Kansas State University

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

# K-STATE TURFGRASS RESEARCH

# 2003

Report of Progress 911

## K-State Turfgrass Researchers

Researchers at Kansas State University are dedicated to improving turf quality in Kansas. Turf research is conducted at field centers in Manhattan, Wichita, and Olathe. Members of the K-State turf team and their responsibilities are:

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## FOREWORD

Turfgrass Research 2002 contains results of projects done by K-State faculty and graduate students. Some of these results will be presented at the Kansas Turfgrass Field Day at the John C. Pair Horticultural Research Center in Wichita on August 7, 2003. Despite current budget restraints, the turfgrass teaching, research, and extension programs are strong. In addition to ongoing work in Manhattan and Wichita, turf research has been initiated at the new research center in Olathe and will be expanding in the coming years. Our strength is attributed, in part, to the support provided by members of the Kansas turfgrass industry.

If you need information on selecting the best turfgrass varieties for our region, you'll find that information here. This publication also contains information about controlling tough weeds such as yellow nutsedge and spurge and diseases such as brown patch and dollar spot. Significant work was done in 2002 to identify irrigation requirements of grasses in our state and how turf managers can conserve water; you'll find that inside as well.

What questions can we answer for you? The K-State research team is responsive to the needs of the industry. If there are problems that you feel need to be addressed, please let one of us know. This is the first year that the K-State Turfgrass Research Report has been published in an electronic format on CDs. This method reduces production costs, which is critical considering the current state budget climate. Printed copies are available upon request at a K-State Research and Extension office; you may be assessed a small fee. In addition to the CD format, you can access this report, and those from previous years, on the Web at:
http://www.oznet.ksu.edu/dp_hfrr/welcome.htm or http://www.oznet.ksu.edu/dp_hfrr/TURF/Welcome.htm

**Personnel Associated with K-State Turfgrass Program**

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**TITLE:** 2001 National Tall Fescue Test

**OBJECTIVE:** To evaluate tall fescue cultivars under Kansas conditions and submit data collected to the National Turfgrass Evaluation Program.

**PERSONNEL:** Linda R. Parsons, Jack D. Fry

**SPONSOR:** USDA National Turfgrass Evaluation Program

## INTRODUCTION:

Tall fescue is the best adapted cool-season turfgrass for the transition zone as it is drought and heat tolerant and has few serious insect and disease problems. However tall fescue possesses a rather coarse leaf texture as it lacks stolons and has only very short rhizomes. Efforts to improve cultivar quality include selection for finer leaf texture, a rich green color, and better sward density, while still maintaining good stress tolerance and disease resistance.

## MATERIALS AND METHODS:

After we incorporated 13-13-13 at a rate of 1 lb NPK/1000 $ft^2$ into 480, 5×5-ft study plots at the John C. Pair Horticultural Center in Wichita, KS, we seeded the area on 28 September 2001 with 160 tall fescue cultivars and experimental numbers in a randomized complete block design at a rate of 4.4 lb of seed per 1000 $ft^2$. We maintain fertility of the plots at 0.25 to 0.5 lb N/1000 $ft^2$ per growing month. We mow the plots weekly during the growing season at 2.5 in. and remove clippings. We irrigate as necessary to prevent stress and control weeds, insects, and diseases only when they present a threat to the trial.

During the course of the study, we will collect information on seedling vigor, spring green-up, genetic color, leaf texture, quality, and other measures when appropriate. Rating is done on a scale of 0=poorest, 6=acceptable, and 9=optimum measure.

## RESULTS:

We first rated the different fescue cultivars on establishment rate, or percent ground cover found at about four weeks after seeding. During 2002, we collected data on turf quality, color, and texture. Our initial observations (Table 1) showed that Falcon II, Elisa, Ky-31 E+, PST-5NAS, and GO-RD4 had the best establishment rate. In 2002, we rated the fescue plots monthly throughout the growing season for turf quality. Ratings were influenced by degree of coverage and weed infestation as well as turf color, texture, and density. Those that performed best overall were Justice (RB2-01), JT-9, Dynasty, Olympic Gold, and Watchdog. At the end of the summer we looked at turf color and texture and found that CIS-TF-60, MRF 28, SRX 805, MRF 210, MRF 211, and NA-TDD were the darkest green and that 01-ORU1, ATF-800, ATF-803, Barrington, and JT-12 had the finest texture.

