each plot.

Turf establishment was assessed by rating visual quality, turf color, and percentage green cover. The initial ratings were taken on October 10, 1996. Additional data were taken in 1997 on April 3 and May 3 and in 1998 on March 25. Visual quality was assessed using a 10 to 1 scale: 10 = best quality, 6 = lowest acceptable quality, and 1 = worst quality (Table 1). Brown or dormant turf was considered a negative aspect of overall turf quality. Therefore, winter dormant warm season grasses received lower turf quality scores based primarily on poor turf color. Turf color was evaluated using a 9 to 1 scale: 9 = best color and 1 = worst color (Table 2). Percentage green turf cover represents the area per plot covered by green turf (Table 3).

Soil temperatures were taken in 1996, 1997, and 1998 directly over the steam line and in the center of each plot. Temperature was measured at the 2-, 6-, and 12-inch depths (Tables 4, 5, and 6).

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

**Table 1.** Visual turf quality of grass species established for the 1996-98 Steam Tunnel Turf Cultivar Study.

| | Grass Type | Started from sod | Started from seed | Oct 1996 | April 1997 | May 1997 | Mean |
|---|---|---|---|---|---|---|---|
| 1 | Perennial ryegrass | | X | 7 | 5 | 6 | 6 |
| 2 | Kentucky bluegrass | X | | 10 | 7 | 8 | 8 |
| 3 | Tall fescue | X | | – | – | – | – |
| 4 | Kentucky bluegrass + p. ryegrass | | X | 4 | 6 | 7 | 5 |
| 5 | Tall fescue + K. bluegrass | | X | 3 | 4 | 5 | 4 |
| 6 | Zoysiagrass | X | | 10 | 5 | 2 | 6 |
| 7 | Zoysiagrass + tall fescue/K. bluegrass | X | X | 10 | 5 | 2 | 6 |
| 8 | Buffalograss | X | | 10 | 5 | 5 | 7 |
| 9 | Buffalograss + K. bluegrass/p. ryegrass | X | X | 10 | 5 | 5 | 7 |
| 10 | Bermudagrass | X | | 9 | 5 | 4 | 6 |
| 11 | Bermudagrass + K. bluegrass/p. ryegrass | X | X | 9 | 5 | 4 | 6 |
| 12 | Zoysiagrass | | X | 2 | 1 | 1 | 1 |
| 13 | Bermudagrass | | X | 5 | 1 | 1 | 2 |
| 14 | Buffalograss | | X | 5 | 1 | 3 | 3 |
| 15 | Zoysiagrass + tall fescue/K. bluegrass | | X | 2 | 1 | 1 | 1 |
| 16 | Bermudagrass +K bluegrass/p. ryegrass | | X | 5 | 1 | 1 | 3 |
| 17 | Buffalograss + K. bluegrass/p. ryegrass | | X | 5 | 1 | 3 | 3 |
| 18 | Tolf Bermudagrass | | X | 4 | 1 | 1 | 2 |
| | LSD$_{0.05}$ | | | 1 | 1 | 1 | 1 |

[1]Turf quality was assessed using a 10 to 1 scale: 10 = best, 6 = lowest acceptable, and 1 = worst quality.
[2]These grasses were not replicated, they were planted in Rep 2 only. Data from these treatments were not included in the analyses.

**Table 2.** Color of grass species established for the 1996-98 Steam Tunnel Turf Cultivar Study.

| | Grass Type | Started from sod | Started from seed | Oct 1996 | April 1997 | May 1997 | March 1998 | Mean |
|---|---|---|---|---|---|---|---|---|
| 1 | Perennial ryegrass | | X | 9 | 7 | 8 | 7 | 8 |
| 2 | Kentucky bluegrass | X | | 9 | 8 | 8 | 8 | 8 |
| 3 | Tall fescue | X | | – | – | – | – | – |
| 4 | Kentucky bluegrass + p. ryegrass | | X | 9 | 7 | 8 | 7 | 8 |
| 5 | Tall fescue + K. bluegrass | | X | 9 | 8 | 7 | 7 | 8 |
| 6 | Zoysiagrass | X | | 9 | 1 | 2 | 1 | 3 |
| 7 | Zoysiagrass + tall fescue/K. bluegrass | X | X | 9 | 1 | 2 | 1 | 3 |
| 8 | Buffalograss | X | | 9 | 1 | 5 | 1 | 4 |
| 9 | Buffalograss + K. bluegrass/p. ryegrass | X | X | 9 | 1 | 5 | 1 | 4 |
| 10 | Bermudagrass | X | | 9 | 1 | 5 | 1 | 4 |
| 11 | Bermudagrass + K. bluegrass/p. ryegrass | X | X | 9 | 1 | 5 | 1 | 4 |
| 12 | Zoysiagrass | | X | 8 | 1 | 1 | 1 | 3 |
| 13 | Bermudagrass | | X | 9 | 1 | 1 | 1 | 3 |
| 14 | Buffalograss | | X | 8 | 2 | 3 | 1 | 3 |
| 15 | Zoysiagrass + tall fescue/K. bluegrass | | X | 8 | 1 | 1 | 1 | 3 |
| 16 | Bermudagrass +K bluegrass/p. ryegrass | | X | 9 | 2 | 1 | 1 | 3 |
| 17 | Buffalograss + K. bluegrass/p. ryegrass | | X | 8 | 2 | 3 | 1 | 4 |
| 18 | Tolf Bermudagrass | | X | 9 | 1 | 2 | 1 | 3 |
| | LSD$_{0.05}$ | | | 0.2 | 1 | 1 | 1 | 0.4 |

[1]Turf color was assessed using a 10 to 1 scale: 10 = best, 6 = lowest acceptable, and 1 = worst color.
[2]These treatments were not replicated, they were in Rep 2 only. Data for these treatments were not included in the analyses.

**Table 3.** Percentage turf cover in plots established for the 1996-98 Steam Tunnel Turf Cultivar Study.

| | Grass Type | Started from sod | Started from seed | Oct 1996 | April 1997 | May 1997 | March 1998 | Mean |
|---|---|---|---|---|---|---|---|---|
| | | | | % | | | | |
| 1 | Perennial ryegrass | | X | 78 | 63 | 72 | 45 | 65 |
| 2 | Kentucky bluegrass | X | | 100 | 90 | 93 | 40 | 81 |
| 3 | Tall fescue | X | | – | – | – | – | – |
| 4 | Kentucky bluegrass + p. ryegrass | | X | 40 | 80 | 77 | 33 | 58 |
| 5 | Tall fescue + K. bluegrass | | X | 28 | 53 | 55 | 40 | 44 |
| 6 | Zoysiagrass | X | | 100 | 3 | 100 | 37 | 60 |
| 7 | Zoysiagrass + tall fescue/K. bluegrass | X | X | 100 | 3 | 100 | 35 | 60 |
| 8 | Buffalograss | X | | 100 | 5 | 100 | 98 | 76 |
| 9 | Buffalograss + K. bluegrass/p. ryegrass | X | X | 100 | 5 | 100 | 98 | 76 |
| 10 | Bermudagrass | X | | 100 | 10 | 100 | 100 | 78 |
| 11 | Bermudagrass + K. bluegrass/p. ryegrass | X | X | 100 | 10 | 100 | 98 | 77 |
| 12 | Zoysiagrass | | X | 5 | 2 | 2 | 82 | 23 |
| 13 | Bermudagrass | | X | 60 | 2 | 4 | 85 | 38 |
| 14 | Buffalograss | | X | 57 | 2 | 48 | 97 | 51 |
| 15 | Zoysiagrass + tall fescue/K. bluegrass | | X | 5 | 2 | 2 | 48 | 14 |
| 16 | Bermudagrass +K bluegrass/p. ryegrass | | X | 63 | 5 | 11 | 83 | 41 |
| 17 | Buffalograss + K. bluegrass/p. ryegrass | | X | 57 | 7 | 67 | 88 | 55 |
| 18 | Tolf Bermudagrass | | X | 33 | 2 | 9 | 85 | 32 |
| | $LSD_{0.05}$ | | | 12 | 13 | 14 | 33 | 12 |

[1]Percentage turf cover was assessed as the area per plot covered by grass.
[2]These treatments were not replicated, they were in Rep 2 only. Data for these treatments were not included in the analyses.

**Table 4.** Soil temperatures (F°) at 2-inch depth for selected grass species included in the1996-98 Steam Tunnel Turf Cultivar Study.

| | Grass Type | October 1996 | March 1997 | April 1997 | December 1997 | March 1998 | Mean |
|---|---|---|---|---|---|---|---|
| | | F° | | | | | |
| 2 | Kentucky bluegrass | 74 | 56 | 72 | 57 | 57 | 61 |
| 4 | Kentucky bluegrass + p. ryegrass | 72 | 53 | 72 | 53 | 56 | 59 |
| 5 | Tall fescue + K. bluegrass | 73 | 53 | 72 | 56 | 56 | 59 |
| 6 | Zoysiagrass | 81 | 61 | 73 | 59 | 56 | 62 |
| 8 | Buffalograss | 78 | 58 | 73 | 63 | 61 | 64 |
| 10 | Bermudagrass | 75 | 56 | 73 | 61 | 61 | 63 |
| | $LSD_{0.05}$ | 6 | 3 | NS | 6 | 1 | 2 |

**Table 5.** Soil temperatures (F°) at 6-inch depth for selected grass species included in the1996-98 Steam Tunnel Turf Cultivar Study.

| | Grass Type | October 1996 | March 1997 | April 1997 | December 1997 | March 1998 | Mean |
|---|---|---|---|---|---|---|---|
| | | F° | | | | | |
| 2 | Kentucky bluegrass | 82 | 63 | 74 | 64 | 60 | 65 |
| 4 | Kentucky bluegrass + p. ryegrass | 78 | 58 | 73 | 60 | 57 | 62 |
| 5 | Tall fescue + K. bluegrass | 78 | 57 | 72 | 63 | 58 | 63 |
| 6 | Zoysiagrass | 88 | 67 | 75 | 67 | 59 | 67 |
| 8 | Buffalograss | 86 | 64 | 75 | 69 | 64 | 68 |
| 10 | Bermudagrass | 84 | 63 | 74 | 69 | 65 | 68 |
| | $LSD_{0.05}$ | 7 | 4 | NS | 6 | 2 | 2 |

**Table 6.** Soil temperatures (F°) at 12-inch depth for selected grass species included in the1996-98 Steam Tunnel Turf Cultivar Study.

| | Grass Type | October 1996 | March 1997 | April 1997 | December 1997 | March 1998 | Mean |
|---|---|---|---|---|---|---|---|
| | | F° | | | | | |
| 2 | Kentucky bluegrass | 93 | 67 | 76 | 72 | 66 | 70 |
| 4 | Kentucky bluegrass + p. ryegrass | 85 | 62 | 76 | 69 | 66 | 68 |
| 5 | Tall fescue + K. bluegrass | 85 | 62 | 73 | 72 | 67 | 69 |
| 6 | Zoysiagrass | 93 | 70 | 77 | 76 | 68 | 73 |
| 8 | Buffalograss | — | 69 | 77 | 78 | 72 | 74 |
| 10 | Bermudagrass | 95 | 68 | 77 | 77 | 72 | 74 |
| | $LSD_{0.05}$ | 5 | 5 | NS | 6 | 2 | 3 |

# Rubber Tire Particles as a Topdressing Amendment for Intensely Trafficked Grass - 1996-97 data

*Jeffrey J. Salmond and David D. Minner*

The U.S. discards about 250 million tires a year. The rubber tire recycling industry produces several grades, sizes, and shapes of processed rubber. All recycled rubber is not the same. Suitable materials for athletic field use must be free of all metal fibers and slivers, and must be a size that is compatible with hollow coring and can easily filter into the turf canopy. Some rubber particles may contain nylon strands from "cord reinforced tires". It is doubtful that the nylon will limit plant growth; however, the effect of the nylon on water retention and plant growth is not known. To ensure a consistent rubber product only a trace of nylon should be present.

Two recycled tire products for turfgrass use are crumb and buffing rubber. Crumb rubber is derived from chipping whole tires and is available in screened particle sizes ranging from 2 to 50 mm. The rubber must be screened to remove the metal and nylon cords. Buffing rubber comes from the retread industry, and it originates when tire treads are ground before being recapped. Little effort has been made to commercially produce screened buffing rubber due to the declining number of markets for passenger retreads (U.S. EPA and PES, 1993). Buffing rubber has no metal or nylon because only the tread is recycled. Particles range from 0.25 to 50 mm. Smaller particles are rounded. However, many particles are shreds that have a length-to-width ratio of approximately 7:1.

*Materials*. Experiments were conducted in 1996 and 1997 at the Iowa State University Horticulture Research Station north of Ames, Iowa, on a mature stand of Kentucky bluegrass. The soil was a Nicolett series (fine-loamy, mixed, mesic Aquic Hapludoll) with a pH of 6.8. On 6 May 1995, before treatment with rubber, the plot was mowed at 1.5 cm, solid-tine core aerified, and topdressed with ten treatments. The topdressing treatments were two types and two depths of crumb rubber, two types and two depths of buffings rubber, sand, and an untreated control. The size description of rubber particles is generally expressed by two sieve numbers. For example, a 10/20 mesh rubber indicates that the rubber passes through a 10 mesh U.S. Tyler sieve and is retained on a 20 mesh U.S. Tyler sieve. The rubber treatments consist of a coarse crumb and medium crumb size, and a coarse buffing and medium buffing size (Table 1). The rubber treatments were topdressed at depths of 1 cm and 2 cm. The sand was topdressed at 2 cm and was 92% 35/100 mesh (Table 1). The treatments were arranged in a randomized complete block design. Each treatment was replicated three times. Overall plot size was 27.5 m x 2.4 m, and the individual plots measured 1.2 m x 1.8 m (4 ft. x 6 ft.). The thirty individual plots were split into two rows along the long axis, so that the traffic treatments could be applied uniformly. The overall plot received 146.7 kg $N \cdot ha^{-1}$ per year and was not supplied with supplemental irrigation during the traffic periods.

*Traffic and evaluations*. The Brouwer Traffic Simulator (Brouwer Co., Dalton, Ohio) was used to supply differential-slip type traffic on 0.3-m (1 ft.) centers across the plots. The double-roller, traffic simulator was equipped with 1.5-cm football cleats. The width of each roller was 0.6-m. Traffic was applied on each Monday, Wednesday, and Friday from 31 Mar. through 21 June 1996, to simulate spring athletic activity. This traffic period was followed by a summer no-traffic period for turfgrass recovery, from 21 June to 14 Aug. Traffic resumed on 14 Aug. through 8 Nov., to simulate fall athletic activity. This traffic period was followed by a winter no-traffic period for turfgrass recovery, 8 Nov. 1996 through 31 Mar. 1997, before a new traffic period was to begin. Treatments for a second season resumed on 31 Mar. to 7 June for spring traffic, 7 June through 20 Aug. for spring recovery, 20 Aug. through 20 Nov. for fall traffic, and 20 Nov. 1997 through 31 Mar. 1998 for fall recovery. Assessments of fall recovery were made on 31 Mar. 1998. An average of six passes were performed each traffic day. A pass consisted of driving the simulator down the length of the overall plot along 0.3-m centers over the width of the overall plot. The plots were evaluated after traffic treatments and recovery periods for quality, density, color, percentage living turfgrass cover, percentage topdressing visible, and surface hardness. One traction assessment was taken on 15 May 1997.

*Quality, density, and color.* Turfgrass quality and density were rated visually on a scale of 1 to 10, where 1 represented the poorest, 6 represented the lowest acceptable, and 10 represented the best for each parameter. Turfgrass color was rated also on a scale of 1 to 10, where 1 represented unresponsive turf (yellow or brown), 6 represented the lowest acceptable color, and 10 represented a dark green color. Turf quality is an overall visual rating of turf color, density, and texture. Turf density and retention of a vegetative mat or thatch were considered more important than color when rating turf quality of treatments that received traffic. Turf density was a visual estimate of plants per individual plot area. Traffic tolerance was assessed by visually estimating quality and percentage turfgrass cover.

*Turf cover and percentage topdressing showing.* Throughout the traffic and recovery periods, percentages of the following were observed: living turf cover, rubber or sand topdressing, and bare soil. Percentage living turfgrass cover is the most important parameter for evaluating the detrimental effects of traffic on athletic turf. Following traffic treatments, turf begins to decline and the underlying materials, bare soil, sand, or rubber, become visible. The percentage cover values estimate how much grass, bare soil, sand, or rubber is visible on the surface. Treatments with a high percentage of turf cover and low percentage of bare soil, sand, or rubber topdressing visible are more desirable.

*Surface hardness and soil moisture.* Surface hardness was measured by using a portable drop-hammer apparatus described by Rogers and Waddington (1990). The 0.5 and 2.25-kg hammers, each with a length of 0.67 m and a missile diameter of 5 cm, were used. Each hammer was fitted with a Brüel and Kjær Model #4393-1639904 accelerometer (Brüel and Kjær, Decatur, Ga.). The hammers were dropped from a height of 45.5 cm through a 5.5 cm diameter PVC tube. An accelerometer is mounted inside the hammer. Upon impact, the accelerometer measures the negative acceleration (deceleration, $g$ ) of the hammer. A Brüel and Kjær 2515 Vibration Analyzer was used to record the impact measurements generated from the accelerometer. A harder, less resilient surface is indicated by a higher $g_{max}$ (peak deceleration) value. Five individual drops were taken in different locations within each plot, averaged, and stored in the vibration analyzer. Gravimetric soil moisture was measured on two core samples each time hardness was measured.

*Traction.* Traction measurements, recorded in torque (N·m), were taken with a studded torque wrench device developed by Canaway and Bell (1986). The apparatus was equipped with 45 kg of weight (100 lbs) and dropped from a height of 5 cm. Traction was estimated as the amount of torque required to tear the underlying sod. Three traction assessments were made within each individual plot on 15 May 1997.

*Statistical Analyses.* The Statistical Analysis System version 6.06 (SAS Institute, 1990) 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 visual quality, density, color, percent turf cover, and percent topdressing showing (Tables 2). LSD means comparisons were also made to test between treatments effects on surface hardness (g-max) (Table 2).

*Quality, density, and color.* The 2-cm depth of medium buffings rubber provided the best overall visual quality (7.7) and density (7.6) for all the treatments (Table 2). The 2-cm depth of medium crumb rubber compared with the all crumb materials resulted in the best quality (7.0) and density (6.8). We did not find any significant differences in color. A positive correlation ($R^2$ = 0.94) existed between turf quality and turf density. Results for turf density were similar to those found for turf quality. The sand treatment, coarse crumb rubber at the 2-cm depth, and coarse buffing rubber at the

1-cm depth did not increase the quality or density of turfgrass. The untreated control did not improve quality and density, and the coarse crumb rubber at the 1-cm depth and the medium crumb rubber at the 1-cm depth were considered unacceptable for quality and density. No differences were found for quality and density between the control and the 1-cm depth of coarse crumb rubber.