Table 1. 2001–2002 performance of tall fescue cultivars at Wichita, KS[1].

| Cultivar/ Experimental Number | % Estab. | Genetic Color | Texture | Quality April | May | June | July | Aug. | Sept. | Oct. | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Justice (RB2-01) | 52 | 6.3 | 5.7 | 4.7 | 6.0 | 5.7 | 5.7 | 6.0 | 6.3 | 6.3 | 5.8 |
| JT-9 | 42 | 6.3 | 6.3 | 3.7 | 5.7 | 6.3 | 6.3 | 6.3 | 6.0 | 5.7 | 5.7 |
| Dynasty | 48 | 5.7 | 6.0 | 4.3 | 5.7 | 5.3 | 6.3 | 6.0 | 6.0 | 6.0 | 5.7 |
| Olympic Gold | 55 | 6.0 | 5.3 | 4.7 | 5.3 | 5.7 | 6.0 | 6.0 | 5.7 | 6.3 | 5.7 |
| Watchdog | 48 | 6.0 | 5.7 | 4.3 | 5.7 | 5.7 | 6.0 | 5.7 | 6.0 | 6.0 | 5.6 |
| Davinci (LTP-7801) | 48 | 6.7 | 6.0 | 4.0 | 5.7 | 5.3 | 5.7 | 6.0 | 6.0 | 6.0 | 5.5 |
| Wolfpack | 45 | 5.3 | 5.3 | 4.7 | 5.7 | 5.3 | 6.0 | 5.7 | 5.7 | 5.7 | 5.5 |
| Averger (L1Z) | 53 | 6.7 | 6.3 | 3.7 | 6.0 | 5.3 | 6.3 | 6.0 | 5.3 | 6.0 | 5.5 |
| CAS-ED | 47 | 6.7 | 5.3 | 4.0 | 5.3 | 5.7 | 6.3 | 5.7 | 6.0 | 5.7 | 5.5 |
| Millennium | 53 | 5.7 | 6.0 | 4.3 | 5.7 | 5.3 | 6.0 | 6.0 | 5.7 | 5.7 | 5.5 |
| MRF 26 | 35 | 7.3 | 6.0 | 3.7 | 5.3 | 5.7 | 6.0 | 5.7 | 5.7 | 6.3 | 5.5 |
| Coyote | 45 | 6.3 | 5.7 | 4.0 | 5.0 | 5.7 | 6.0 | 5.7 | 5.7 | 6.3 | 5.5 |
| MRF 210 | 50 | 7.7 | 5.7 | 4.0 | 5.7 | 5.3 | 5.3 | 5.7 | 6.0 | 6.0 | 5.4 |
| Picasso | 47 | 6.0 | 5.3 | 3.7 | 6.0 | 5.3 | 5.7 | 5.7 | 6.0 | 5.7 | 5.4 |
| Rebel Sentry | 48 | 6.7 | 5.7 | 4.3 | 5.7 | 5.3 | 5.7 | 5.3 | 6.0 | 5.7 | 5.4 |
| SR 8600 | 38 | 5.7 | 6.0 | 4.7 | 5.7 | 5.3 | 5.7 | 5.3 | 5.7 | 5.7 | 5.4 |
| ProSeeds 5301 | 45 | 6.3 | 6.0 | 3.7 | 5.0 | 5.3 | 6.0 | 6.0 | 5.3 | 6.3 | 5.4 |
| DLSD | 40 | 6.0 | 5.7 | 4.3 | 5.3 | 5.3 | 5.7 | 5.7 | 5.0 | 6.3 | 5.4 |
| Laramie | 58 | 5.7 | 5.7 | 4.0 | 6.0 | 5.7 | 5.7 | 5.3 | 5.3 | 5.7 | 5.4 |
| PST-5A1 | 48 | 6.3 | 6.3 | 4.0 | 5.7 | 5.0 | 5.7 | 5.3 | 6.0 | 6.0 | 5.4 |
| Rembrandt | 43 | 6.0 | 5.3 | 4.0 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.3 | 5.4 |
| Stetson | 55 | 5.0 | 5.3 | 4.3 | 5.7 | 5.0 | 5.7 | 5.0 | 6.0 | 6.0 | 5.4 |
| BAR Fa 1003 | 53 | 6.7 | 5.0 | 3.7 | 5.0 | 5.3 | 6.3 | 5.7 | 5.7 | 5.7 | 5.3 |
| Falcon II | 67 | 6.0 | 5.3 | 4.7 | 5.3 | 5.3 | 6.0 | 5.0 | 5.3 | 5.7 | 5.3 |
| Prospect | 47 | 6.0 | 6.0 | 4.3 | 5.7 | 5.3 | 6.0 | 5.3 | 5.3 | 5.3 | 5.3 |
| ATF-803 | 50 | 6.0 | 6.7 | 3.7 | 5.7 | 5.7 | 5.7 | 5.3 | 5.3 | 5.7 | 5.3 |
| Barlexas II | 50 | 6.3 | 6.3 | 3.7 | 5.7 | 5.7 | 6.0 | 5.3 | 5.0 | 5.7 | 5.3 |