*Turf cover and percentage topdressing showing*. The 2-cm depth of medium buffings was the best treatment in providing turfgrass cover (87.7%)(Table 2). However, the 2-cm depth of medium buffings rubber showed the least topdressing on the surface (10.2%)(Table 2). The 2-cm depth of medium crumb rubber provided the best cover and least percentage of topdressing showing for the crumb materials. Positive correlations existed between turf cover and quality ($R^2 = 0.9$) and density ($R^2 = 0.86$). The untreated control did not improve. No differences were found for percentage cover and percentage topdressing showing for the control and the 1-cm depth of coarse crumb rubber. A negative correlation existed between topdressing showing and quality ($R^2 = -0.78$) and density ($R^2 = -0.76$).

*Surface hardness*. Many of the surface hardness measurements were out of the proposed range suggested by Canaway et al. (1990) for the 0.5-kg hammer. All treatments reduced surface hardness with the 0.5-kg and 2.25-kg hammers compared to the control (Table 2). The 2-cm depth of coarse crumb rubber had the lowest surface hardness for the 2.25-kg hammer (67.7) and the 2-cm depth of medium buffings rubber had the lowest surface hardness for the 0.5-kg hammer (80.3). For the two-year average, the 2.25-kg hammer and soil moisture had a correlation coefficient of -0.704, whereas the 0.5-kg hammer and soil moisture had a correlation coefficient of -0.598. The 2.25-kg hammer was more correlated with soil moisture than the 0.5-kg hammer. A comparison between surface hardness and soil moisture on an annual basis showed strong correlation.

*Traction*. All of the treatments resulted in traction above the preferred minimum limit of 25 N·m proposed by Canaway et al. (1990). However, only medium buffings rubber at the 1-cm depth (43.9 N·m) and medium buffings rubber at the 2-cm depth (44.0 N·m) had greater traction than the control (38.4 N·m)(Table 2). The 2-cm depth of medium buffings rubber provided the greatest traction at 44.0 N·m (Table 2).

One of the interesting effects from rubber occurred on frozen ground (Table 3). During the winter period, results indicate the sand treatment continued to show a higher, harder g-max with the 0.5 and 2.25 kg hammers. Furthermore, on the totally frozen conditions, the soil control is significantly harder than the high rates of coarse crumb, medium buffing, and coarse buffing and lower rates of the medium crumb and medium buffings with the 0.5-kg hammer. Using the 2.25-kg hammer on totally frozen ground shows a significant difference between the sand and soil control as compared to the high rates of coarse crumb and coarse buffings.

If you are considering using rubber particles for a turfgrass topdressing amendment, Table 4 gives information pertaining to the amount of rubber needed for a particular area.

## References

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.

Canaway, P.M., M.J. Bell, G. Holmes, and S.W. Baker. 1990. Standards for the playing quality of natural turf for association football, pgs. 29-47. In: R.C. Schmidt, E.F. Hoerner, E.M. Milner, and C.A. Morehouse, (eds.). Natural and artificial playing fields: characteristics and safety features. American Society for Testing and Materials, Philadelphia, Pa.

Rogers, J.N., III and D.V. Waddington. 1990. Portable apparatus for assessing impact characteristics of athletic field surfaces, pgs. 96-110. In: R.C. Schmidt, E.F. Hoerner, E.M. Milner, and C.A.

Morehouse, (eds.). Natural and artificial playing fields: characteristics and safety features. American Society for Testing and Materials, Philadelphia, Pa.

U.S. Environmental Protection Agency and Pacific Environmental Services. 1993. Scrap tire technology and markets. Noyes Data Corp., Park Ridge, N.J.

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

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

**Table 2.** Means of coarse crumb, medium crumb, coarse buffing, and medium buffing rubber particles topdressed treatments and an untreated control pooled for a two year study performed on Kentucky bluegrass 'Midnight'. Traction measurements (N·m) taken with a torque wrench apparatus on 15 May 1997.

| Treatments | Amount applied (cm) | Quality [z] | Density [y] | % Turf cover | % Topdressing showing | Surface hardness [x] ($g_{max}$) 2.25-kg | Surface hardness [x] ($g_{max}$) 0.5-kg | Traction [w] (N·m) |
|---|---|---|---|---|---|---|---|---|
| Coarse crumb | 1 | 4.7 [v] | 4.5 | 50.4 | 47.9 | 77.6 | 106.3 | 34.4 |
| | 2 | 6.5 | 6.4 | 68.6 | 38.9 | 67.7 | 81.0 | 37.2 |
| Medium crumb | 1 | 5.8 | 5.7 | 57.1 | 35.8 | 80.3 | 120.0 | 40.8 |
| | 2 | 7.0 | 6.8 | 80.6 | 16.7 | 76.7 | 91.3 | 41.6 |
| Coarse buffing | 1 | 6.5 | 6.4 | 70.2 | 23.6 | 82.7 | 94.0 | 38.1 |
| | 2 | 7.2 | 7.1 | 76.2 | 24.8 | 74.4 | 97.0 | 38.7 |
| Medium buffing | 1 | 7.3 | 7.3 | 77.5 | 16.3 | 84.0 | 92.3 | 43.9 |
| | 2 | 7.7 | 7.6 | 87.7 | 10.2 | 71.6 | 80.3 | 44.0 |
| Sand | 2 | 6.4 | 6.5 | 66.7 | 26.9 | 73.0 | 102.0 | 38.4 |
| Control | -- | 4.3 | 4.2 | 38.3 | 49.7 | 87.0 | 162.0 | 36.5 |
| $LSD_{(0.05)}$ [u] | | 0.5 | 0.6 | 8.0 | 8.7 | 4.8 | 28.4 | 6.2 |

[z] Quality was rated on a 1-10 scale: 1 = poorest quality, 6 = least acceptable quality, and 10 = best quality.
[y] Density was rated on a 1-10 scale: where 1 = poorest density, 6 = least acceptable density, and 10 = best density.
[x] Surface hardness measurements consisted of dropping the each hammer at a height of 45.5 cm five times within each plot.
[w] Traction measurement consisted of dropping a 45-kg cleated plate from a height of 5 cm three times within each plot.
[v] Treatments means are the average of three replicates pooled for two years.
[u] LSD at $P \leq 0.05$ according to Fisher's least significance difference test.

**Table 3.** Surface hardness measured with the 0.5-kg and 2.25-kg hammers under frozen field conditions in 1996 and 1997.

| Treatments | Depth (cm) | 0.5-kg hammer | | | 2.25-kg hammer | | |
|---|---|---|---|---|---|---|---|
| | | 3-9-96† | 1-22-97† | 2-23-97§ | 3-9-96† | 1-22-97† | 2-23-97§ |
| | | $g_{max}$ | | | | | |
| Coarse crumb | 1 | 148 | 305 | 193 | 185 | 291 | 212 |
| | 2 | 109 | 159 | 222 | 110 | 201 | 174 |
| Medium crumb | 1 | 165 | 239 | 205 | 200 | 325 | 191 |
| | 2 | 126 | 280 | 246 | 116 | 278 | 220 |
| Coarse buffing | 1 | 113 | 282 | 239 | 185 | 275 | 233 |
| | 2 | 104 | 180 | 210 | 112 | 187 | 178 |
| Medium buffing | 1 | 129 | 218 | 313 | 192 | 296 | 280 |
| | 2 | 121 | 200 | 242 | 107 | 259 | 235 |
| Sand | 2 | 370 | 271 | 313 | 349 | 327 | 283 |
| Control | -- | 162 | 346 | 163 | 241 | 301 | 187 |
| $LSD_{(0.05)}$ ¶ | | 56 | 105 | NS | 65 | 69 | 73 |

† Frozen ground conditions throughout profile.
§ Top 1 cm of profile thawed, remaining profile frozen.
¶ LSD at $P \leq 0.05$ according to Fisher's least significance difference test.
NS = not significant at $P \leq 0.05$.

**Table 4.** Volume and weight of rubber required for various topdressing depths. Data based on a medium crumb rubber (24% 4/10 mesh; 57% 10/18 mesh) with a bulk density of 25 lbs/ft$^3$.

| Depth (cm) | Depth (inches) | Pounds per 1000 ft$^2$ | Tons per 1000 ft$^2$ | Cubic feet per 1000 ft$^2$ |
|---|---|---|---|---|
| 0.64 | 0.25 | 639 | 0.32 | 20.8 |
| 1.00 | 0.38 | 959 | 0.48 | 31.2 |
| 1.27 | 0.50 | 1278 | 0.64 | 41.6 |
| 2.00 | 0.75 | 1918 | 0.96 | 62.5 |
| 2.54 | 1.00 | 2557 | 1.30 | 83.3 |

For example, an area to be topdressed with rubber particles on a football field, between the hash marks and the twenty-yard lines, is approximately 9000 ft$^2$. At the recommended depth for one application at 0.25 in. at 639 lbs/1000 ft$^2$, the amount of rubber needed for this area is 5750 lbs or 2.9 tons of rubber.

Equation:

at 0.25 in. $\frac{639 \text{ lbs}}{1000 \text{ ft}^2} = \frac{x \text{ amount of lbs. needed}}{y \text{ amount of ft}^2 \text{ in area}}$

# The Effect of Topdressing with Rubber Buffings on Intensely Trafficked Football Turf - 1996-97 data

*Jeffrey J. Salmond and David D. Minner*

The rubber recycling industry was introduced to the turfgrass industry about 15 years ago. Since then, ways have been improved for the incorporation of the rubber into the soil profile. Crumb rubber is typically the rubber particle used for topdressing turf. The spherical crumb rubber particle shape allows for easier incorporation of the material into core aerification holes. Buffing rubber has a length-to-width aspect ratio of 7:1. Buffing rubber, therefore, is not used as often for two reasons. One, the number of passenger retreads have decreased (U.S. EPA and PES, 1993) and two, the longer buffings do not filter into the turf canopy or core holes very easily. Other research reported in this publication indicates that turf injury was less when topdressed with buffing rubber compared to crumb rubber.

Traffic studies usually consist of a machine simulating a traffic pattern (i.e. Brinkman and Brouwer traffic simulators). Our goal was to use football players to apply live traffic to buffing rubber. The objectives of the two-year study were to evaluate buffing rubber as a topdressing and to determine its effects on seed germination.

*Materials*. A study was initiated in the summer of 1996 at the Ames High School football field in Ames, Iowa to evaluate the effects of buffings rubber on a intensely trafficked football turf for a two-year study. The data were collected during a 5-day football training camp in August of 1996 and August of 1997. The experimental plots were arranged on a mature stand of common Kentucky bluegrass (*Poa pratensis* L.) overseeded with perennial ryegrass (*Lolium perenne* L.) in an area just off the playing field. Overall plot size was 1.8 m x 6.1 m (6 ft. x 20 ft.) with individual plots being 0.9 m x 0.6 m (2 ft. x 3 ft.) for a total of 18 plots, 2 rows of 9 plots each (Table 1). Each rubber treatment was adjacent to a non-rubber control plot. The three medium buffing (MB) treatments were arranged in a randomized complete block design. The rubber treatments were placed at 0.6, 1.3, 2 cm depths, (1/4", 1/2" and 3/4" respectively), and replicated three times. The overall plot was mowed at 1.5 cm and core aerified with 1.3 cm diameter hollow tines and topdressed with the rubber treatments. Topdressing with the 2 cm treatment was excessive, therefore a remaining amount of rubber was added later, after settling had occurred, to achieve the desired amount.

The particle size of the medium buffing rubber ranged from 1.0 mm diameter (18 mesh) to 0.5 mm diameter (35 mesh). The average ratio of length to width for the longest shreds in the buffing rubber was approximately 7:1.

Percent turfgrass cover was used to assess turf injury from traffic. Temperatures were recorded within the grass canopy and at a 2.5 cm depth. The surface temperature was measured using a hand-held infrared probe (Cole-Parmer, Type J, model # H-39652-00, Niles, IL) plugged into a thermocouple thermometer held at a height of 61 cm above the plot. The effective diameter cone measured was 15 cm with an area of 182.6 $cm^2$. The 2.5 cm depth temperature was measured with a 30.5 cm, 0.64 cm diameter heavy-duty penetration probe (Cole-Parmer, Type T, model # H-93601-26, Niles, IL).

Surface hardness was measured with the Brüel and Kjær 2515 Vibration Analyzer (Brüel and Kjær, Decatur, GA) (Table 2).

The experimental plot was measured to the size of a football exercise apparatus called 'ropes'. The object of the exercise is to develop balance of the athlete and to teach foot and eye coordination. Human athletes, wearing 1 cm high-density plastic cleats, were used to uniformly apply traffic to the plots during the football practice exercise. The athlete runs through the ropes by placing his foot into the desired square sector. The coach can instruct the athlete to do various exercises such as a criss-cross, bunny-hop, side step, diagonal and others. The 1.8 m x 6.1 m apparatus was placed over the experimental plot area such that each square of the apparatus was over the top of the 0.9 m x

0.6 m treatments and controls. The number of feet to hit each plot was calculated with a hand-held counter and later recorded to find the total number of feet placed into each individual plot.

Data were analyzed by using the general linear model (GLM) procedure of SAS (SAS Institute, 1990). Data collected from the two-year experiment were pooled and analyzed using the method for multiple year, single location as described by Steel and Torrie (1980). Fisher's least significant difference (LSD) test was used to compare main effect over-all treatment means for each collection day and for the temperatures ($P \leq 0.05$).

The analysis showed no overall differences between the two years. The number of feet trafficked into each plot increased from 1996 (Table 3) to 1997 (Table 4). Differences between the rubber treatments and the untreated control were not apparent on three of the five collection days. The rubber treatments, however, had a higher percentage of living turfgrass cover throughout the traffic period than the controls (Table 5). The 0.6, 1.3, and 2 cm depths of medium buffing rubber showed a 57, 71, and 82% increase in turf cover compared to their respective untreated controls by the end of the traffic treatments, respectively. On the fifth collection day, the medium buffing at 2 cm depth had an average percent turf cover of 33 and the control had 6% turf cover. Likewise, the 1.3 cm depth of rubber had an average turf cover of 32% and the control had 9% turf cover. The 1.3 and 2.0 cm depths showed a 50% increase in turf cover compared to the 0.6 depth of rubber by the end of the traffic treatments (Table 5). The 0.6 cm depth of rubber had 15% turf cover compared to 32% and 33% turf cover for the 1.3 and 2 cm depths, respectively. The 2 cm depth of rubber provided more turfgrass cover on four of the five collection days (Table 5).

Rubber treatments did not result in a significant difference between subsurface temperatures compared to control treatments. Surface temperature increased 0.4 to 2.4 °C for the rubber treatments versus the controls (Table 6). Subsurface temperatures verify that the rubber treatments are slightly cooler than the controls. Subsurface temperatures of the rubber treatments were slightly cooler (0.4 to 0.9 °C) than the control plots (Table 6).

**Table 1.** Treatments and the arrangement of treatments in the experimental plots.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | C | 2 | C | 3 | C | 1 | C | 2 | C |
| C | 3 | C | 1 | C | 2 | C | 3 | C | 1 |
| Rep I | | | Rep II | | | Rep III | | | left over |

Depths
1. 1/4" medium rubber buffings (0.635 cm)
2. 1/2" medium rubber buffings (1.27 cm)
3. 3/4" medium rubber buffings (1.9 cm)

C = control

**Table 2.** Initial surface hardness ($g_{max}$) before traffic.

| Treatments | $g_{max}$ |
|---|---|
| 1. 0.6 cm MB | 62§ |
| 2. control for trt 1 | 67 |
| 3. 1.3 cm MB | 61 |
| 4. control for trt 2 | 67 |
| 5. 2 cm MB | 60 |
| 6. control for trt 3 | 68 |

MB = Medium rubber buffing.

§ Treatment means are the average of three replications.

**Table 3.** Average number of feet in 1996 hit into each plot.

| Collection day | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Avg. feet per plot | 130 | 330 | 550 | 445 | 346 | 1,801 |
| Total number of feet for 3 reps | 2,340 | 5,940 | 9,900 | 8,010 | 6,228 | 32,418 |

**Table 4.** Average number of feet in 1997 hit into each plot.

| Collection day | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Avg. feet per plot | 380 | 441 | 330 | 587 | 431 | 2,169 |
| Total number of feet for 3 reps | 6,840 | 7,938 | 5,942 | 10,566 | 7,758 | 39,044 |

**Table 5.** Percentage turfgrass cover after each day of traffic. Data are the average of 1996 and 1997.

| | Collection day | | | | |
|---|---|---|---|---|---|
| Treatments | 1 | 2 | 3 | 4 | 5 |
| | Percentage turfgrass cover | | | | |
| 1. 0.6 cm MB | 99 | 86 | 70 | 33 | 15 |
| 2. control for trt 1 | 91 | 75 | 57 | 27 | 7 |
| 3. 1.3 cm MB | 98 | 80 | 73 | 21 | 32 |
| 4. control for trt 2 | 97 | 80 | 59 | 23 | 9 |
| 5. 2 cm MB | 97 | 83 | 78 | 38 | 33 |
| 6. control for trt 3 | 96 | 72 | 47 | 20 | 6 |
| $LSD_{(0.05)}$ ¶ | 6 | NS | NS | NS | 7 |

MB = Medium rubber buffing.

¶ LSD at P ≤ 0.05 according to Fisher's least significance difference test.

NS = not significant at P ≤ 0.05.

**Table 6.** Surface and subsurface temperatures of the rubber treatments and their control plots. Data are the average of 1996 and 1997.

| Treatments | Surface† (canopy) | Subsurface‡ (2.5 cm) |
|---|---|---|
| | °C | |
| 1. 0.6 cm MB | 32.1 | 28.9 |
| 2. control for trt 1 | 31.7 | 29.3 |
| 3. 1.3 cm MB | 31.8 | 28.5 |
| 4. control for trt 2 | 31.4 | 29.3 |
| 5. 2 cm MB | 33.7 | 28.3 |
| 6. control for trt 3 | 31.3 | 29.2 |
| $LSD_{(0.05)}$ ¶ | NS | NS |

MB = Medium rubber buffing.

† Surface temperature taken with hand-held infrared probe.

‡ Subsurface temperature took with heavy-duty penetration probe into soil at a 2.5 cm depth.

¶ LSD at P ≤ 0.05 according to Fisher's least significance difference test.

NS = not significant at P ≤ 0.05.

# The Effect of Deicing Chemicals on Turfgrass

*David D. Minner and Barbara R. Bingaman*

Runoff from deicing products applied to walkways and other hard surfaces can result in accumulation of salts in turf borders. The purpose of this study was to assess the level of damage caused by several common deicer products. Our approach was to simulate a brine runoff by spraying salt solution directly on turf plots throughout the winter and evaluating injury during the growing season.

## Methods:

Year one of this field study was conducted from February through October, 1996 at the Iowa State University Horticulture Research Station, Ames, Iowa. Year two was run from January through October, 1997 at Iowa State University, Ames, Iowa. Individual experimental plots were 0.6 x 1.2 m with three replications. Because of possible deicer runoff, each individual plot was completely surrounded by a 0.3-meter border. The experimental design was a randomized complete block with 25 treatments.

Treatments containing potassium chloride (KCl), 30% urea + 70% calcium chloride ($CaCl_2$), 50% urea [$CO(NH_2)_2$] + 50% $CaCl_2$, urea, rock salt ($NaCl_2$), Safe Step (50% $NaCl_2$ + 50% KCl), and magnesium chloride($MgCl_2$)- hexahydrate (47% $MgCl_2$ and 53 % water). A control, treated with water, was included for comparison. Application rates of 68, 136, and 272 $g \cdot m^{-2}$ were used for all ice melt products, except $MgCl_2$ - hexahydrate, to simulate typical amounts of product used by the ice melt industry (Table 1). To keep the salt component of each ice melt product on an equal weight basis, the rate of $MgCl_2$ - hexahydrate was increased to compensate for the additional weight of the water. The $MgCl_2$ - hexahydrate rates at 136 and 306 $g/m^2$ compare on an equal weight basis with the other ice melt products at 136 and 272 $g/m^2$.

The deicers were dissolved in water and applied as a brine solution using a carbon dioxide backpack sprayer. One liter of brine solution applied to the 0.6 by 1.2 m. plots simulated the melting of approximately 0.3 cm of ice. TeeJet flat fan EVS #8008, white nozzles were used at 45 psi. Windbreak 'cages' were employed to prevent drift of the materials. Neither runoff nor drift was observed after treatment differences became apparent.. The turf was mowed weekly at 6.4 cm and no supplemental irrigation was supplied.

Nine sequential applications of each rate were made per season. Total amounts per season totaled 610, 1220, and 2440 $g \cdot m^{-2}$ for each ice melt product (1322, 2611, and 5188 $g/m^2$ for $MgCl_2$ - hexahydrate). Year one applications were made from 22 February through 19 March 1996 and year two from 14 January through 26 February 1997.

Soil samples were taken from each plot spring and fall 1997. Samples were taken 4" deep and 10 samples were taken per plot. The soil was air dried, ground, and analyzed for electroconductivity by the Plant Nutrition Lab in the Department of Horticulture (Table 5).

Phytotoxicity and percent living plant material data were taken at greenup and early spring 1996 and 1997 (Table 1). Phytotoxicity was assessed using a 10 to 1 scale: 10 = no turf injury and 1 = foliage completely brown.

Turf cover, turf quality, and turf color data were collected in spring and summer of both years. Turf cover was assessed as the percentage of area per plot covered by turfgrass species. Turf quality was measured using a 10 to 1 scale: 10 = best quality, 2 = weeds only, and 1 = no green material. Turf color was defined using a 9 to 1 scale: 9 = best, 1 = worst color, and 0 = no turf present.

On 29 August 1996 and 1997, the study areas were treated with Roundup to kill all remaining vegetation in preparation for fall seeding. The intent was to evaluate what effect residual salt levels may have on seedling establishment of turf. The dead plant material was removed prior to seeding. The plots were seeded with perennial ryegrass at 59 $g{\cdot}m^{-2}$ using a drop spreader. Ryegrass seedling vigor and percentage ryegrass cover data were taken on 10 October 1996 and (Table 4). Ryegrass seedling vigor was assessed using a 10 to 1 scale: 10 = best and 1 = worst vigor. Percentage ryegrass cover was determined as the percentage of area per plot covered by ryegrass.

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 test for treatment effects on turfgrass factors.

## Results:

Deicer treatments applied during the winter caused a bleaching and light tan appearance to the dormant turf. This appearance remained visible for some treatments during spring green-up and was rated as phytotoxicity. The average of phytotoxicity on 10 April and 9 May indicated that all treatments had significantly more turf injury than the untreated control (Table 1). There was a significant increase in turf phytotoxicity as rate increased from 610 to 1220 $g{\cdot}m^{-2}$ for each ice melt material except urea. Urea alone or in combination with $CaCl_2$ 67/33 caused severe phytotoxicity even at the low rate of 610 $g{\cdot}m^{-2}$. Urea-$CaCl_2$ 30/70 at 610 $g{\cdot}m^{-2}$ had significantly less phytotoxicity and significantly more living green plant material than all other ice melt treatments. When $MgCl_2$ - hexahydrate is compared to other ice melt products at the same rate (i.e. approximately 1322 $g{\cdot}m^{-2}$, compare treatment 23 with treatments 3, 6, 9, 12, 15, 18, 21, and 27) it produced less phytotoxicity than urea-$CaCl_2$ combinations, KCl, urea, rock salt, and $CaCl_2$, but was similar to Safe Step. However, when $MgCl_2$ and other deicers are compared on an equal weight basis, without the extra water present, $MgCl_2$ causes more phytotoxicity than urea-$CaCl_2$ combinations 30/70 or 50/50, KCl, rock salt, Safe Step and $CaCl_2$ (i.e. compare treatment 23 with treatments 2, 5, 8, 11, 14, 17, 20, and 26).

Percent turf and weed cover (Table 2) and turf quality and color (Table 3) were evaluated during the summer to determine recovery following deicer affects. A reduction in percent turfgrass cover caused by winter application of ice melt products was still noticeable during late summer. The untreated control had 91 percent turf cover while other ice melt treatments ranged from zero to 89 percent turf cover. The only treatments that had turf cover statistically similar to the untreated control were at the low application rate, 610 $g{\cdot}m^{-2}$. These included urea-$CaCl_2$ 30/70 and 50/50, KCl, rock salt, Safe Step, and $CaCl_2$. Urea, urea-$CaCl_2$ 67/33, and $MgCl_2$ - hexahydrate had significantly reduced turf cover compared to the untreated control. The area of each field plot covered by turf, weeds, or bare soil was evaluated with the sum of the three types of cover equal to 100%. High rates of urea (treatments 7, 9, 10, 15, and 16) severely reduce turf and weed cover, and resulted in 50 to 97% bare soil. It is very clear that urea should not be used alone or as a major component of an ice melt product. However, it is apparent that moderate percentages of urea combined with $CaCl_2$ (i.e. urea-$CaCl_2$ 30/70 or 50/50) and applied at 610 $g{\cdot}m^{-2}$ can enhance turf cover (Table 2), quality and color (Table 3).

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

Average turf quality and color for July and August, 1996 are presented in Table 4. At 610 $g{\cdot}m^{-2}$ all urea + $CaCl_2$ combinations, KCl, rock salt, Safe Step, and $CaCl_2$ were statistically similar to the untreated control. Urea and $MgCl_2$ had inferior turf quality.

At 1220 $g \cdot m^{-2}$ all deicer treatments had significantly poorer turf quality than the untreated control, however, urea + $CaCl_2$, 30/70, KCl, and Safe Step were superior to urea + $CaCl_2$ 50/50 or 67/33, urea, rock salt, and $MgCl_2$ (Table 3). At 2440 $g \cdot m^{-2}$ all deicer treatments were similar and had very poor turf quality (Table 3).

The elements in some deicer compounds are also essential elements for plant growth. Turf color was evaluated to determine if any beneficial color enhancement occurred, especially from urea treatments containing nitrogen. Urea combinations with $CaCl_2$ enhanced turf color. Urea + $CaCl_2$ 50/50 provided the best color enhancement and was superior to the untreated control (Table 3).

In the fall of 1996, the entire study area was killed with a non-selective herbicide and reseeded with perennial ryegrass to determine if winter deicer products inhibit fall re-establishment. As indicated earlier some ice melt treatments (treatments 6, 7, 9, 10, 14, 15, 16, and 19) caused a severe reduction in turf and weed cover that resulted in a high percentage (20 to 97%) of the plot area covered by bare ground (Table 2). This indicates that urea and rock salt, used at high rates, can produce severe grass injury. Poor re-establishment of perennial ryegrass for the urea and rock salt treatments (treatments 7, 9, 10, 14, 15, 16, and 19) indicated that there was a residual affect in the soil that may prolong re-establishment of affected areas near sidewalks.

**Summary:**

Seven different deicer products were sprayed directly to turf on nine different dates during the winter to evaluate possible injury to Kentucky bluegrass turf. Injury was dependent upon deicer type and rate of application. On an equal weight basis, urea and rock salt produced more turf injury than Safe Step, $CaCl_2$, KCl, and combinations of urea + $CaCl_2$ 30/70. Urea at rates greater than 610 $g \cdot m^{-2} \cdot yr$, and rock salt at rates greater than 2440 $g \cdot m^{-2} \cdot yr$ can cause severe vegetation loss and poor re-establishment of turf from seeding. Calcium chloride combined with small amounts of urea (30%) enhanced turf color.

**Table 1.** Phytotoxicity[1] data for turf treated with deicer products for the 1996 and 1997 Brine Deicer Studies.

| | | Total | 1996 | | | 1997 | | |
|---|---|---|---|---|---|---|---|---|
| | Deicer product | $g \cdot m^{-2}$ | Spring | Summer | Mean | Spring | Summer | Mean |
| 1 | Untreated Control | NA | 7.7 | 9.7 | 8.7 | 8.3 | 10.0 | 9.2 |
| 2 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 610 | 5.7 | 8.7 | 7.2 | 7.0 | 10.0 | 8.5 |
| 3 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 1220 | 2.7 | 3.0 | 2.8 | 4.0 | 9.0 | 6.5 |
| 4 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 2440 | 1.0 | 1.0 | 1.0 | 2.7 | 6.3 | 4.5 |
| 5 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 610 | 5.0 | 6.0 | 5.5 | 6.3 | 8.7 | 7.5 |
| 6 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 1220 | 1.7 | 1.3 | 1.5 | 3.3 | 6.0 | 4.7 |
| 7 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 2440 | 1.0 | 1.0 | 1.0 | 2.0 | 3.7 | 2.8 |
| 8 | Potassium chloride (KCl) | 610 | 5.0 | 7.7 | 6.3 | 6.0 | 10.0 | 8.0 |
| 9 | Potassium chloride (KCl) | 1220 | 2.0 | 3.3 | 2.7 | 5.0 | 10.0 | 7.5 |
| 10 | Potassium chloride (KCl) | 2440 | 1.0 | 1.0 | 1.0 | 3.3 | 8.3 | 5.8 |
| 11 | Urea [$CO(NH_2)_2$] | 610 | 1.7 | 1.3 | 1.5 | 2.0 | 7.7 | 4.8 |
| 12 | Urea [$CO(NH_2)_2$] | 1220 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 13 | Urea [$CO(NH_2)_2$] | 2440 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 14 | Rock salt ($NaCl_2$) | 610 | 5.0 | 7.0 | 6.0 | 5.7 | 10.0 | 7.8 |
| 15 | Rock salt ($NaCl_2$) | 1220 | 1.7 | 1.7 | 1.7 | 3.3 | 6.7 | 5.0 |
| 16 | Rock salt ($NaCl_2$) | 2440 | 1.0 | 1.0 | 1.0 | 1.7 | 3.3 | 2.5 |
| 17 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 610 | 4.7 | 7.7 | 6.2 | 5.3 | 9.7 | 7.5 |
| 18 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 1220 | 2.3 | 4.3 | 3.3 | 6.0 | 10.0 | 8.0 |
| 19 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 2440 | 1.0 | 1.0 | 1.0 | 2.3 | 7.3 | 4.8 |
| 20 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 1322 | 2.7 | 5.0 | 3.8 | 4.0 | 10.0 | 7.0 |
| 21 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 2611 | 1.3 | 1.0 | 1.2 | 1.3 | 5.7 | 3.5 |
| 22 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 5188 | 1.0 | 1.0 | 1.0 | 1.0 | 1.7 | 1.3 |
| 23 | Calcium chloride ($CaCl_2$) pellets | 610 | 4.0 | 7.7 | 5.8 | 3.3 | 10.0 | 6.7 |
| 24 | Calcium chloride ($CaCl_2$) pellets | 1220 | 1.7 | 2.7 | 2.2 | 2.3 | 10.0 | 6.2 |
| 25 | Calcium chloride ($CaCl_2$) pellets | 2440 | 1.0 | 1.0 | 1.0 | 1.7 | 8.0 | 4.8 |
| | $LSD_{0.05}$ | | 1.0 | 1.2 | 0.9 | 1.9 | 3.0 | 2.1 |

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

**Table 2.** Percentage turf cover[1] data for turf treated with deicer products for the 1996 and 1997 Brine Deicer Studies.

| | Deicer product | Total $g \cdot m^{-2}$ | 1996 Spring | 1996 Summer | 1996 Mean | 1997 Spring | 1997 Summer | 1997 Mean |
|---|---|---|---|---|---|---|---|---|
| | | | % | | | % | | |
| 1 | Untreated Control | NA | 93.3 | 88.3 | 90.8 | 98.3 | 100.0 | 99.2 |
| 2 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 610 | 76.7 | 80.0 | 78.3 | 96.7 | 93.3 | 95.0 |
| 3 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 1220 | 53.3 | 38.0 | 45.7 | 91.7 | 96.7 | 94.2 |
| 4 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 2440 | 0.0 | 0.0 | 0.0 | 76.7 | 66.7 | 71.7 |
| 5 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 610 | 90.0 | 88.3 | 89.2 | 91.7 | 76.7 | 84.2 |
| 6 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 1220 | 1.7 | 11.7 | 6.7 | 68.3 | 68.3 | 68.3 |
| 7 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 2440 | 0.0 | 0.0 | 0.0 | 35.0 | 25.0 | 30.0 |
| 8 | Potassium chloride (KCl) | 610 | 83.3 | 48.3 | 65.8 | 100.0 | 100.0 | 100.0 |
| 9 | Potassium chloride (KCl) | 1220 | 41.7 | 28.3 | 35.0 | 100.0 | 95.0 | 97.5 |
| 10 | Potassium chloride (KCl) | 2440 | 0.0 | 0.0 | 0.0 | 83.3 | 71.7 | 77.5 |
| 11 | Urea [$CO(NH_2)_2$] | 610 | 5.0 | 10.0 | 7.5 | 73.3 | 71.7 | 72.5 |
| 12 | Urea [$CO(NH_2)_2$] | 1220 | 0.0 | 0.7 | 0.3 | 2.3 | 12.3 | 7.3 |
| 13 | Urea [$CO(NH_2)_2$] | 2440 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 1.0 |
| 14 | Rock salt ($NaCl_2$) | 610 | 73.3 | 66.7 | 70.0 | 98.3 | 98.3 | 98.3 |
| 15 | Rock salt ($NaCl_2$) | 1220 | 10.0 | 5.0 | 7.5 | 66.7 | 70.0 | 68.3 |
| 16 | Rock salt ($NaCl_2$) | 2440 | 0.0 | 0.0 | 0.0 | 30.0 | 33.3 | 31.7 |
| 17 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 610 | 90.0 | 66.7 | 78.3 | 98.3 | 100.0 | 99.2 |
| 18 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 1220 | 65.0 | 56.7 | 60.8 | 98.3 | 100.0 | 99.2 |
| 19 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 2440 | 0.0 | 0.0 | 0.0 | 71.7 | 75.0 | 73.3 |
| 20 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 1322 | 75.0 | 50.0 | 62.5 | 98.3 | 100.0 | 99.2 |
| 21 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 2611 | 1.7 | 5.0 | 3.3 | 55.0 | 68.3 | 61.7 |
| 22 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 5188 | 0.0 | 0.0 | 0.0 | 7.0 | 31.7 | 19.3 |
| 23 | Calcium chloride ($CaCl_2$) pellets | 610 | 88.0 | 71.7 | 79.8 | 98.3 | 98.3 | 98.3 |
| 24 | Calcium chloride ($CaCl_2$) pellets | 1220 | 38.3 | 23.3 | 30.8 | 98.3 | 91.7 | 95.0 |
| 25 | Calcium chloride ($CaCl_2$) pellets | 2440 | 0.0 | 0.0 | 0.0 | 81.7 | 76.7 | 79.2 |
| | $LSD_{0.05}$ | | 24.3 | 32.4 | 26.2 | 36.4 | 31.7 | 31.3 |

[1]Percentage turf cover represents the area per plot covered by turf species.

**Table 3.** Turf color[1] data for turf treated with deicer products for the 1996and 1997 Brine Deicer Studies.

| | Deicer product | Total $g \cdot m^{-2}$ | 1996 Spring | 1996 Summer | 1996 Mean | 1997 Spring | 1997 Summer | 1997 Mean |
|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 7.0 | 7.0 | 7.0 | 6.0 | 6.7 | 6.3 |
| 2 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 610 | 8.7 | 5.7 | 7.2 | 6.7 | 5.0 | 5.8 |
| 3 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 1220 | 6.7 | 3.0 | 4.8 | 7.7 | 5.3 | 6.5 |
| 4 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 2440 | 1.0 | 0.0 | 0.5 | 8.0 | 6.3 | 7.2 |
| 5 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 610 | 9.3 | 9.0 | 9.2 | 8.7 | 5.3 | 7.0 |
| 6 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 1220 | 1.0 | 4.7 | 2.8 | 8.7 | 6.0 | 7.3 |
| 7 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 2440 | 1.0 | 0.0 | 0.5 | 8.0 | 3.0 | 5.5 |
| 8 | Potassium chloride (KCl) | 610 | 7.0 | 4.3 | 5.7 | 7.0 | 5.3 | 6.2 |
| 9 | Potassium chloride (KCl) | 1220 | 7.0 | 2.3 | 4.7 | 6.0 | 5.0 | 5.5 |
| 10 | Potassium chloride (KCl) | 2440 | 1.0 | 0.0 | 0.5 | 8.0 | 3.3 | 5.7 |
| 11 | Urea [$CO(NH_2)_2$] | 610 | 1.0 | 2.3 | 1.7 | 8.7 | 5.0 | 6.8 |
| 12 | Urea [$CO(NH_2)_2$] | 1220 | 1.0 | 0.0 | 0.5 | 8.0 | 2.3 | 5.2 |
| 13 | Urea [$CO(NH_2)_2$] | 2440 | 1.0 | 0.0 | 0.5 | 9.0 | 2.0 | 5.5 |
| 14 | Rock salt ($NaCl_2$) | 610 | 7.3 | 4.3 | 5.8 | 6.3 | 6.7 | 6.5 |
| 15 | Rock salt ($NaCl_2$) | 1220 | 3.0 | 0.0 | 1.5 | 8.0 | 6.0 | 7.0 |
| 16 | Rock salt ($NaCl_2$) | 2440 | 1.0 | 0.0 | 0.5 | 8.7 | 3.0 | 5.8 |
| 17 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 610 | 6.7 | 6.7 | 6.7 | 7.3 | 7.3 | 7.3 |
| 18 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 1220 | 7.0 | 2.3 | 4.7 | 6.3 | 6.3 | 6.3 |
| 19 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 2440 | 1.0 | 0.0 | 0.5 | 8.3 | 3.7 | 6.0 |
| 20 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 1322 | 7.0 | 2.0 | 4.5 | 7.0 | 7.7 | 7.3 |
| 21 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 2611 | 3.0 | 0.0 | 1.5 | 9.0 | 4.7 | 6.8 |
| 22 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 5188 | 1.0 | 0.0 | 0.5 | 8.7 | 4.0 | 6.3 |
| 23 | Calcium chloride ($CaCl_2$) pellets | 610 | 7.0 | 4.7 | 5.8 | 6.3 | 6.7 | 6.5 |
| 24 | Calcium chloride ($CaCl_2$) pellets | 1220 | 5.3 | 2.3 | 3.8 | 7.0 | 5.7 | 6.3 |
| 25 | Calcium chloride ($CaCl_2$) pellets | 2440 | 4.0 | 0.0 | 2.0 | 7.0 | 3.7 | 5.3 |
| | $LSD_{0.05}$ | | 3.0 | 4.1 | 2.7 | 1.6 | 2.1 | 1.4 |

[1]Turf color was assessed using a 10 to 1 scale: 10 = darkest and 1 = lightest green. Color does not consider quality.