| Cultivar/ Experimental Number | % Estab. | Genetic Color | Texture | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | April | May | June | July | Aug. | Sept. | Oct. | Avg. |
| Blackwatch (Pick-OD3-01) | 45 | 6.0 | 5.7 | 3.3 | 5.3 | 5.3 | 5.7 | 6.3 | 5.0 | 6.0 | 5.3 |
| EA 163 | 43 | 6.3 | 5.3 | 4.0 | 5.3 | 5.0 | 6.3 | 5.3 | 5.0 | 6.0 | 5.3 |
| Grande II | 42 | 6.7 | 6.3 | 4.0 | 5.0 | 5.0 | 5.7 | 5.7 | 6.0 | 5.7 | 5.3 |
| MRF 25 | 48 | 6.7 | 6.0 | 4.3 | 5.7 | 5.3 | 5.3 | 5.0 | 6.0 | 5.3 | 5.3 |
| PST-5KU | 43 | 6.3 | 5.7 | 3.3 | 5.7 | 5.0 | 5.7 | 5.0 | 6.3 | 6.0 | 5.3 |
| Titan Ltd. | 50 | 5.3 | 5.3 | 4.0 | 5.3 | 5.3 | 5.7 | 5.3 | 6.0 | 5.3 | 5.3 |
| CAS-MC1 | 43 | 6.0 | 5.7 | 4.0 | 5.0 | 5.3 | 5.3 | 5.7 | 5.3 | 6.0 | 5.2 |
| GO-OD2 | 43 | 6.0 | 5.0 | 4.0 | 5.7 | 5.3 | 5.7 | 5.3 | 5.7 | 5.0 | 5.2 |
| MA 127 | 43 | 6.7 | 5.3 | 3.3 | 5.0 | 5.0 | 6.0 | 5.7 | 6.0 | 5.7 | 5.2 |
| Tar Heel | 47 | 6.0 | 5.0 | 3.7 | 5.0 | 5.0 | 6.0 | 5.7 | 5.7 | 5.7 | 5.2 |
| Bravo | 43 | 6.3 | 5.7 | 4.0 | 5.3 | 5.0 | 5.7 | 5.3 | 5.3 | 5.7 | 5.2 |
| F-4 | 42 | 6.3 | 6.0 | 3.7 | 5.0 | 5.3 | 5.7 | 5.7 | 5.0 | 6.0 | 5.2 |
| Jaguar 3 | 45 | 5.7 | 5.3 | 4.0 | 5.0 | 5.0 | 6.0 | 5.3 | 5.3 | 5.7 | 5.2 |