**Table 4.** Visual turf quality[1] data for turf treated with deicer products for the 1996and 1997 Brine Deicer Studies.

| | Deicer product | Total $g \cdot m^{-2}$ | 1996 Spring | 1996 Summer | 1996 Mean | 1997 Spring | 1997 Summer | 1997 Mean |
|---|---|---|---|---|---|---|---|---|
| 1 | Untreated Control | NA | 7.7 | 7.0 | 7.3 | 7.7 | 7.3 | 7.5 |
| 2 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 610 | 8.3 | 6.0 | 7.2 | 7.3 | 5.0 | 6.2 |
| 3 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 1220 | 5.0 | 4.3 | 4.7 | 6.0 | 5.3 | 5.7 |
| 4 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 2440 | 2.0 | 2.0 | 2.0 | 4.7 | 5.3 | 5.0 |
| 5 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 610 | 9.0 | 8.3 | 8.7 | 6.3 | 4.7 | 5.5 |
| 6 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 1220 | 1.3 | 3.3 | 2.3 | 4.3 | 5.0 | 4.7 |
| 7 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 2440 | 1.0 | 1.0 | 1.0 | 3.0 | 1.7 | 2.3 |
| 8 | Potassium chloride (KCl) | 610 | 7.0 | 4.7 | 5.8 | 7.7 | 7.0 | 7.3 |
| 9 | Potassium chloride (KCl) | 1220 | 3.7 | 3.3 | 3.5 | 7.3 | 5.0 | 6.2 |
| 10 | Potassium chloride (KCl) | 2440 | 2.0 | 2.0 | 2.0 | 6.3 | 4.7 | 5.5 |
| 11 | Urea [$CO(NH_2)_2$] | 610 | 1.3 | 2.3 | 1.8 | 5.0 | 4.7 | 4.8 |
| 12 | Urea [$CO(NH_2)_2$] | 1220 | 1.0 | 1.7 | 1.3 | 1.3 | 1.3 | 1.3 |
| 13 | Urea [$CO(NH_2)_2$] | 2440 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 14 | Rock salt ($NaCl_2$) | 610 | 5.7 | 5.7 | 5.7 | 7.7 | 7.3 | 7.5 |
| 15 | Rock salt ($NaCl_2$) | 1220 | 2.7 | 2.0 | 2.3 | 4.7 | 5.7 | 5.2 |
| 16 | Rock salt ($NaCl_2$) | 2440 | 1.3 | 1.7 | 1.5 | 3.0 | 1.3 | 2.2 |
| 17 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 610 | 7.3 | 6.0 | 6.7 | 7.7 | 7.7 | 7.7 |
| 18 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 1220 | 6.0 | 4.7 | 5.3 | 8.0 | 8.0 | 8.0 |
| 19 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 2440 | 2.0 | 2.0 | 2.0 | 5.7 | 4.3 | 5.0 |
| 20 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 1322 | 6.3 | 4.3 | 5.3 | 7.3 | 8.0 | 7.7 |
| 21 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 2611 | 2.3 | 2.0 | 2.2 | 5.3 | 4.7 | 5.0 |
| 22 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 5188 | 2.0 | 2.0 | 2.0 | 1.7 | 2.3 | 2.0 |
| 23 | Calcium chloride ($CaCl_2$) pellets | 610 | 7.3 | 5.3 | 6.3 | 7.3 | 6.3 | 6.8 |
| 24 | Calcium chloride ($CaCl_2$) pellets | 1220 | 3.7 | 2.7 | 3.2 | 7.7 | 6.0 | 6.8 |
| 25 | Calcium chloride ($CaCl_2$) pellets | 2440 | 2.0 | 2.0 | 2.0 | 5.0 | 4.7 | 4.8 |
| | $LSD_{0.05}$ | | 1.6 | 2.2 | 1.7 | 2.5 | 2.2 | 2.2 |

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

**Table 5.** Electroconductivity for soil samples from field plots treated with deicer products for the 1997 Brine Deicer Study.

| | Deicer product | Rate oz/yd | Total applied oz/yd | Electroconductivity [mmho/cm] Spring | Fall |
|---|---|---|---|---|---|
| 1 | Untreated Control | NA | NA | 0.97 | 0.88 |
| 2 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 2 | 18 | 2.91 | 0.99 |
| 3 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 4 | 36 | 4.50 | 0.95 |
| 4 | 30% Urea [$CO(NH_2)_2$] + 70% Calcium chloride ($CaCl_2$) | 8 | 72 | 2.15 | 1.06 |
| 5 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 2 | 18 | 2.45 | 0.95 |
| 6 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 4 | 36 | 4.00 | 0.97 |
| 7 | 50% Urea [$CO(NH_2)_2$] + 50% Calcium chloride ($CaCl_2$) | 8 | 72 | 5.27 | 1.44 |
| 8 | 61% Magnesium chloride [$MgCl_2$] (47% a.i.) + 39% Urea [$CO(NH_2)_2$] | 2 | 18 | 2.33 | 0.95 |
| 9 | 61% Magnesium chloride [$MgCl_2$] (47% a.i.) + 39% Urea [$CO(NH_2)_2$] | 4 | 36 | 3.08 | 0.98 |
| 10 | 61% Magnesium chloride [$MgCl_2$] (47% a.i.) + 39% Urea [$CO(NH_2)_2$] | 8 | 72 | 3.23 | 0.85 |
| 11 | Potassium chloride (KCl) | 2 | 18 | 1.43 | 1.11 |
| 12 | Potassium chloride (KCl) | 4 | 36 | 1.85 | 1.07 |
| 13 | Potassium chloride (KCl) | 8 | 72 | 1.88 | 1.28 |
| 14 | Urea [$CO(NH_2)_2$] | 2 | 18 | 3.10 | 0.83 |
| 15 | Urea [$CO(NH_2)_2$] | 4 | 36 | 2.60 | 1.51 |
| 16 | Urea [$CO(NH_2)_2$] | 8 | 72 | 3.50 | 5.32 |
| 17 | Rock salt ($NaCl_2$) | 2 | 18 | 1.88 | 0.88 |
| 18 | Rock salt ($NaCl_2$) | 4 | 36 | 4.20 | 1.19 |
| 19 | Rock salt ($NaCl_2$) | 8 | 72 | 6.75 | 1.58 |
| 20 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 2 | 18 | 2.16 | 0.89 |
| 21 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 4 | 36 | 3.68 | 1.03 |
| 22 | Safe Step [50% ($NaCl_2$) + 50% Potassium chloride (KCl)] | 8 | 72 | 3.80 | 1.12 |
| 23 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 4 | 39 | 1.47 | 0.88 |
| 24 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 9 | 77 | 3.13 | 0.97 |
| 25 | Magnesium chloride ($MgCl_2$) (47% a.i.) | 17 | 153 | 2.87 | 0.96 |
| 26 | Calcium chloride ($CaCl_2$) pellets | 2 | 18 | 1.67 | 0.75 |
| 27 | Calcium chloride ($CaCl_2$) pellets | 4 | 36 | 1.58 | 0.86 |
| 28 | Calcium chloride ($CaCl_2$) pellets | 8 | 72 | 1.55 | 0.86 |
| 29 | 42% Ammonium nitrate ($NH_4NO_3$)+58% Calicum chloride ($CaCl_2$) | 2 | 18 | 1.70 | 0.72 |
| 30 | 42% Ammonium nitrate ($NH_4NO_3$)+58% Calicum chloride ($CaCl_2$) | 4 | 36 | 2.58 | 0.89 |
| 31 | 42% Ammonium nitrate ($NH_4NO_3$)+58% Calicum chloride ($CaCl_2$) | 8 | 72 | 3.03 | 0.84 |
| 32 | 54% Ammonium sulfate [$(NH_4)_2SO_4$] + 46% Calicum chloride ($CaCl_2$) | 2 | 18 | 2.47 | 0.82 |
| 33 | 54% Ammonium sulfate [$(NH_4)_2SO_4$] + 46% Calicum chloride ($CaCl_2$) | 4 | 36 | 3.13 | 1.04 |
| 34 | 54% Ammonium sulfate [$(NH_4)_2SO_4$] + 46% Calicum chloride ($CaCl_2$) | 8 | 72 | 4.97 | 1.62 |
| 35 | 75% Rock Salt ($NaCl_2$) + 25% Calicum chloride ($CaCl_2$) flakes | 2 | 18 | 0.99 | 0.63 |
| 36 | 75% Rock Salt ($NaCl_2$) + 25% Calicum chloride ($CaCl_2$) flakes | 4 | 36 | 2.76 | 0.68 |
| 37 | 75% Rock Salt ($NaCl_2$) + 25% Calicum chloride ($CaCl_2$) flakes | 8 | 72 | 1.43 | 0.71 |
| 38 | 67% Rock Salt ($NaCl_2$) + 33% Calicum chloride ($CaCl_2$) flakes | 2 | 18 | 1.10 | 0.65 |
| 39 | 67% Rock Salt ($NaCl_2$) + 33% Calicum chloride ($CaCl_2$) flakes | 4 | 36 | 1.10 | 0.66 |
| 40 | 67% Rock Salt ($NaCl_2$) + 33% Calicum chloride ($CaCl_2$) flakes | 8 | 72 | 1.18 | 0.69 |
| 41 | 50% Rock Salt ($NaCl_2$) + 50% Calicum chloride ($CaCl_2$) flakes | 2 | 18 | 1.06 | 0.55 |
| 42 | 50% Rock Salt ($NaCl_2$) + 50% Calicum chloride ($CaCl_2$) flakes | 4 | 36 | 1.11 | 0.55 |
| 43 | 50% Rock Salt ($NaCl_2$) + 50% Calicum chloride ($CaCl_2$) flakes | 8 | 72 | 1.15 | 0.59 |
| | $LSD_{0.05}$ | | | 1.70 | 0.76 |

# Stabilizing Sand-based Athletic Fields With Enkamat

*David D. Minner and Jeffrey J. Salmond*

## Objectives

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 that 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 the 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.

TREATMENTS

**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 sub-dividing 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 inches 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 inches 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.

From May through August plots will be evaluated for turf appearance, surface hardness, and traction. From mid-August through September all treatments will receive simulated traffic treatments. Traffic will be 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 traffic that produces a tearing action of the grass surface. Turf will be evaluated during a non-traffic recovery period from 1 October to mid-November. The entire study area will receive both hollow and solid coring in 1998 to determine if Enkamat disrupts this routine management practice.

## 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.

## 1997 Enkamat Study Plot Plan

←N

Sodded November 7, 1997

'Midnight' Kentucky bluegrass

← **13 ft.** →

↑ **16 ft.** ↓

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 3 | 1 | 2 |
| 2 | 3 | 1 |

**Objective:** To determine required depth of placement for Enkamat.

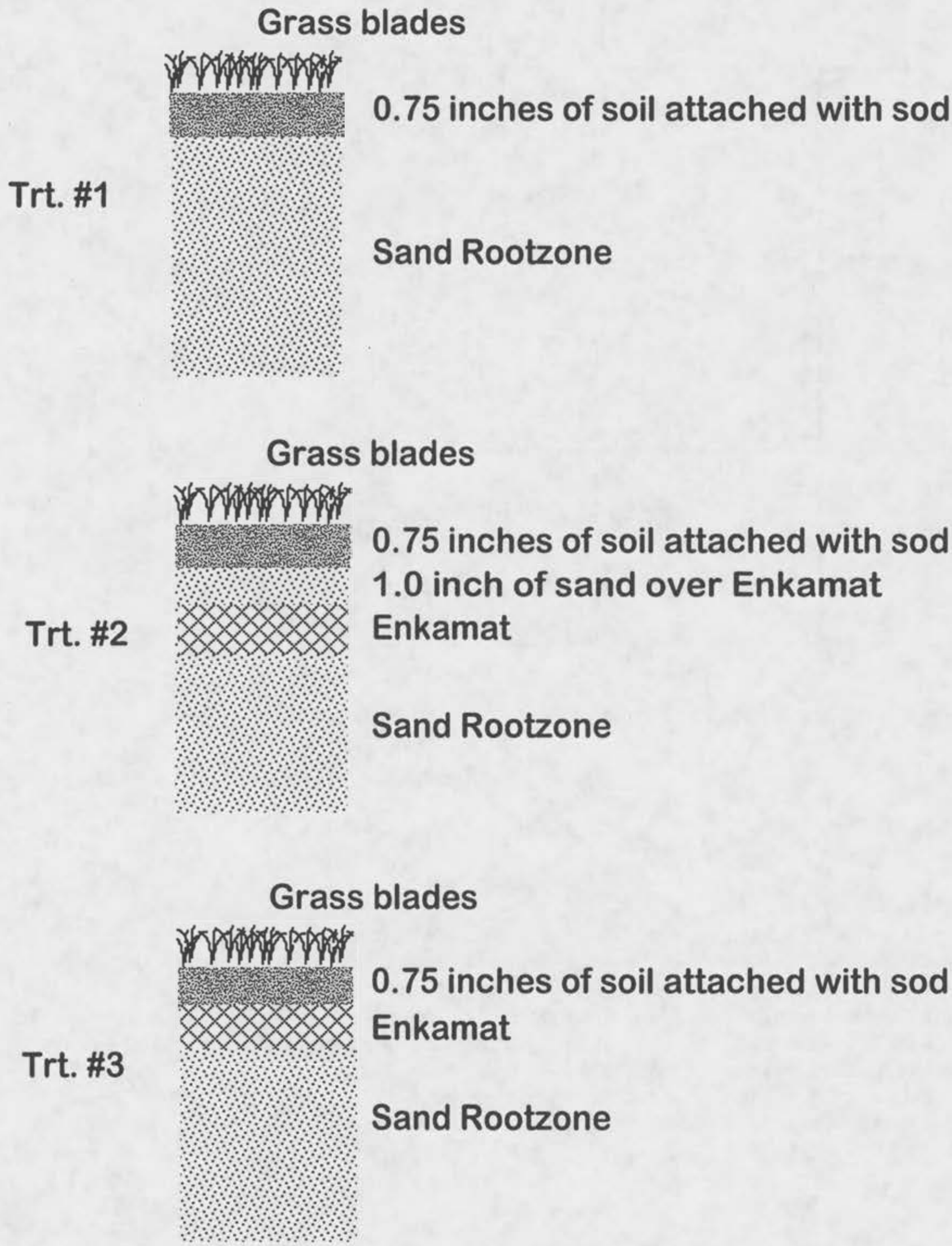
**Treatments:**

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.

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



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

*David D. Minner and Jeffrey J. Salmond*

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 biomas 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 and coring treatments were applied on 19 September 1997. Primo treatments will begin in 1998. Verticutting was applied by making two passes over the plot in opposite directions using a Bluebird vertical mower set to cut approximately 1/4-inch into the surface (even with 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 aerifyer 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.

*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 will evaluate the performance of a SportGrass® system with respect to hardness and footing.

In both studies, surface hardness and traction measurements were taken on 12 November. 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. Soil moisture content was performed on five plots in the mat management study. 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.

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).

**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.

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.

## 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<br>North « | | | | |

| |
|---|
| Rep 1 |
| Rep 2 |
| Rep 3 |

**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.** Soil moisture taken on selected plots.

| Treatment | Rep | Sample description | By weight % soil moisture | By weight % 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 bluegrass
[2] 'Pinnacle' perennial ryegrass

# Managing Bentgrass Stress on Putting Green Slopes

*David D. Minner, Nick E. Christians, Iowa State University*
*Tom Verrips, Otter Creek Golf Course, Ankeny, IA*

Meaningful research is necessary if superintendents are to make confident changes in their golf management program. A recent GCSAA survey showed that 82% of the respondents felt that "research trials conducted on golf courses yield more accurate and usable information for the golf industry than the same trials conducted on university field plots". The actual research location may not be so important but the take-home message here is that researchers must begin to manage field plot facilities under the same level of stress that actually occurs under golfing conditions. For example, intense traffic, extremely low mowing height, and excessive ball marks are seldom found in research plots. Further more, research greens are usually perfectly flat, often deep rooted, and seldom require a regiment of hand watering even during hot and dry summers.

Difficult summer growing conditions, such as high temperature and moisture extremes, can dictate the fate of problem greens even when the best turf management practices are used. Excessive rain followed by high humidity and heat leads to a shallow dysfunctional root system. Dry spots develop and greens require more frequent watering. Summer diseases begin to show up and fungicide application is increased. Some turf loss occurs and algae begins to invade the moist surface where grass is thin. The amount of turf loss in any given year is unfortunately dependent upon the weather and how long the adverse conditions persist. Turf management practices are usually applied uniformly across a putting surface, however problem areas on a green are anything but uniform. Severe turf loss occurs in high stress areas of putting greens, and therefore, it is important to evaluate management practices and products under realistic conditions of high stress.

A sloped research green (SRG) was constructed at the Horticulture Research Station, Ames, IA, in 1997 to evaluate bentgrass management under difficult and variable growing conditions. The green was seeded with Crenshaw creeping bentgrass in September 1997 and currently has 70% turf cover. Treatments are scheduled to begin September 1998. Construction of the green was funded by Iowa State University, Iowa Golf Course Superintendents Association, and the Golf Course Superintendents Association of America. The SRG was erected to simulate the undulating topography that occurs on many putting greens - as opposed to a typical flat research green. The sand-based portion of the SRG is 100 ft by 40 ft by 1 ft. The subgrade, gravel blanket, and sand rootzone all follow the same contour. The 12-inch sand rootzone contains no amendment and is positioned over a 4-inch gravel blanket with 4-inch drain lines. 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.

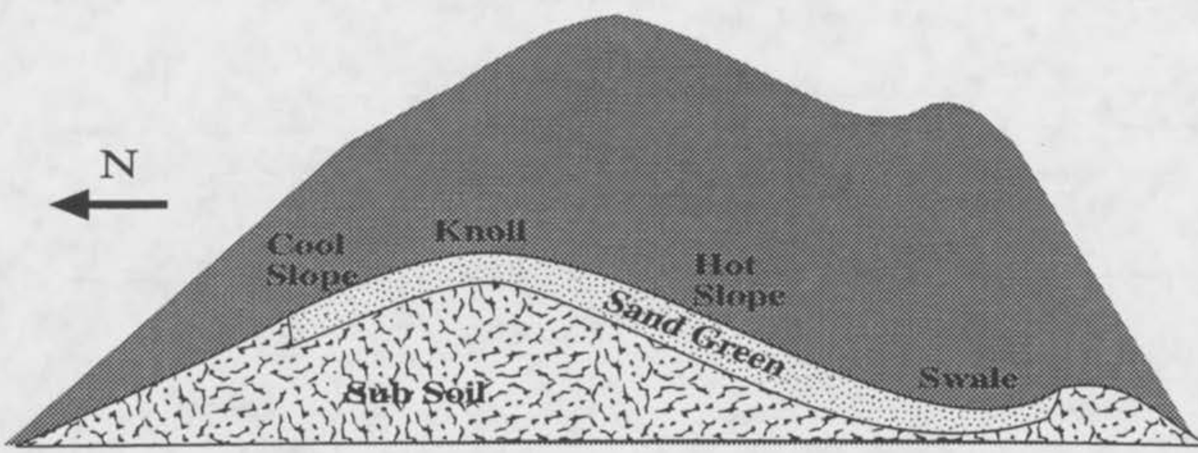
To our knowledge, the type of sloped green project that we are proposing has never been used for putting green research.