| MRF 27 | 43 | 6.7 | 6.0 | 3.7 | 5.3 | 5.0 | 5.3 | 5.3 | 5.7 | 6.0 | 5.2 |
| P-58 | 40 | 6.0 | 5.3 | 2.7 | 5.0 | 5.7 | 6.0 | 6.3 | 5.0 | 5.7 | 5.2 |
| PST-5BAB | 37 | 6.0 | 6.0 | 3.7 | 5.3 | 5.0 | 5.3 | 5.7 | 5.7 | 5.7 | 5.2 |
| 01-ORU1 | 42 | 6.3 | 6.7 | 4.0 | 5.3 | 5.3 | 5.7 | 5.3 | 5.3 | 5.3 | 5.2 |
| ATF-800 | 48 | 6.3 | 6.7 | 3.3 | 5.3 | 5.3 | 5.3 | 5.0 | 6.0 | 5.7 | 5.1 |
| GO-RD4 | 60 | 5.3 | 5.3 | 4.3 | 5.7 | 5.0 | 5.3 | 5.3 | 5.0 | 5.3 | 5.1 |
| SBM | 47 | 6.0 | 5.7 | 3.7 | 5.3 | 5.3 | 5.7 | 5.7 | 5.3 | 5.0 | 5.1 |
| Biltmore | 45 | 6.7 | 5.7 | 3.7 | 5.3 | 5.7 | 5.0 | 5.3 | 5.3 | 5.7 | 5.1 |
| CIS-TF-77 | 43 | 6.3 | 5.3 | 3.3 | 5.0 | 4.7 | 5.0 | 5.7 | 6.3 | 6.0 | 5.1 |
| ATF 704 | 50 | 6.3 | 5.3 | 3.3 | 5.3 | 5.0 | 5.7 | 5.7 | 5.7 | 5.0 | 5.1 |
| Masterpiece | 45 | 6.0 | 5.7 | 3.3 | 5.0 | 5.0 | 5.7 | 5.7 | 5.3 | 5.7 | 5.1 |
| CIS-TF-67 | 43 | 6.3 | 6.3 | 3.7 | 5.3 | 4.7 | 5.3 | 5.7 | 5.3 | 5.7 | 5.1 |
| DLF-J210 | 45 | 6.3 | 5.0 | 4.0 | 5.3 | 5.0 | 6.0 | 5.0 | 5.0 | 5.3 | 5.1 |
| DP 50-9226 | 43 | 6.7 | 5.7 | 3.3 | 5.3 | 5.0 | 5.7 | 5.3 | 5.7 | 5.3 | 5.1 |
| MCN-RC | 43 | 6.3 | 5.7 | 3.3 | 4.7 | 5.0 | 5.0 | 5.7 | 5.7 | 6.3 | 5.1 |

| Cultivar/ Experimental Number | % Estab. | Genetic Color | Texture | Quality April | May | June | July | Aug. | Sept. | Oct. | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PST-5T1 | 40 | 6.0 | 5.3 | 3.7 | 5.3 | 5.3 | 5.3 | 5.7 | 5.0 | 5.3 | 5.1 |
| Pick TF H-97 | 43 | 5.7 | 6.3 | 3.3 | 5.0 | 5.0 | 6.0 | 5.0 | 5.7 | 5.7 | 5.1 |
| Plantation | 47 | 6.3 | 5.3 | 3.3 | 5.3 | 5.3 | 5.7 | 5.0 | 5.7 | 5.3 | 5.1 |
| Scorpion | 45 | 6.3 | 5.7 | 3.7 | 5.3 | 5.0 | 5.3 | 5.7 | 5.0 | 5.7 | 5.1 |
| K01-WAF | 47 | 5.7 | 5.7 | 3.7 | 4.7 | 5.0 | 5.7 | 5.3 | 5.7 | 5.3 | 5.0 |
| Signia | 45 | 7.0 | 5.3 | 3.3 | 5.0 | 5.3 | 5.3 | 5.3 | 5.0 | 6.0 | 5.0 |
| ATF 702 | 52 | 7.0 | 5.7 | 3.3 | 5.0 | 5.0 | 5.0 | 6.0 | 5.3 | 5.7 | 5.0 |
| ATF-593 | 40 | 6.0 | 5.3 | 3.0 | 5.0 | 5.0 | 5.7 | 5.7 | 5.3 | 5.7 | 5.0 |
| Dominion | 50 | 6.0 | 5.0 | 3.3 | 5.3 | 5.0 | 6.0 | 5.0 | 5.0 | 5.7 | 5.0 |
| Elisa | 62 | 5.0 | 6.3 | 4.3 | 5.0 | 4.7 | 5.7 | 5.3 | 5.3 | 5.0 | 5.0 |
| JT-18 | 38 | 7.0 | 5.3 | 3.7 | 5.0 | 5.0 | 5.3 | 5.0 | 5.3 | 6.0 | 5.0 |
| MA 138 | 42 | 5.3 | 5.7 | 3.7 | 5.0 | 5.0 | 5.7 | 5.0 | 5.3 | 5.7 | 5.0 |
| PST-5BZ | 40 | 6.0 | 5.3 | 3.3 | 5.0 | 4.7 | 6.0 | 5.3 | 5.3 | 5.7 | 5.0 |
| R-4 | 50 | 6.7 | 5.7 | 3.0 | 5.0 | 5.3 | 5.0 | 5.3 | 5.7 | 6.0 | 5.0 |
| Tulsa (ATF 706) | 43 | 5.7 | 5.3 | 3.7 | 5.0 | 5.3 | 5.3 | 5.0 | 5.3 | 5.7 | 5.0 |
| BE1 | 47 | 6.0 | 6.3 | 3.3 | 5.3 | 5.0 | 5.7 | 5.0 | 5.0 | 5.7 | 5.0 |
| Cayenne | 47 | 5.7 | 5.7 | 3.3 | 5.3 | 5.0 | 5.0 | 5.0 | 5.7 | 5.7 | 5.0 |
| Cochise III (018) | 50 | 6.3 | 5.7 | 3.7 | 5.3 | 5.0 | 5.3 | 5.7 | 4.7 | 5.3 | 5.0 |
| Daytona (MRF 23) | 45 | 7.0 | 5.3 | 3.7 | 5.0 | 4.7 | 5.3 | 5.0 | 5.7 | 5.7 | 5.0 |
| JT-13 | 43 | 6.7 | 5.7 | 3.0 | 5.0 | 5.3 | 5.3 | 5.3 | 5.3 | 5.7 | 5.0 |
| Matador | 42 | 6.3 | 6.0 | 3.0 | 5.0 | 5.0 | 5.3 | 5.0 | 5.7 | 6.0 | 5.0 |
| Padre (NJ4) | 42 | 5.7 | 5.3 | 3.3 | 5.3 | 4.7 | 5.3 | 5.7 | 5.7 | 5.0 | 5.0 |
| Pick ZMG | 40 | 6.3 | 5.0 | 3.0 | 4.7 | 5.3 | 5.7 | 5.7 | 5.0 | 5.7 | 5.0 |
| Tempest | 48 | 7.0 | 5.7 | 4.3 | 5.0 | 4.7 | 5.3 | 5.0 | 5.3 | 5.3 | 5.0 |
| PST-5NAS | 62 | 6.0 | 6.0 | 4.0 | 5.0 | 4.7 | 5.7 | 5.7 | 4.3 | 5.7 | 5.0 |
| ATF 707 | 47 | 6.0 | 5.7 | 3.7 | 5.0 | 5.0 | 6.0 | 5.3 | 4.7 | 5.0 | 5.0 |
| ATF 799 | 40 | 6.0 | 5.7 | 2.7 | 5.3 | 5.0 | 5.7 | 5.3 | 5.0 | 5.7 | 5.0 |
| BAR Fa 1CR7 | 57 | 7.3 | 6.0 | 3.3 | 5.3 | 5.0 | 5.3 | 4.7 | 5.0 | 6.0 | 5.0 |