No amendments, organic or inorganic, were used to construct the 12-inch rootzone. The sand has a pH of 8.2 and is calcareous. Topdressing treatments will begin in 1998 and will be routinely applied to 40 ft. by 3.5 ft plots. The long and narrow plots are situated so that each treatment covers all four distinct micro-environments on the green. This plot arrangement allows for three replications of nine topdressing treatments. The nine topdressing treatments include combinations of organic (Dakota Peat or hypnum peat) and inorganic amendments (porous ceramic clay, diatomaceous earth, and zeolite).

To evaluate treatments and simulate actual growing conditions, greens will receive routine traffic and mowing at 0.135 inches (3.4 mm). Simulated traffic (18,000 rounds per year) will be applied with a Brouwer TR224 cleated roller that was converted to apply differential slip type traffic (design by Dr. Bob Carrow). Heavy spring rains will be simulated by excessive irrigation in May. Dry conditions will be simulated by restricting irrigation on a temporary basis from June through August. A "spoon feeding" fertility program will be applied based on soil and tissue testing results from the non-amended control plots.

We are not seeking subtle differences in turf quality, but instead seek the difference between survival and complete loss of turf that may be related to stresses that accumulate on sloped areas of greens.

**Fig 1. Sloped Research**



# Effects of Soil Amendments on the Chemical and Physical Soil Parameters of a Sand-based Golf Green

*Young K. Joo, Nick E. Christians, Deying Li, and David D. Minner*

The objective of this study is to investigate the effects of inorganic soil amendment materials Bio-ceramic, Profile, Axis, and Bio-Flex-A-Clay on the chemical and physical soil parameters of a sand-based golf green. Bio-ceramic is a ceramic material from Korea. Axis is a diatomaceous earth and Profile is a porous ceramic clay material. Bio-Flex-A-Clay is a polymer coated sand from a product of True Pitch, Inc. of Altoona, Iowa. The Bio-Flex-A-Clay is the same product with a kelp material incorporated on the Flex-A-Clay. A USGA type sand-based green was constructed in the summer of 1996. The green consisted of a 12-inch sand rootzone placed over a 4-inch gravel blanket. No intermediate "choaker" layer was used between the sand and the gravel blanket. The sand and pea gravel materials used in the plot met the particle size specifications of a USGA green. A network of 4-inch drain lines were trenched into the subsoil below the gravel blanket. No organic or inorganic amendments were used in green construction since they were added at a later date as treatments. The study area consisted of five treatments (Table 1) replicated six times. The 15 plots each measured 6 x 9 ft. The sand from each plot was removed to a 6-inch depth. The sand was combined with 5% volume/volume Dakota peat and 10% of each of the amendments as outlined in Table 1. The mixture was then replaced on the plot area and allowed to settle. The area was seeded with 1 lb. 'Crenshaw' creeping bentgrass/1000 $ft^2$ in September of 1996. A 10-20-10 fertilizer was applied to supply 1 lb. N/1000 $ft^2$ as a starter fertilizer.

**Table 1.** The five treatments established in the sand green.

| | Treatment | Sand % | Amendment % | Dakota Peat % |
|---|---|---|---|---|
| 1 | Control | 95 | 0 | 5 |
| 2 | Bio-ceramic | 85 | 10 | 5 |
| 3 | Profile | 85 | 10 | 5 |
| 4 | Axis | 85 | 10 | 5 |
| 5 | Bio-Flex-A-Clay | 85 | 10 | 5 |

The grass was severely damaged by winter kill and was reseeded with 1.5 lb. Crenshaw/1000 $ft^2$ on May 13, 1997. Starter fertilizer was reapplied at the same rate as that used in the fall.

The grass became fully established during the 1997 season. In November of 1997, soil samples were collected for chemical testing. The samples were submitted to Harris Laboratory of Lincoln, NE and a full set of chemical evaluations were conducted. Undisturbed-intact soil columns were collected in November 1997 to develop a water release curve and test other soil physical parameters. These tests included saturated water conductivity, water retention at 40 cm, and soil bulk density. Each treatment was also sampled immediately after plot construction to develop soil physical measurements on recompacted samples. The samples were recompacted according to United States Golf Association specifications and each test was repeated.

Establishment data for May, July, and August demonstrated that the Bio-Flex-A-Clay had a very positive effect on the growth of the creeping bentgrass during grow-in (Table 2). This material contains kelp, which evidently affected establishment.

In chemical analysis, Profile was most effective in increasing cation exchange of the media (Table 3). Profile also doubled the amount of exchangeable potassium (K) and increased magnesium (Mg) by nearly 50%.

Saturated water conductivity was reduced by Bio-Flex-A-Clay (Table 4). Profile and Axis increased water retention and decreased bulk density as compared to the control.

Water release curves were very similar for the control, Bio-ceramic, and Bio-Flex-A-Clay. The Profile and Axis both resulted in higher water retention at each of the pressure treatments from 0 to 2 bars (Figure 1).

***We would like to acknowledge the National Natural Science Foundation of China for partial support of this research.***

**Table 2.** Establishment data (% cover) in May, July, and September of 1997.

| | Treatment | May | July | August | October |
|---|---|---|---|---|---|
| 1 | Control | 10 | 60 | 77 | 100 |
| 2 | Bio-ceramic | 13 | 60 | 80 | 100 |
| 3 | Profile | 10 | 57 | 80 | 100 |
| 4 | Axis | 10 | 47 | 67 | 100 |
| 5 | Bio-Flex-A-Clay | 80 | 100 | 100 | 100 |
| | $LSD_{0.05}$ | 5 | 15 | 13 | - |

**Table 3.** Soil test results for the inorganic soil modification study.

| Treatments | CEC | PH | SS | Na | OM | NIT | P | K | Mg | Ca |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 8.8 | 8.3 | 1 | 16 | 0.4 | 1 | 7.7 | 25 | 103 | 1551 |
| Bio-ceramic | 9.2 | 8.3 | 1 | 17 | 0.4 | 1 | 6.3 | 27 | 114 | 1625 |
| Profile | 9.5 | 8.2 | 1 | 20 | 0.4 | 1 | 7.7 | 51 | 145 | 1604 |
| Axis | 8.8 | 8.3 | 1 | 17 | 0.4 | 1 | 8.7 | 25 | 105 | 1548 |
| Bio-Flex-A-Clay | 8.0 | 8.3 | 1 | 14 | 0.5 | 1 | 7.3 | 24 | 1038 | 1394 |
| $LSD_{0.05}$ | 0.4 | NS[1] | NS | NS | NS | NS | NS | 8 | 14 | 49 |

| | S | Zn | Mn | Cu | Fe | B | AK | AMg | ACa | ANa |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 1.7 | 0.9 | 3.1 | 0.5 | 11.9 | 0.3 | 0.7 | 9.8 | 88.7 | 0.8 |
| Bio-ceramic | 1.0 | 1.4 | 3.6 | 2.1 | 15.5 | 0.3 | 0.8 | 10.3 | 88.1 | 0.8 |
| Profile | 1.3 | 0.9 | 2.9 | 0.9 | 17.3 | 0.3 | 1.4 | 12.8 | 84.9 | 0.9 |
| Axis | 1.7 | 0.7 | 3.3 | 0.4 | 15.3 | 0.3 | 0.7 | 10.0 | 88.4 | 0.9 |
| Bio-Flex-A-Clay | 2.7 | 1.2 | 3.3 | 0.9 | 11.9 | 0.3 | 0.8 | 11.3 | 87.2 | 0.8 |
| $LSD_{0.05}$ | NS | NS | NS | NS | NS | NS | 0.2 | 1.2 | 1.3 | NS |

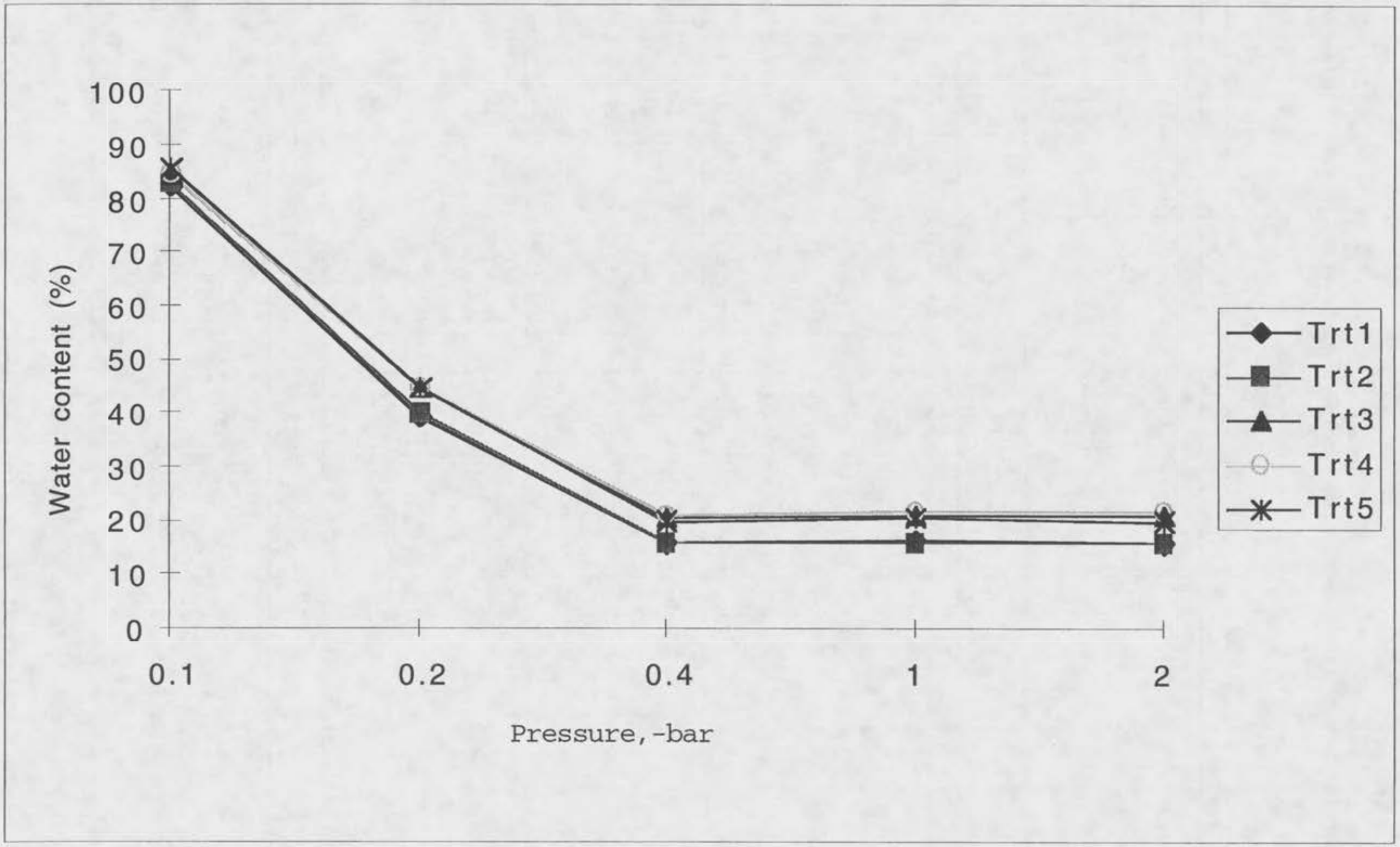
[1]NS = Not significant at 0.05 level
CEC = Cation Exchange Capacity (meg/100g)
SS = Soluble salts (mmhos/cm)
Na = Sodium (ppm)
OM = Organic matter (%)
NIT = Nitrate N (ppm)
AK = Actual potassium (% base saturation)
AMg = Actual magnesium (% base saturation)
ACa = Actual calcium (% base saturation)
ANa = Actual sodium (% base saturation)
All others units = ppm

**Table 4.** Physical test for the inorganic modified soil.

| | Undisturbed | | | Recompacted | | |
|---|---|---|---|---|---|---|
| Treatment | $K_{sat}$[1] | $W_{ret}$[2] | $D_b$[3] | $K_{sa}$ | $W_{re}$ | $D_b$ |
| Control | 45.7 | 24.1 | 1.49 | 34.0 | 21.9 | 1.49 |
| Bio-ceramic | 43.9 | 23.7 | 1.48 | 37.7 | 20.9 | 1.48 |
| Profile | 46.8 | 27.2 | 1.44 | 40.7 | 23.5 | 1.44 |
| Axis | 44.5 | 27.3 | 1.42 | 33.4 | 24.9 | 1.42 |
| Bio-Flex-A-Clay | 39.5 | 23.6 | 1.55 | 27.5 | 20.3 | 1.55 |
| $LSD_{0.05}$ | 3.8 | 1.2 | 0.05 | 3.5 | 2.2 | 0.04 |

[1]$K_{sat}$=Saturated water conductivity (cm/hr)
[2]$W_{ret}$=Water retention at -40cm water pressure (% of water based on dry soil)
[3]$D_b$=Soil dry bulk density (g/cm$^3$)
[4]Recompacted according the undisturbed value

Figure 1. Soil moisture release curve for undisturbed samples of each amendment treatment completed in November 1997.



# Effects of Bio-Flex-A-Clay on Creeping Bentgrass Establishment and Growth

*Nick E. Christians, Melissa C. McDade, David D. Minner, Deying Li, and Young K. Joo*

## Introduction:

Bio-Flex-A-Clay is a product of True Pitch, Inc. of Altoona, Iowa. Flex-A-Clay is a material normally used for stabilization of pitching mounds and other athletic field areas. Bio-Flex-A-Clay is the same product with a kelp material incorporated on the Flex-A-Clay. Preliminary field tests conducted at Iowa State University in 1996 and 1997 demonstrated improved establishment of creeping bentgrass in sand-based field plots that had been treated with Bio-Flex-A-Clay. The study discussed in this report was designed to determine which of the components of this product were responsible for the improved establishment observed in the field studies.

## Objectives:

The objectives of the study were to observe the effects of Bio-Flex-A-Clay, each of its component parts, and of equivalent amounts of nitrogen (N), phosphorus (P), and potassium (K), on the establishment, growth, and root development of creeping bentgrass under controlled environmental conditions in the greenhouse. Dakota peat, a standard used for rootzone modification, was also included as a comparison.

## Materials and Methods:

Pure sand that had been screened to meet United States Golf Association (USGA) standards for golf course green construction was used as the growing media. The sand media was placed in plastic sleeves with a 1.5-inch inside diameter, 1.77 sq. inch surface area, and length of 24 inches. The soil profile followed USGA recommendations for putting green construction. Each profile had a 14-inch rootzone, a 2-inch intermediate layer, and an 8-inch pea gravel subgrade. The plastic sleeve was then inserted into a 2-inch diameter PVC pipe and placed on a 30° angle from vertical. Roots growing in a downward direction intercepted the plastic sleeve and were visually measured using a non-destructive technique. The sleeve was sealed on the bottom and punctured to provide drainage.

The amendments (Table 1) were incorporated into the upper six inches of mixture. The treatments included pure sand as a control with no amendments, the Bio-Flex-A-Clay at 2.5, 5, and 10% v/v of the mixture, N-P-K treatment that contained equivalent amounts of nutrients as supplied by the kelp in the Bio-Flex-A-Clay treatment, Flex-A-Clay alone with no kelp, polymer alone, the clay alone, the kelp alone, Clay+polymer+kelp, and Dakota peat at 10% v/v. Crenshaw creeping bentgrass was seeded at 4.9 $g/m^2$ to the surface. A randomized complete block design with four replications was used. The study was initiated in October, 1997 and terminated on January 24, 1998. Data were collected on the number of days required for plants to become established to the three-leaf stage, shoot density, and total root biomass. Weekly evaluations of rooting depth were made by lifting the plastic sleeves from the PVC pipe and measuring the longest root.

**Table 1**. Bio-Flex-A-Clay Greenhouse Study -1997/98.

| | Treatment | Materials | Rate |
|---|---|---|---|
| 1 | Control | Pure sand | 100% |
| 2 | Bio-Flex-A-Clay (BFAC) | BFAC 2.5% (v/v) | 4.51 g dry wt. basis |
| 3 | Chemical Fertilizer. #1 | same N, P, K for 'Trt 2' | 10.8 mg N, 0.4 mg P, 7.2 mg K |
| 4 | Bio-Flex-A-Clay (BFAC) | BFAC 5.0% (v/v) | 9.03 g dry wt. basis |
| 5 | Chemical Fertilizer. #2 | same N, P, K for 'Trt 4' | 21.7 mg N, 0.8 mg P, 14.3 mg K |
| 6 | Bio-Flex-A-Clay (BFAC) | BFAC 10% (v/v) | 18.05 g dry wt. basis |
| 7 | Chemical Fertilizer. #3 | same N, P, K for 'Trt 6' | 43.3 mg N, 1.59 mg P, 28.6 mg K |
| 8 | Flex-A-Clay (FAC) | FAC 10% | 22.01 g same volume of 'Trt 6' |
| 9 | Clay | Clay (20.2% w/w) | 3.65 g same amount in 'Trt 6' |
| 10 | Polymer | Polymer (7.1% w/w) | 1.28 g same amount in 'Trt 6' |
| 11 | Kelp | Kelp (6.6% w/w) | 1.19 g same amount in 'Trt 6' |
| 12 | Clay + Polymer + Kelp | Trt (9+10+11) | same amount in 'Trt 6' |
| 13 | Peat | Dakota peat 10% (v/v) | 14.67 $cm^3$ |

There were no significant differences among the treatments in the number of days for the newly established plants to reach the 3-leaf stage (Table 2). Root length increased from 19.2 cm in the control to 37 cm in the 2.5% Bio-Flex-A-Clay treatments, to 43.8 cm in the 5% Bio-Flex-A-Clay, to 63.7 cm in the 10% Bio-Flex-A-Clay treatment. The maximum root length observed at the end of the project was greatest in the treatments that received the Bio-Flex-A-Clay at 10% v/v. This root length in the 10% Bio-Flex-A-Clay treatment was 3.4 times greater than in treatments that received an equivalent amount of N-P-K, was 2.8 times greater than the treatment that received an equivalent amount of kelp to that included in the 10% Bio-Flex-A-Clay treatment, and 1.7 times greater than Dakota peat.

Shoot density was highly variable. The Dakota peat had the highest shoot density at termination. The Bio-Flex-A-Clay provided no apparent advantage in shoot density. The effect of the peat was likely due to extra water holding capacity, which would improve seedling establishment in the sand media.