| Cultivar/ Experimental Number | % Estab. | Genetic Color | Texture | Quality April | May | June | July | Aug. | Sept. | Oct. | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| K01-E03 | 47 | 6.7 | 6.3 | 3.3 | 4.7 | 4.7 | 5.3 | 5.7 | 5.3 | 5.7 | 5.0 |
| K01-E09 | 42 | 6.7 | 6.3 | 3.3 | 5.0 | 5.0 | 5.3 | 5.3 | 5.0 | 5.7 | 5.0 |
| Magellan (OD-4) | 45 | 6.7 | 5.3 | 3.3 | 5.3 | 4.3 | 5.0 | 5.3 | 6.0 | 5.3 | 5.0 |
| PST-57E | 43 | 5.7 | 6.0 | 3.3 | 5.3 | 5.0 | 5.3 | 5.3 | 4.7 | 5.7 | 5.0 |
| PST-5LO | 45 | 5.3 | 5.3 | 4.0 | 5.3 | 5.0 | 5.3 | 5.3 | 4.7 | 5.0 | 5.0 |
| PST-5TUO | 45 | 6.0 | 5.7 | 3.3 | 5.3 | 5.0 | 5.7 | 5.3 | 5.0 | 5.0 | 5.0 |
| Pure Gold | 42 | 5.7 | 6.0 | 3.3 | 5.0 | 5.3 | 5.3 | 5.0 | 5.3 | 5.3 | 5.0 |
| Wyatt | 47 | 6.3 | 5.7 | 3.7 | 4.7 | 5.0 | 5.3 | 5.3 | 5.3 | 5.3 | 5.0 |
| 2nd Millennium | 43 | 6.0 | 6.0 | 3.0 | 5.0 | 4.7 | 5.3 | 5.3 | 5.3 | 5.7 | 4.9 |
| Barrera | 40 | 6.7 | 5.7 | 3.0 | 5.3 | 4.3 | 5.3 | 5.3 | 5.3 | 5.7 | 4.9 |
| South Paw (MRF 24) | 48 | 6.0 | 5.0 | 3.7 | 5.0 | 4.3 | 5.3 | 5.0 | 5.3 | 5.7 | 4.9 |
| UT-RB3 | 45 | 6.7 | 5.3 | 3.3 | 5.0 | 5.0 | 5.3 | 5.0 | 5.0 | 5.7 | 4.9 |
| sr 8550 (SRX 8BE4) | 43 | 6.7 | 5.3 | 3.0 | 5.3 | 4.7 | 4.7 | 5.3 | 5.7 | 5.7 | 4.9 |
| Barrington | 38 | 6.7 | 6.7 | 4.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.3 | 4.9 |
| Endeavor | 45 | 5.7 | 5.3 | 3.7 | 4.7 | 4.7 | 5.0 | 5.7 | 5.7 | 5.0 | 4.9 |
| Rendition | 43 | 6.3 | 5.7 | 3.0 | 5.0 | 5.0 | 5.0 | 5.3 | 5.7 | 5.3 | 4.9 |
| 01-TFOR3 | 45 | 6.3 | 5.0 | 4.0 | 5.3 | 5.0 | 5.0 | 5.3 | 4.7 | 4.7 | 4.9 |
| Bingo | 35 | 7.0 | 5.3 | 3.0 | 4.7 | 4.7 | 5.3 | 6.0 | 4.7 | 5.7 | 4.9 |
| Finesse II | 37 | 6.7 | 5.7 | 3.0 | 5.0 | 5.0 | 5.0 | 5.3 | 5.3 | 5.3 | 4.9 |
| GO-FL3 | 58 | 5.0 | 5.0 | 3.7 | 5.0 | 5.0 | 5.0 | 5.0 | 5.7 | 4.7 | 4.9 |
| MA 158 | 38 | 6.7 | 6.0 | 3.0 | 5.3 | 4.7 | 5.7 | 5.0 | 5.3 | 5.0 | 4.9 |
| Roberts SM4 | 42 | 6.7 | 5.0 | 3.0 | 4.7 | 5.0 | 5.3 | 5.3 | 5.0 | 5.7 | 4.9 |
| CAS-157 | 40 | 6.0 | 5.7 | 2.7 | 4.7 | 5.0 | 5.3 | 5.0 | 5.7 | 5.7 | 4.9 |
| Focus | 43 | 6.3 | 5.7 | 3.3 | 5.0 | 4.7 | 5.3 | 5.3 | 5.3 | 5.0 | 4.9 |
| Kitty Hawk 2000 | 43 | 6.0 | 5.3 | 3.7 | 4.7 | 5.0 | 5.0 | 5.0 | 5.3 | 5.3 | 4.9 |
| PST-5FZD | 38 | 6.0 | 5.7 | 3.3 | 5.3 | 5.0 | 5.7 | 5.3 | 4.0 | 5.3 | 4.9 |
| Quest | 43 | 6.3 | 6.0 | 3.0 | 5.0 | 4.7 | 5.7 | 5.0 | 5.3 | 5.3 | 4.9 |
| Silverado II (PST-578) | 43 | 6.0 | 5.7 | 3.0 | 5.0 | 4.7 | 4.7 | 5.7 | 5.7 | 5.3 | 4.9 |