Root biomass was 6.3 times higher in the 10% v/v Bio-Flex-A-Clay treatment than in the control and nearly double any of the other treatments. The bentgrass treated with Bio-Flex-A-Clay had 8.3 times more roots than the sand treated with Flex-A-Clay alone. There were 3.7 times more roots in the 10% v/v Bio-Flex-A-Clay treatment than in the 5% treatment. Treatments that included Bio-Flex-A-Clay at the 10% level had 1.9 times more root mass than units modified with the Dakota peat.

Weekly evaluations of root growth taken during the study showed a clear advantage to the 10% v/v Bio-Flex-A-Clay treatment (Figure 1). This was true from the first testing date and continued throughout the study.

## CONCLUSION

There was a clear advantage in rooting of creeping bentgrass that was treated with the Bio-Flex-A-Clay. The 10% v/v treatment with this material was much better than the 2.5 or 5% Bio-Flex-A-Clay treatments. It also far exceeded the rooting in treatments that contained the same N-P-K rates as that provided by the kelp contained in the Bio-Flex-A-Clay and it exceeded sand treated with equivalent amounts of kelp without the Flex-A-Clay and treatments receiving Dakota peat. There was no apparent advantage in shoot density in units treated with Bio-Flex-A-Clay in this greenhouse trial although we did see a clear advantage in shoot density in early field trials.

More work should be conducted under field conditions to determine if topdressing with Bio-Flex-A-Clay provides any advantage in sand-based systems.

***We would like to acknowledge the National Natural Science Foundation of China for partial support of this research.***

**Table 2.** Effects of inorganic soil modification on bentgrass growth.

| | Treatments | Three-leaf Stage[2] (days after seeding) | Root Length[3] (cm) | Shoot Density[3] (# of shoot/$cm^2$) | Root Biomass[4] (g/column) |
|---|---|---|---|---|---|
| 1 | Pure sand | 36.3 | 19.2 | 2.80 | 0.025 |
| 2 | Bio-Flex-A-Clay 2.5% (v/v) | 37.3 | 37.0 | 2.23 | 0.047 |
| 3 | 10.8 mg N, 0.4mg P, 7.2 mg K | 41.5 | 27.1 | 1.30 | 0.016 |
| 4 | Bio-Flex-A-Clay 5.0% (v/v) | 38.0 | 43.8 | 0.88 | 0.043 |
| 5 | 21.7 mg N, 0.8 mg P, 14.3 mg K | 36.3 | 28.0 | 1.13 | 0.010 |
| 6 | Bio-Flex-A-Clay 10% (v/v) | 31.5 | 63.7 | 2.73 | 0.157 |
| 7 | 43.3 mg N, 1.59 mg P, 28.6 mg K | 41.5 | 19.0 | 3.70 | 0.062 |
| 8 | Flex-A-Clay 10% (v/v) | 43.0 | 21.9 | 1.78 | 0.019 |
| 9 | Clay 20.2% (w/w) | 38.5 | 30.3 | 3.68 | 0.036 |
| 10 | Polymer 7.1% (w/w) | 33.3 | 10.9 | 0.40 | 0.003 |
| 11 | Kelp 6.6% (w/w) | 27.0 | 22.9 | 3.15 | 0.070 |
| 12 | Clay, Polymer, Kelp | 32.3 | 29.4 | 2.98 | 0.076 |
| 13 | Dakota Peat 10% (v/v) | 31.3 | 38.4 | 4.25 | 0.084 |
| | $LSD_{0.05}$ | NS[1] | 11.2 | 1.88 | 0.044 |

[1]NS = Not significant at 0.05 level
[2]Seeded Oct. 16, 1997
[3]Measured Jan. 15, 1998
[4]Measured Jan. 24, 1998. Column equals 11.1 $cm^2$ (1.77 $inch^2$) X 60 cm

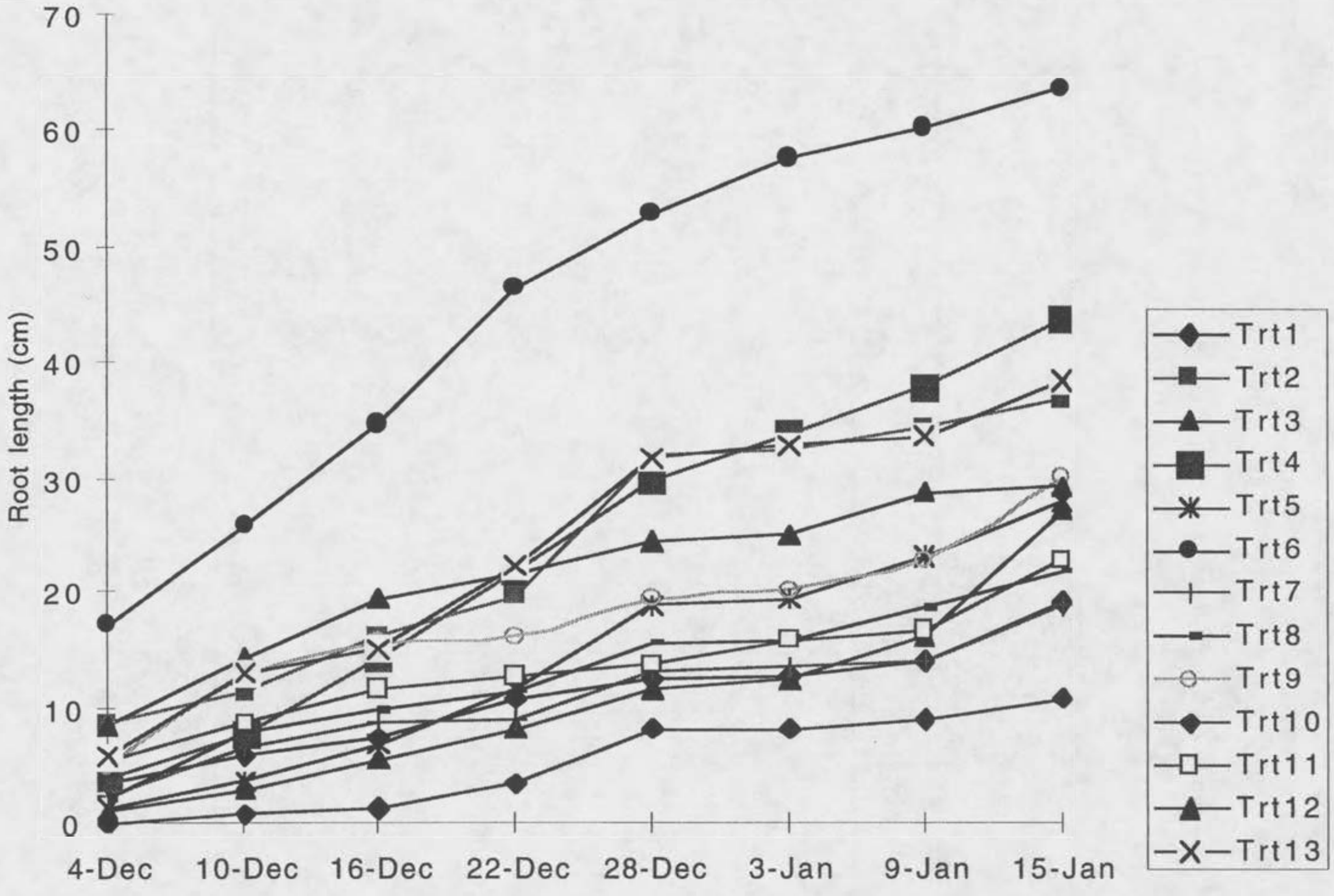



Figure 1. Root growth affected by soil modification

**Treatments:**

1: Pure sand
2: Bio-Flex-A-Clay 2.5% (v/v)
3: 10.8 mg N, 0.4 mg P, 7.2 mg K
4: Bio-Flex-A-Clay 5.0% (v/v)
5: 21.7 mg N, 0.8 mg P, 14.3 mg K
6: Bio-Flex-A-Clay 10% (v/v)
7: 43.3 mg N. 1.59 mg P, 28.6 mg K
8: Flex-A-Clay 10% (v/v)
9: Clay 20.2% (w/w)
10: Polymer 7.1% (w/w)
11: Kelp 6.6% (w/w)
12: 20.2% Clay, 7.1% Polymer, 6.6% Kelp (w/w)
13: Dakota Peat 10% (v/v)

# Responses of Creeping Bentgrass to Organic and Inorganic Soil Amendments Under Stressed Conditions

*Young K. Joo, J. P. Lee, David D. Minner, and Nick E. Christians*

The objectives of this research were to investigate the effects of inorganic soil amendments on the growth of creeping bentgrass established on a sand-based soil media under stressed conditions. The organic amendments included hypnum, Dakota, and Irish peat at 10% v/v (volume/volume) of the sand mix. The inorganic amendments included Axis (a diatomaceous earth), Profile (a porous ceramic clay), Flex-A-Clay (a polymer coated sand), and Bio-ceramic (a ceramic material from Korea). Following establishment, the grass was subjected to water, nutrient, and high temperature stress. The study was initiated in June, 1996 and was terminated in January 1997.

The amendments were uniformly incorporated into the upper 14 inches of the sand column. The treatments included a pure sand control, and the amendments were mixed at 10% v/v of mixture. Bio-ceramic was also included at 5% of the mixture. The sand and other materials used in the columns were sieved to meet particle size specifications of a USGA green. Soil profiles in the columns followed USGA recommendations for putting green construction. Each profile had an intermediate 4-inch choker layer and a 6-inch pea gravel sub-layer. The 24-inch profiles were established in a clear plastic sleeve with a 1.5 in$^2$ surface area. The sleeves were placed in a PVC pipe with 2 inch inside diameter. The sleeve was sealed on one end and punctured to provide drainage. 'Crenshaw' creeping bentgrass was seeded on the column surface at the equivalent of 1 lb seed/1000 ft$^2$. The grass was grown under normal conditions for four weeks. High pressure sodium lamps were used as the light source and greenhouse temperature was maintained at 65 to 72° F. The tubes were tilted on a 30° angel from vertical at the end of the 4-week establishment period to force the roots to grow down the lower side of sleeve. This allowed for a biweekly, nondestructive measurement of root growth. The study was designed as a randomized complete block with four replications.

The water and nutrient stress treatments were started at the 4th week and lasted three months. The tubes were irrigated at least two times/week with a total of 2 inches of water for normal grass growth. Water stress treatments received one-quarter of the water applied to the other normal units. The normal fertilizer treatment received 0.5 lbs. N/1000 ft$^2$ (1:1:1 N, $P_2O_5$, $K_2O$) every two weeks. The nutrient stressed units received one-fourth of the normal fertilization rate. High temperature stress treatments were started after three and one-half months of the normal growing conditions in the greenhouse. The high temperatures were established in a growth chamber set at 95° F (day) and 85° F (night). The high temperature treatments were maintained for 16 weeks.

Visual turf quality, dry weight of clippings, and root length were measured every two weeks. Root weight data were collected at harvest.

Both organic and inorganic amendments produced better quality ratings than the control under normal, moisture stressed, and low nutrient conditions. The organic treatments generally provided higher quality than the inorganics (Table 1). The inorganic amendments did not produce greater clipping yields than the control under normal and low nutrient conditions. They did, however, improve growth under moisture stressed conditions. Organic amendments increased clipping yields over the control and over the inorganic amendments under all three conditions (Table 2).

Root lengths generally increased for both inorganic and organic amended treatments for both normal and moisture stressed conditions, with organic treatments generally exceeding inorganics. Neither group of soil amendments improved root length in low nutrient conditions. Total root weights were not improved by inorganic or organic amendments in normal and low nutrient conditions. Both amendments improved total root mass under moisture stressed conditions (Table 3).

There were no significant effects of amendments on clipping production during the first three months of high temperature treatment (Table 4). By the end of the 4th month, the grass grown on columns with Dakota peat had much higher clipping weights than any of the other treatments. Turf quality ratings were generally improved by inorganic and organic amendments, with Flex-A-Clay (small) and Dakota peat providing the highest ratings. Total plant weight at termination (HTTW) was enhanced by inorganic and organic amendments.

**Table 1.** Visual quality ratings for columns receiving normal moisture and fertility levels.

| | Normal Conditions | | | | | | | Moisture Stress | | | | | | | Low Nutrient | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amendment | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | MQ | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | MQ | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | MQ |
| Pure Sand (Control) | 4.25 | 5.25 | 4.75 | 6.00 | 6.75 | 7.25 | 5.71 | 4.25 | 4.00 | 3.50 | 3.50 | 4.00 | 3.75 | 3.83 | 3.75 | 4.50 | 4.75 | 5.25 | 3.75 | 4.00 | 4.33 |
| Inorganic | | | | | | | | | | | | | | | | | | | | | |
| Bio-ceramic 5% | 4.50 | 5.75 | 6.00 | 7.75 | 8.25 | 8.25 | 6.75 | 4.00 | 4.50 | 6.00 | 6.00 | 6.25 | 5.75 | 5.42 | 5.50 | 7.50 | 6.75 | 6.75 | 6.00 | 5.00 | 6.25 |
| Bio-ceramic 10% | 5.00 | 6.00 | 6.75 | 8.25 | 8.25 | 8.50 | 7.13 | 4.75 | 3.75 | 5.25 | 5.25 | 5.00 | 5.00 | 4.92 | 5.50 | 7.00 | 7.00 | 6.75 | 5.75 | 4.75 | 6.13 |
| Profile | 5.25 | 6.25 | 5.75 | 7.00 | 7.50 | 8.75 | 6.75 | 6.50 | 5.25 | 3.50 | 3.50 | 3.50 | 4.25 | 4.42 | 5.00 | 6.25 | 6.25 | 5.75 | 5.00 | 4.50 | 5.46 |
| Axis | 5.50 | 6.75 | 6.75 | 8.00 | 8.00 | 7.75 | 7.13 | 4.25 | 4.00 | 4.00 | 4.75 | 4.25 | 4.75 | 4.33 | 4.00 | 6.50 | 5.75 | 5.75 | 5.50 | 4.50 | 5.33 |
| Flex-A-clay (Large) | 4.75 | 6.00 | 6.75 | 8.00 | 7.25 | 7.25 | 6.67 | 4.00 | 4.25 | 5.25 | 5.75 | 5.00 | 5.50 | 4.96 | 5.25 | 6.50 | 7.00 | 6.50 | 5.00 | 4.50 | 5.79 |
| Flex-A-clay (Small) | 4.50 | 7.25 | 6.50 | 8.25 | 8.50 | 9.00 | 7.33 | 4.25 | 4.75 | 6.00 | 6.75 | 5.75 | 5.75 | 5.54 | 5.25 | 6.25 | 6.25 | 6.25 | 5.25 | 4.00 | 5.54 |
| Organic | | | | | | | | | | | | | | | | | | | | | |
| Hypnum peat | 4.75 | 6.25 | 7.25 | 7.25 | 6.75 | 8.50 | 6.79 | 4.50 | 5.50 | 7.25 | 7.00 | 6.50 | 7.00 | 6.30 | 4.75 | 5.75 | 6.50 | 6.00 | 4.75 | 4.50 | 5.38 |
| Dakota peat | 7.00 | 8.75 | 8.50 | 8.00 | 8.25 | 8.50 | 8.17 | 7.00 | 9.00 | 7.00 | 6.75 | 7.00 | 6.50 | 7.21 | 6.75 | 9.00 | 8.25 | 7.50 | 6.50 | 6.00 | 7.33 |
| Irish peat | 6.00 | 6.25 | 8.25 | 8.50 | 7.50 | 9.00 | 7.58 | 6.25 | 7.50 | 7.50 | 6.50 | 6.25 | 5.75 | 6.63 | 6.25 | 8.00 | 7.25 | 6.50 | 6.00 | 5.75 | 6.63 |
| LSD.05 | N.S | 1.54 | 1.69 | N.S | N.S | 1.08 | 0.75 | 1.39 | 1.70 | 1.77 | 1.31 | 1.56 | 1.61 | 0.90 | 1.55 | 1.50 | N.S | 1.16 | 1.32 | N.S | 0.76 |
| Pure sand vs. Inorganic (p-value) | 0.28 | 0.07 | 0.01 | 0.00 | 0.04 | 0.02 | 0.00 | 0.48 | 0.52 | 0.03 | 0.00 | 0.11 | 0.02 | 0.00 | 0.03 | 0.00 | 0.02 | 0.02 | 0.00 | 0.38 | 0.00 |
| Pure sand vs. Organic (p-value) | 0.02 | 0.01 | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| Inorganic vs. Organic (p-value) | 0.02 | 0.01 | 0.00 | 0.90 | 0.22 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.02 | 0.07 | 0.20 | 0.31 | 0.03 | 0.00 |

Q1 to Q6 = biweekly quality ratings; 9 = best and 1 = worst quality. MQ = mean quality.

**Table 2.** Dry clipping weights for columns receiving normal, moisture stress, and low nutrient treatments.

| | Normal Conditions | | | | | | Moisture Stress | | | | | | Low Nutrient | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amendment | C1 | C2 | C3 | C4 | C5 | TC | C1 | C2 | C3 | C4 | C5 | TC | C1 | C2 | C3 | C4 | C5 | TC |
| Pure Sand (Control) | 0.03 | 0.05 | 0.10 | 0.17 | 0.22 | 0.57 | 0.03 | 0.02 | 0.05 | 0.06 | 0.07 | 0.22 | 0.02 | 0.08 | 0.13 | 0.11 | 0.02 | 0.37 |
| Inorganic | | | | | | | | | | | | | | | | | | |
| Bio-ceramic 5% | 0.02 | 0.07 | 0.15 | 0.18 | 0.24 | 0.66 | 0.04 | 0.02 | 0.15 | 0.17 | 0.07 | 0.44 | 0.03 | 0.09 | 0.15 | 0.16 | 0.03 | 0.47 |
| Bio-ceramic 10% | 0.03 | 0.07 | 0.18 | 0.20 | 0.25 | 0.73 | 0.03 | 0.04 | 0.14 | 0.11 | 0.08 | 0.40 | 0.05 | 0.12 | 0.15 | 0.09 | 0.03 | 0.44 |
| Profile | 0.04 | 0.09 | 0.17 | 0.17 | 0.24 | 0.72 | 0.06 | 0.01 | 0.03 | 0.07 | 0.07 | 0.25 | 0.04 | 0.12 | 0.16 | 0.10 | 0.02 | 0.44 |
| Axis | 0.03 | 0.11 | 0.17 | 0.22 | 0.20 | 0.73 | 0.03 | 0.03 | 0.10 | 0.11 | 0.10 | 0.38 | 0.03 | 0.08 | 0.11 | 0.11 | 0.03 | 0.37 |
| Flex-A-clay (Large) | 0.03 | 0.07 | 0.32 | 0.17 | 0.22 | 0.81 | 0.04 | 0.05 | 0.14 | 0.16 | 0.10 | 0.49 | 0.05 | 0.14 | 0.15 | 0.16 | 0.03 | 0.53 |
| Flex-A-clay (Small) | 0.02 | 0.06 | 0.16 | 0.12 | 0.19 | 0.54 | 0.02 | 0.04 | 0.16 | 0.17 | 0.13 | 0.52 | 0.04 | 0.12 | 0.15 | 0.17 | 0.02 | 0.51 |
| Organic | | | | | | | | | | | | | | | | | | |
| Hypnum peat | 0.04 | 0.09 | 0.23 | 0.23 | 0.20 | 0.80 | 0.05 | 0.14 | 0.22 | 0.16 | 0.09 | 0.66 | 0.04 | 0.13 | 0.15 | 0.13 | 0.03 | 0.47 |
| Dakota peat | 0.12 | 0.22 | 0.29 | 0.26 | 0.28 | 1.17 | 0.11 | 0.22 | 0.13 | 0.09 | 0.08 | 0.63 | 0.13 | 0.25 | 0.17 | 0.14 | 0.05 | 0.74 |
| Irish peat | 0.04 | 0.14 | 0.25 | 0.24 | 0.23 | 0.90 | 0.07 | 0.14 | 0.17 | 0.19 | 0.07 | 0.64 | 0.08 | 0.14 | 0.14 | 0.21 | 0.05 | 0.62 |
| LSD.05 | 0.02 | 0.06 | N.S | N.S | N.S | 0.28 | 0.03 | 0.05 | 0.06 | 0.07 | N.S | 0.10 | 0.04 | 0.07 | N.S | N.S | N.S | 0.18 |
| Pure sand vs. Inorganic (p-value) | 0.92 | 0.22 | 0.17 | 0.77 | 0.99 | 0.21 | 0.34 | 0.50 | 0.00 | 0.01 | 0.14 | 0.00 | 0.19 | 0.20 | 0.53 | 0.46 | 0.88 | 0.16 |
| Pure sand vs. Organic (p-value) | 0.00 | 0.00 | 0.03 | 0.06 | 0.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.31 | 0.21 | 0.14 | 0.00 |
| Inorganic vs. Organic (p-value) | 0.00 | 0.00 | 0.13 | 0.01 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.41 | 0.44 | 0.00 | 0.00 | 0.00 | 0.47 | 0.36 | 0.03 | 0.00 |

C1 to C5 = biweekly clipping weight in grams. TC = total clipping weight based on $9.6cm^2$

**Table 3.** Root growth (cm) measured every two weeks in columns receiving normal moisture and fertility treatments and Root Mass (g) measured at termination.

| | Normal Conditions | | | | Moisture Stress | | | | Low Nutrient | | | | Normal | Moisture Stress | Low Nutient |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TL1 | TL2 | TL3 | TL4 | TL1 | TL2 | TL3 | TL4 | TL1 | TL2 | TL3 | TL4 | | | |
| Amendment | Root Length (cm) | | | | | | | | | | | | Root Weight (g) | | |
| Pure Sand (Control) | 20.75 | 26.63 | 37.13 | 50.38 | 18.13 | 24.38 | 36.63 | 46.00 | 26.63 | 46.38 | 60.13 | 61.13 | 0.16 | 0.10 | 0.27 |
| Inorganic | | | | | | | | | | | | | | | |
| Bio-ceramic 5% | 24.03 | 36.65 | 46.53 | 56.00 | 25.38 | 36.63 | 45.88 | 55.88 | 29.63 | 50.50 | 59.50 | 60.00 | 0.25 | 0.17 | 0.27 |
| Bio-ceramic 10% | 24.13 | 35.88 | 46.88 | 59.25 | 29.75 | 40.88 | 52.50 | 58.00 | 28.75 | 46.88 | 58.30 | 61.88 | 0.18 | 0.17 | 0.29 |
| Profile | 23.50 | 30.63 | 39.88 | 53.13 | 24.50 | 39.25 | 47.25 | 55.75 | 29.00 | 49.00 | 61.63 | 62.00 | 0.20 | 0.10 | 0.67 |
| Axis | 27.88 | 40.25 | 47.75 | 58.38 | 29.75 | 42.38 | 53.25 | 59.63 | 25.50 | 41.38 | 58.25 | 61.75 | 0.21 | 0.11 | 0.24 |
| Flex-A-clay (Large) | 21.75 | 30.30 | 39.18 | 48.30 | 15.25 | 35.50 | 46.63 | 56.75 | 27.25 | 47.38 | 59.00 | 60.88 | 0.19 | 0.16 | 0.29 |
| Flex-A-clay (Small) | 24.00 | 33.75 | 44.25 | 54.38 | 25.88 | 40.25 | 51.25 | 60.00 | 27.13 | 45.50 | 60.00 | 61.75 | 0.27 | 0.18 | 0.29 |
| Organic | | | | | | | | | | | | | | | |
| Hypnum peat | 24.63 | 29.38 | 36.88 | 50.88 | 26.00 | 45.88 | 57.38 | 58.63 | 28.00 | 42.38 | 56.88 | 60.25 | 0.18 | 0.16 | 0.22 |
| Dakota peat | 29.00 | 39.00 | 44.20 | 51.58 | 37.88 | 55.00 | 58.38 | 58.38 | 34.13 | 48.38 | 57.88 | 60.25 | 0.17 | 0.17 | 0.27 |
| Irish peat | 30.75 | 44.25 | 52.63 | 59.13 | 26.75 | 40.00 | 53.13 | 57.75 | 32.38 | 48.25 | 54.13 | 55.88 | 0.20 | 0.19 | 0.23 |
| LSD.05 | N.S | 8.66 | 8.55 | N.S | 8.70 | 9.88 | 11.00 | 7.27 | N.S | N.S | N.S | N.S | N.S | 0.04 | N. S |
| Pure sand vs. Inorganic (p-value) | 0.26 | 0.02 | 0.04 | 0.15 | 0.04 | 0.00 | 0.00 | 0.00 | 0.66 | 0.93 | 0.83 | 0.90 | 0.12 | 0.00 | 0.58 |
| Pure sand vs. Organic (p-value) | 0.03 | 0.00 | 0.04 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.99 | 0.27 | 0.30 | 0.44 | 0.00 | 0.83 |
| Inorganic vs. Organic (p-value) | 0.06 | 0.17 | 0.82 | 0.60 | 0.02 | 0.00 | 0.02 | 0.75 | 0.05 | 0.87 | 0.14 | 0.06 | 0.24 | 0.03 | 0.23 |

TL1 to TL4 = biweekly root length measurements in centimeters.
Root weight based on 9.6cm$^2$ at harvest

**Table 4.** Data from high temperature stress conditions.

| Amendment | HT1 | HT2 | HT3 | HT4 | THT | HV1 | HV2 | HTTW |
|---|---|---|---|---|---|---|---|---|
| Pure Sand (Control) | 0.26 | 0.36 | 0.07 | 0.06 | 0.75 | 6.33 | 5.00 | 0.32 |
| Inorganic | | | | | | | | |
| Bio-ceramic 5% | 0.28 | 0.32 | 0.10 | 0.07 | 0.77 | 7.00 | 6.00 | 0.48 |
| Bio-ceramic 10% | 0.23 | 0.30 | 0.06 | 0.08 | 0.68 | 7.33 | 6.33 | 0.44 |
| Profile | 0.25 | 0.31 | 0.07 | 0.06 | 0.69 | 6.33 | 5.67 | 0.35 |
| Axis | 0.38 | 0.35 | 0.13 | 0.09 | 0.95 | 7.00 | 5.67 | 0.58 |
| Flex-A-clay (Large) | 0.25 | 0.28 | 0.16 | 0.05 | 0.73 | 6.67 | 6.67 | 0.51 |
| Flex-A-clay (Small) | 0.35 | 0.28 | 0.16 | 0.05 | 0.85 | 7.00 | 8.00 | 0.49 |
| Organic | | | | | | | | |
| Hypnum peat | 0.28 | 0.42 | 0.12 | 0.09 | 0.91 | 7.67 | 6.33 | 0.39 |
| Dakota peat | 0.31 | 0.36 | 0.26 | 0.21 | 1.14 | 8.33 | 8.00 | 0.50 |
| Irish peat | 0.27 | 0.27 | 0.10 | 0.05 | 0.70 | 6.33 | 6.67 | 0.37 |
| LSD.05 | N.S | N.S | N.S | 0.04 | N.S | 1.12 | 0.93 | 0.11 |
| Pure sand vs. Inorganic (p-value) | 0.49 | 0.22 | 0.31 | 0.84 | 0.78 | 0.19 | 0.00 | 0.00 |
| Pure sand vs. Organic (p-value) | 0.55 | 0.83 | 0.06 | 0.00 | 0.17 | 0.02 | 0.00 | 0.04 |
| Inorganic vs. Organic (p-value) | 0.94 | 0.13 | 0.11 | 0.00 | 0.07 | 0.05 | 0.01 | 0.05 |

HT1-HT4 = dry weight of clippings after 1 to 4 months of high temperature treatment.
THT = total dry clipping wt. from 4 months of growth.
HV1 and HV2 are quality ratings at 4 and 8 weeks, respectively.
HTTW = total plant weight (g) based on 9.6cm$^2$ at harvest.

# Rubber Particles for Vehicular and Foot Traffic Areas - Demonstration Plot

*Jeffrey J. Salmond and David D. Minner*

A demonstration area was initiated in June 1996 to evaluate the effects of rubber particles for topdressing in areas that receive equipment traffic. Other experiments in this Research Report have found beneficial results from rubber topdressing when small plots and artificial traffic are used. Golf courses and other recreational areas where vehicles and mowers are repeatedly used typically develop turf wear and soil compaction problems.

A 16 ft. x 64 ft. area receiving intense equipment traffic at the Horticulture Research Station was arranged with four non-replicated treatments. The area was scalp-mowed, hollow core aerified, and the cores were then removed. Topdressing treatments consisted of a coarse crumb rubber, medium crumb rubber, and sand. All three topdressing materials were applied at a 0.5 in. depth, and an untreated control received no topdressing. Individual plot size was 16' x 16' (Table 1).

The total plot area was roped off for turfgrass re-establishment. The evaluation plots did not received traffic in 1996 or 1997. Traffic will begin in spring, 1998.

**Table 1.** Plot arrangement for topdressing treatments at 0.5 in. and an untreated control.

|-------------------------------------------- 64'--------------------------------------------|

| | | | |
|---|---|---|---|
| untreated control | coarse crumb | sand | medium crumb |

N→

# 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 will be seeded in spring 1998 with a bluegrass blend containing 'Nublue', 'Limousine', and 'Touchdown'.

The control will be topdressed with sand in 1998 and the calcined clay-amended plots will be topdressed with Turface® MVP.

**Table 1.** Experimental plot layout of calcined clay tilled renovation. Treatments were applied on November 13, 1997.

| Field location | Treatment [Center of field] | Plot # | Rep / Notes |
|---|---|---|---|
| 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 | Turface | 1 |
| 2 | Turface | 2 |
| 3 | Untreated control* | NA |

Turface 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*

Calcined clay materials have been used to amend soils that are compacted by excessive traffic. Our objective was to evaluate calcined clay as a topdressing material and its effects on turfgrass growth. The study is being conducted on a local high school football/soccer practice field and the calcined clay materials are being compared with sand treatments.

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 twenty-yard lines. Each individual plot measured 15 ft. by 50 ft. for a total of 12 plots. Treatments consisted of two topdressing materials, calcined clay or sand, with six replications. Six plots were topdressed with calcined clay (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 calcined clay. Plots were arranged every 5 yards. Core plugs were not removed and the plugs and topdressing were mixed on the surface by separately dragging each plot.

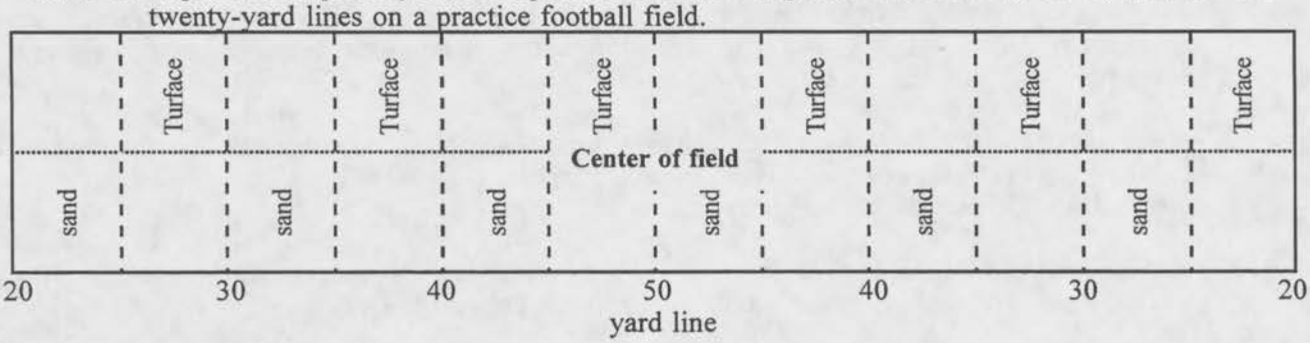
The procedure for topdressing materials is presented in Table 1. To date, the calcined clay plots contain a rate of 1785 lbs/ 1000 sq.ft. or 1339 lbs per plot area. One-quarter inch of topdressed calcined clay on the individual plots is equivalent to a rate of 714 lbs/ 1000 sq.ft. The experimental plot layout is presented in Table 2.

Plots will be evaluated each month on turfgrass quality and percent turfgrass cover. The study will be continued through 1999.

**Table 1**. Renovation schedule for topdressed calcined clay.

| | | | | | |
|---|---|---|---|---|---|
| Sept. 1, 1996 | core aerify | Turface 1/4 in. (714 lbs/1000 sq. ft.) | core aerify | seed | fertilize |
| Nov. 1, 1996 | core aerify | Turface 1/4 in. (714 lbs/1000 sq. ft.) | core aerify | seed | fertilize |
| April 1, 1996 | core aerify | Turface 1/8 in. (357 lbs/1000 sq. ft.) | core aerify | seed | fertilize |

**Table 2.** Experimental plot layout for topdressed calcined clay and sand between the hash marks and twenty-yard lines on a practice football field.



# 10 Reasons for Landscape Plant Failure

*Jeff Iles*

**#1 Improper Site Selection** - Most landscape plants have specific environmental and spatial requirements that must be met if they are to have long and functional lives. Questions to ask before plants are installed include, (1) will trees and shrubs outgrow the space allocated to them, and (2) will they thrive given the unique environmental conditions present on the site (sun, shade, wind, etc.)?

**#2 Poor Soil Drainage** - Roots, responsible for water and mineral element uptake, energy storage, the synthesis of important organic compounds, and plant anchorage, require oxygen to function. But heavy clay, waterlogged soils are frequently oxygen deficient which can lead to poor growth and even death.

**#3 Lack of Winter/Summer Hardiness** - A plant's ability to tolerate both high and low temperatures must be a prime consideration when selecting it for a given region.

**#4 Planting Problems** - Planting too deep, either intentionally or unintentionally, can cause landscape plants to die within months of installation, or lead to other chronic problems (girdling roots, stem or trunk rots, etc.) that significantly shorten their lives.

**#5 Improper Watering** - Watering is the most important task for owners of newly planted trees and shrubs, but proper frequency and amount needed will vary according to area rainfall, moisture-holding capacity of the soil, and the site's drainage characteristics. Too much water, particularly if the planting area is poorly drained, can easily kill trees.

**#6 Mechanical Injury** - For trees and other landscape plants to perform as they were intended, they must be afforded protection from all forms of "people pressure." Wounds to trunks and branches administered by vehicles, bicycles, hot charcoal, lawn mowers, and string-trimmers can injure plants directly, and/or predispose them to secondary attack by insects and disease-causing pathogens.

**#7 Problem Plants** - Plants poorly adapted to a region, and those with serious insect and disease problems should be avoided.

**#8 Construction Injury** - As landscape plants mature, they attain a rather delicate balance with their surrounding environment. In fact, woody plants grow best in an environment of minimal change. Unfortunately, our urban, suburban, and even rural landscapes are places where drastic changes occur with regularity. Construction activities like driveway and sidewalk installation, grade changes, road widening, and utility trenching in the vicinity of trees and shrubs can cause substantial root injury, and in some cases, death.

**#9 Animals** - Deer, rabbits, voles, horses, and dogs top the list of animals that cause problems for landscape plants. Because repellents are often ineffective, high value plants should be protected with fencing to prevent injury.

**#10 Well-intentioned Maintenance Practices** - Remember, anything you wrap around the trunk or stem of a plant can cause problems if it is not inspected regularly.

# Trees Can Reduce Energy Consumption

*Jeff Iles*

Trees planted in key positions around homes and businesses can reduce energy consumption and save money. For example, properly placed trees can slash air-conditioning demand in summer by as much as 50 percent. Thoughtfully placed trees also can reduce winter heating costs by 4 to 22 percent. But to achieve maximum energy savings and environmental improvement, appropriate tree species must be planted in strategic locations and in the correct relationship to the buildings or areas they are designed to benefit. Simply stated, the goal is to get maximum shade in summer but minimum shade in winter.

Highest priority should be given to planting shade trees due west of west-facing windows followed by planting trees east of eastern windows. Trees located on the east and west sides of buildings offer the most advantageous combination of solar control and energy savings by blocking early morning and late evening sun in the summer but offering no obstruction to winter sunlight. Select trees that can be planted within 20 feet of windows and will grow at least 10 feet taller than windows. If space permits, use tree combinations to create a continuous planting opposite all major west and east-facing windows. But don't waste time and financial resources planting trees on the south side of buildings! A large tree oriented to the south will cast little, if any shade on buildings to the north in summer. And in winter, the same tree will cast an undesirable shadow on structures to the north for most of the day. If shade trees are already present on southern exposures, removing their lower branches will permit more sunlight to reach the buildings to the north in winter.

Deciduous trees (those that drop their leaves in autumn) are the preferred natural heating and cooling regulators in temperate climates. To obtain maximum benefit, the "ideal" shade tree should have a broad crown and dense foliage in summer when shade is most desirable. Then when temperatures begin to cool in fall, the ideal tree would lose its leaves, permitting the suns energy to penetrate a sparsely-branched canopy. Trees meeting these criteria are classified as "solar friendly." Kentucky coffeetree, ash, and sugar and red maples are good examples of solar friendly trees because they provide dense summer shade and sparse winter branching.

In general, large-growing trees are best because they provide the maximum environmental benefit per tree. But because "solar friendly" trees are most effective when planted close to the east and west sides of buildings, only sturdy trees with good branching habits that resist damage from storms should be planted. Do not plant large, fast-growing, weak-wooded species like silver maple and cottonwood next to homes and businesses. Also avoid trees that drop their leaves late in the fall (Norway maple), trees that retain their leaves throughout the winter (oaks), have exceptionally sparse branching (ginkgo), or are densely-branched (littleleaf linden). To aid municipal tree managers in making tree selection decisions, a list of recommended deciduous shade trees for energy conservation is provided on the next page.

**Deciduous Shade Trees for Energy Conservation**

| Common name | Scientific Name | Mature height | Mature spread |
|---|---|---|---|
| Red maple | *Acer rubrum* | 40 - 60' | 30 - 50' |
| Sugar maple | *Acer saccharum* | 60 - 75' | 40 - 60' |
| Black maple | *Acer nigrum* | 60 - 75' | 40 - 60' |
| Ohio buckeye | *Aesculus glabra* | 40 - 60' | 30 - 40' |
| Black alder | *Alnus glutinosa* | 40 - 60' | 20 - 40' |
| River birch | *Betula nigra* | 40 - 70' | 40 - 50' |
| Northern catalpa | *Catalpa speciosa* | 40 - 60' | 20 - 40' |
| Common hackberry | *Celtis occidentalis* | 40 - 60' | 40 - 60' |
| White ash | *Fraxinus americana* | 50 - 80' | 40 - 60' |
| Green ash | *Fraxinus pennsylvanica* | 50 - 60' | 30 - 40' |
| Blue ash | *Fraxinus quadrangulata* | 50 - 70' | 40 - 50' |
| Kentucky coffeetree | *Gymnocladus dioicus* | 60 - 75' | 40 - 50' |
| Tuliptree | *Liriodendron tulipifera* | 70 - 90' | 40 - 50' |
| Ironwood | *Ostrya virginiana* | 30 - 40' | 20 - 30' |
| Amur corktree | *Phellodendron amurense* | 30 - 45' | 40 - 50' |
| American linden | *Tilia americana* | 60 - 80' | 40 - 60' |

If a site isn't large enough to accommodate large-growing tree species, you might consider using woody plants to establish a zone of insulating dead air space along the walls of buildings. Plants like arborvitae and juniper installed close to buildings will create a layer of still or slow-moving air that can slow heat loss in winter and heat gain in summer. This technique is most effective when plants are installed in a continuous line that extends along the walls to be protected and around the corners. Landscape interest can be created by using a variety of plants, but take care to group like kinds together.

In addition to shielding buildings from environmental extremes, plant materials can be used to minimize the so-called "urban heat island effect." Researchers have found that summer temperatures in urban areas can be two to eight degrees (Fahrenheit) higher than in rural surroundings. To moderate high temperatures during the summer months, large-growing trees can be carefully located to shade paved surfaces during the hottest time of day, and nonpaved surfaces should be covered with either turfgrass or another perennial groundcover, shrubs, and/or low-growing trees. The use of light-colored parking lot surfaces also is recommended.

Energy-conserving landscapes do not happen by accident. Rather, careful planning and preparation is required to realize environmental and financial benefits from strategically placed woody plants. Before you plant that next tree, make certain it is positioned for aesthetic beauty and energy conservation.

# Fertilizing Trees and Shrubs

*Jeff Iles*

You would think after decades of research, thousands of anecdotal reports from the field, and the endless procession of articles in print, there would be unanimous agreement regarding the importance of tree and shrub fertilization. Instead, confusion, controversy, and heated words exchanged in "letters to the editor" sections of trade journals indicate the apparent lack of consensus among landscape maintenance professionals when it comes to applying fertilizers.

Some use fertilizers as preventive medicine, slinging mineral elements around the landscape in an effort to ward off marauding insect and disease pests. Others use fertilizer as a rescue treatment for plants besieged by any number of biotic and abiotic stresses. Still others adopt a policy of nonintervention, avoiding all together the application of fertilizer. So, who's right? As is often the case, everybody and nobody. Yes, vigorous plants supplied with optimal levels of mineral elements are better equipped to handle stress, but fertilizer cannot remedy poor growth resulting from causes other than nutrient deficiencies such as compacted soils, poor drainage, restricted rooting areas, mechanical injury, or competition from turfgrass. In fact, the only valid reason to fertilize landscape plants is to correct nutrient deficiencies.

**Why Fertilize?**
Have you ever been asked this one? "If trees in the forest are able to thrive without the addition of fertilizer, why should I pay you to fertilize the trees and shrubs in my yard?" The difference is, trees in their natural setting benefit from a layer of decayed leaves, twigs, and other organic matter that accumulates on the forest floor. Small, absorbing roots of trees and other woody plants colonize this rich, well-aerated, nutrient-laden soil, and derive everything they need from the cycling of organic matter production and decomposition. But in urban and suburban landscapes where the environment has been drastically altered from its original state, mineral cycling does not occur and supplemental fertilization often becomes necessary.

**What a Plant Needs**
Fertilizers often are incorrectly referred to as "plant food." More precisely, fertilizers provide essential mineral elements that trees and shrubs need to produce their own food (sugars) through the process of *photosynthesis*, and to carry out other important biological functions.

For proper growth and development, woody plants must obtain 17 essential mineral elements from their environment. The *macronutrients*, so called because plants require them in large amounts, include hydrogen, carbon, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. *Micronutrients* or trace elements are needed in smaller amounts and include iron, chlorine, manganese, zinc, boron, copper, molybdenum, and cobalt. Throughout a plant's life, mineral elements are required for growth and maintenance; however, all woody plants do not have the same mineral requirements. For example, a beech tree requires more calcium, potassium, and phosphorus than most pines.

**Importance of Soil pH**
The availability of a number of mineral elements, particularly phosphorus and the micronutrients, is directly influenced by soil pH. Soil reaction, expressed as pH, refers to the acidity or alkalinity of a soil or the relative proportion of hydrogen (acid) and hydroxide (alkaline) ions. Equal concentrations of the two produce a neutral reaction (pH 7.0). As a soil becomes more acid, its pH decreases; as it becomes more alkaline, its pH increases.

Certain trees (pin oak, red maple, river birch, etc.) growing on high pH soils frequently display iron or manganese deficiency symptoms (yellow leaves with green veins). Most woody plants tolerate a wide range in pH (5.5 to 7.5) particularly if the soil is well-drained, but a soil pH between 6.0 and 6.5 is thought to be best. Soils with pH levels above 7.0 can be successfully treated with elemental sulfur (96%) to lower soil pH and improve plant growth; however, a better solution might be to use plants that grow naturally on alkaline soils. Trees like hackberry, sycamore, catalpa, honeylocust, blue ash, Kentucky coffeetree, bur oak, and chinquapin oak are known to tolerate soils having a pH of 8.0 or higher!

**Knowing Which Plants to Fertilize**

Soil tests can help determine when to fertilize trees and shrubs. Unfortunately, researchers have not been able to determine optimum mineral element levels for many landscape plants. Therefore, the landscape manager must rely on deficiency symptoms to identify nutritional problems. A few common deficiency symptoms include, (1) unusually small leaves, (2) abnormal leaf color (light green or yellow), (3) poor annual shoot elongation, (4) dead twigs at ends of branches, and (5) general lack of vigor. If these symptoms are present and are not the result of other factors such as drought, disease, root injury, herbicide damage, or mechanical injury, then fertilization is probably warranted.

**How Much Fertilizer to Apply?**

The soil around woody plants is most commonly supplemented with nitrogen, phosphorus, and potassium. But because nitrogen is so important to plant growth and is usually the element most likely to be deficient, most fertilizer recommendations are keyed to this vital element.

Recently transplanted and/or poorly established plants have minimal fertilization needs. In fact, the fate of recently installed landscape plants is more closely tied to proper water management than to fertilization. But once established (the establishment period can last from months to years), fertilization can stimulate growth and improve the appearance of landscape plants. A rate of 3 pounds of actual nitrogen/1,000 square feet/year will satisfy the nutritional needs of most trees and shrubs. Dwarf and slow-growing trees and shrubs require only half this rate. Mature plants and those compromised by root injury will benefit from fertilization, but rates are usually in the neighborhood of 1 to 2 lbs. N/1,000 square feet/year. But remember, fertilizer is not a rescue treatment for seriously injured or declining plants.

**When to Apply?**

Fertilizers should be applied when environmental conditions favor root activity. Of all the environmental conditions, soil moisture and temperature have the greatest influence on root growth. The most intense root growth occurs when soils are moist and when temperatures are between 68 and 84 F.

Of course, correct timing of fertilizer application varies with geographic region. But in general, late summer or early autumn is usually the preferred time to apply fertilizer. At this time, vegetative growth has ceased, the soil is warm, carbohydrate supplies are at their highest, daytime high temperatures are moderating, and moisture is usually not limiting growth.

Another benefit to fall fertilization is early shoot growth in the spring depends almost entirely on nitrogen absorbed the previous summer and autumn. Nitrogen can still be applied in the spring, however, it must be in the root zone about one month before growth begins for it to have any effect on early season growth. Fertilizer applied later in the spring isn't necessarily wasted, but it may not produce the desired growth until the following year.

To prevent loss or leaching of nitrogen from the root zone of plants in sandy, well-drained soils, split applications in spring and fall can be used. But if leaching is not a problem, no benefit has been shown from applying the same total amount of fertilizer in more than one application.

Other macronutrients can be applied when deficiencies are discovered, regardless of calendar date. But when treating micronutrient deficiency symptoms (for example, iron or manganese), water-soluble chelates of iron or manganese should be applied to the soil in the fall to have a positive impact on early season shoot growth.

**Application Methods**

Fertilizers can be, (1) broadcast on the soil surface, (2) placed in holes in the soil, (3) dissolved in water and injected into the soil, (4) sprayed on the foliage, (5) driven into the soil in fiber impregnated spikes, or (6) implanted or injected into the plant. The method chosen will depend on the nature and slope of the soil surface, mineral elements being applied, presence of competing vegetation (turfgrass most commonly), and equipment available. No single method is best suited for every situation, but for the fertilizer to be effective, it must reach, or be placed near the root zone.

Because the root zone of most trees and shrubs lies just below the soil surface (4 to 12 inches deep), surface application (broadcasting) is the easiest, least expensive, and most effective method for applying mobile elements like nitrogen. But when applying immobile elements like phosphorus, working on severe slopes, or trying to place mineral elements below a highly competitive groundcover like turfgrass, granular or liquid formulations applied 8 to 12 inches deep are useful.

Fertilizers sprayed on the foliage are effective for correcting micronutrient imbalances (primarily iron and manganese). Plant response is quick, but applications must be repeated, at the very least, every season. Fertilizer stakes, spikes, and tablets driven into the soil at regular intervals around plants are popular with homeowners because they are easy to apply, but they are expensive, cause compaction where the spike is inserted, and provide poor lateral distribution of mineral elements in the root zone.

Trunk implants and injections have become the method of choice for correcting micronutrient deficiencies in trees over 4 inches in diameter when they have not previously responded to soil treatments. These methods deliver mineral elements directly into the vascular system of the tree and provide a quick and positive response. Implants and injections should be reserved for high value trees because of the time and expense associated with these methods. Drilling holes also may cause decay around the injection or implantation site.

A fertilization program tailored to the specific needs of every tree and shrub in the landscape is only one piece of the maintenance puzzle for landscape technicians. Without proper plant selection and installation techniques, timely watering, mulching, appropriate pruning, weed control, and a host of other maintenance activities, the functional and aesthetic benefits of the landscape deteriorate. Finally, fertilizers should be applied only when a nutrient deficiency has been identified. Fertilizing "to be safe" wastes time, money, and could contribute to contamination of surface and groundwater supplies.

**Further Reading**

*Darr, B.* 1996. Tree fertilization: A world of options. Arbor Age 16(2):14-17.
*Ferrandiz, L.S.* 1990. Tree fertilization techniques. Grounds Maintenance 25(6):10-14.
*Gilman, E.F.* 1990. Tree root growth and development. I. Form, spread, depth and periodicity. J. Environ. Hort. 8(4):215-220.
*Harris, R.W.* 1992. Arboriculture: Integrated management of landscape trees, shrubs, and vines. Prentice-Hall, Englewood Cliffs, NJ.
*Lanphear, L.S.* 1996. Stimulating healthy growth. Arbor Age 16(9):12-14.
*Shaw, M.* 1998. Tree nutrition 101. Arbor Age 18(3):16-19.
*Ware, G.* 1990. Constraints to tree growth imposed by urban soil alkalinity. J. Arboric. 16(2):35-38.
*Warren, S.* 1995. Nitrogen fertilizer and beyond. Arbor Age 15(4):10-12.
*Watson, G.W.* 1992. Trees and shrub fertilization. Grounds Maintenance 27(1):42-46.

# Prairie Demonstration

*Kevin Jones and David D. Minner*

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. A prairie restoration area will be seeded in the fall of 1998 adjacent to the prairie plant identification plots.

**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 Department |
| **Doug Campbell** | Research Associate, Horticulture Department |
| **Nick Christians, Ph.D.** | Professor, Turfgrass Science Research and Teaching<br>Horticulture Department |
| **Jason DePaepe** | Field Technician, Horticulture Department |
| **Jim Dickson** | Field Manager, Horticulture Department |
| **Mike Faust** | Graduate Student and Research Associate, M.S. (Christians) |
| **Mark Gleason, Ph.D.** | Professor, Extension Plant Pathologist<br>Plant Pathology Department |
| **Clinton Hodges, Ph.D.** | Professor, Turfgrass Science Research and Teaching<br>Horticulture Department |
| **Jay Hudson** | Graduate Student and Research Associate, M.S. (Minner) |
| **Jeff Iles, Ph.D.** | Assistant Professor, Extension, Nursery Crops/Ornamentals<br>Horticulture Department |
| **Young K. Joo, Ph.D.** | Visiting Scientist from Korea |
| **Kevin Jones** | Field Technician, Horticulture Department |
| **Brian Kelting** | Field Technician, Horticulture Department |
| **Deying Li** | Visiting Scientist from China |
| **Melissa McDade** | Graduate Student and Research Associate, M.S. (Christians) |
| **Jason Miller** | Field Technician, Horticulture Department |
| **David Minner, Ph.D.** | Associate Professor, Turfgrass Science Research and Extension<br>Horticulture Department |
| **Richard Moore** | Superintendent, Horticulture Research Station |
| **Forrest Nutter, Ph.D.** | Associate Professor, Plant Pathology Department |
| **Chad Olsen** | Field Technician, Horticulture Department |
| **Gary Peterson** | Commercial Horticulture Specialist |
| **Phil Riedell** | Field Technician, Horticulture Department |
| **Jeff Salmond** | Graduate Student and Research Associate, M.S. (Minner)<br>Graduated May 1998 |
| **Mark Semm** | Field Technician, Horticulture Department |
| **Brian Wehner** | Field Technician, Horticulture Department |

## Companies and Organizations That Made Donations or Supplied Products to the Iowa State University Turfgrass Research Program

Special thanks are expressed to the Big Bear Turf Equipment Company and Cushman Turf for providing a Cushman Turfgrass Truckster, a 15 cu. ft. topdresser, and Ryan GA30 aerifier; to Tri-State Turf and Irrigation for providing a Greensmaster 3100 Triplex Greensmower and a Groundsmaster 325D rotary mower; and, to Great American Outdoor for providing a John Deere 2243 Triplex Greensmower for use at the research area.

We would also like to acknowledge Williams Lawn Seed Company of Maryville, MO for supplying a Perma Lock Inc. pesticide storage building for use at the turfgrass research area.

**Agr-Evo USA Company**
5967 N. Winwood Drive
Johnston, IA 50131

**AIMCOR-Profile**
One Parkway North
Deerfield, IL 60015

**Akzo Nobel**
Enkamat
Asheville, NC 28802

**Aquatrols, Inc.**
Cherry Hill, NJ 08002

**Big Bear Turf Equipment Company**
10405 'J' Street
Omaha, NE 68127

**Cushman Turf**
5232 Cushman
Lincoln, NE 68501

**D & K Turf Products**
5191 NE 17th Street
Des Moines, IA 50313

**Dakota Peat**
PO Box 14088
Grand Forks, ND 58208

**Dow Chemical Co.**
S. Madison St.
Ledington, MI 49431

**DowElanco**
Midland, MI 48674

**Gardens Alive**
5100 Schenley Place
Lawrenceburg, IN 47025

**Glen Oaks Country Club**
1401 Glen Oaks Drive
West Des Moines, IA 50266

**Golf Course Superintendents Association of America**
1421 Research Park Drive
Lawrence, KS 66049-3859

**Grain Processing Corporation**
PO Box 349
Muscatine, IA 52761

**Great American Outdoor**
10100 Dennis Drive
Urbandale, IA 50322

**Heatway**
3131 W. Chestnut Expressway
Springfield, MO 65802

**Hunter Industries, Inc.**
1940 Diamond St.
San Marcos, CA 92069

**Iowa Golf Course Superintendents Association**

**Iowa Professional Lawn Care Association**

**Iowa Sports Turf Managers Association**

**Iowa Turfgrass Institute**

**LESCO Incorporated**
PO Box 10915
Rocky River, OH 44116-0915

**Milorganite**
735 North Water Street
Milwaukee, WI 53200

**Monsanto Company**
Agricultural Products Division
800 North Lindbergh Boulevard
St. Louis, MO 63167

**Novartis**
Agriculture Division
Greensboro, NC 27049

**Ossian Inc.**
635 S. Elmwood Avenue
Davenport, IA 52808

**PBI/Gordon Corporation**
1217 West 12th Street
PO Box 4090
Kansas City, MO 64101-9984

**Pepsi-Cola General Bottlers, Inc.**
3825 106th St.
Des Moines, IA 50322

**Pickseed West Incorporated**
PO Box 888
Tangent, OR 97389

**Pursell**
201 W. Fourth St.
PO Box 450
Sylacauga, AL 35150

**Rainbird Irrigation Company**

**Reams Sprinkler Supply**
13410 C Street
Omaha, NE 68144

**Renaissance Fertlizer Co.**
5275 Edina Industrial Blvd.
Edina, MN 55435

**Rhone-Poulenc Chemical Company**
Black Horse Lane
PO Box 125
Monmouth Junction, NJ 08852

**Ringer Corporation**
Eden Prairie, MN 55344

**Rohm and Haas Co.**
7808 Highland Farms Road
Houston, TX 77095

**The Scotts Company**
14111 Scottslawn Road
Marysville, Ohio 43041

**SportGrass, Inc.**
6849 Old Dominion Drive,
Suite 219
McLean, VA 22101

**Spraying Systems Company**
N Avenue at Schmale Road
Wheaton, IL 60187

**Standard Golf Company**
PO Box 68
Cedar Falls, IA 50613

**SubAir**
PO Box 910
Vernon, NY 13476

**TeeJet Spray Products**
2400 NW 86th St.
Urbandale, IA 50322

**Terra Chemical Corporation**
Box 218
Quimby, IA 51049

**The Toro Company**
Minneapolis, MN

**Tri State Turf & Irrigation Co.**
6125 Valley Drive
Bettendorf, IA 52722

**True Pitch, Inc.**
803 8th Street SW
Altoona, IA 50009

**Turf-Seed, Inc.**
PO Box 250
Hubbard, OR 97032

**United Horticultural Supply**
14075 NE Arndt Road
Aurora, OR 97002

**Viridian Inc.**
(Formerly Sherritt Inc.)
3500 Manulife Place
10181 101st Street
Edmonton, Alberta
Canada TJ5 354

**Weathermatic Corporation**
Telsco Industries
PO Box 180205
Dallas, TX 75218-2005

**Williams Lawn Seed Company**
224 South Hills Drive
PO Box 112
Maryville, MO 64468

**Zeneca Professional Products**
4300 Cornhusker Hwy #B6
Lincoln, NE 68504

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Stanley R. Johnson, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.