| Cultivar/ Experimental Number | % Estab. | Genetic Color | Texture | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | April | May | June | July | Aug. | Sept. | Oct. | Avg. |
| Southern Choice II | 43 | 6.3 | 6.0 | 3.3 | 5.0 | 5.0 | 5.3 | 5.0 | 5.0 | 5.3 | 4.9 |
| Inferno (JT-99) | 45 | 5.3 | 6.3 | 3.7 | 5.3 | 4.7 | 5.7 | 5.0 | 4.3 | 5.0 | 4.8 |
| 01-RUTOR2 | 45 | 6.0 | 6.0 | 3.0 | 5.0 | 4.7 | 5.7 | 4.7 | 5.0 | 5.7 | 4.8 |
| B-7001 | 40 | 6.3 | 5.0 | 3.7 | 5.3 | 4.3 | 5.0 | 5.0 | 5.3 | 5.0 | 4.8 |
| CIS-TF-65 | 38 | 6.7 | 5.7 | 3.0 | 5.0 | 4.7 | 5.0 | 5.0 | 5.7 | 5.3 | 4.8 |
| PST-5S12 | 50 | 5.7 | 5.0 | 3.0 | 5.3 | 5.3 | 5.3 | 4.7 | 5.0 | 5.0 | 4.8 |
| ATF 806 | 40 | 6.3 | 6.3 | 3.0 | 5.3 | 4.3 | 5.0 | 5.0 | 5.3 | 5.3 | 4.8 |
| Barlexas | 52 | 6.3 | 6.0 | 3.3 | 5.0 | 5.0 | 5.3 | 4.7 | 4.7 | 5.3 | 4.8 |
| Forte (BE-2) | 42 | 6.3 | 5.3 | 3.0 | 5.0 | 4.7 | 5.3 | 4.7 | 5.7 | 5.0 | 4.8 |
| Legitimate | 38 | 6.3 | 5.0 | 3.3 | 4.3 | 4.3 | 5.3 | 4.7 | 5.7 | 5.7 | 4.8 |
| PST-53T | 40 | 6.3 | 5.7 | 3.7 | 4.7 | 4.7 | 5.3 | 4.7 | 5.0 | 5.3 | 4.8 |
| SR 8250 | 38 | 6.3 | 5.3 | 3.0 | 4.7 | 4.7 | 5.0 | 5.3 | 5.3 | 5.3 | 4.8 |
| BAR Fa 1005 | 42 | 6.0 | 5.3 | 3.0 | 4.7 | 4.7 | 5.7 | 5.3 | 5.0 | 4.7 | 4.7 |
| DP 50-9082 | 43 | 5.3 | 6.3 | 3.0 | 4.7 | 5.0 | 5.3 | 4.7 | 5.3 | 5.0 | 4.7 |
| GO-SIU2 | 47 | 5.3 | 5.7 | 4.0 | 5.0 | 4.3 | 5.3 | 5.0 | 4.7 | 4.7 | 4.7 |
| JTTFF-2000 | 42 | 6.0 | 6.0 | 3.7 | 5.3 | 4.7 | 4.7 | 4.7 | 5.0 | 5.0 | 4.7 |
| Kalahari | 40 | 6.3 | 5.3 | 3.0 | 4.7 | 4.7 | 5.3 | 5.3 | 4.7 | 5.3 | 4.7 |
| MRF 28 | 45 | 8.0 | 5.3 | 3.7 | 5.0 | 4.7 | 4.7 | 4.7 | 5.0 | 5.3 | 4.7 |
| PST-DDL | 40 | 6.3 | 5.3 | 2.7 | 4.7 | 5.0 | 5.7 | 5.0 | 5.0 | 5.0 | 4.7 |
| Tar Heel II (PST-5TR1) | 45 | 5.7 | 5.0 | 2.3 | 4.7 | 4.7 | 5.7 | 5.0 | 5.3 | 5.3 | 4.7 |
| Raptor (CIS-TF-33) | 37 | 6.7 | 5.3 | 3.3 | 4.7 | 5.0 | 5.0 | 5.0 | 4.3 | 5.3 | 4.7 |
| Silverstar (PST-5ASR) | 37 | 6.0 | 5.3 | 2.7 | 4.3 | 4.7 | 5.0 | 5.0 | 5.3 | 5.7 | 4.7 |
| Bonsa | 42 | 6.0 | 5.3 | 3.0 | 5.3 | 4.3 | 5.0 | 4.3 | 5.0 | 5.3 | 4.6 |
| JT-15 | 37 | 6.7 | 5.7 | 3.0 | 4.7 | 4.3 | 5.0 | 5.0 | 5.0 | 5.3 | 4.6 |
| PST-5JM | 40 | 6.7 | 5.7 | 3.3 | 4.7 | 4.3 | 5.0 | 5.0 | 5.0 | 5.0 | 4.6 |
| TF66 | 50 | 6.3 | 5.7 | 3.3 | 4.3 | 4.3 | 4.7 | 4.7 | 5.3 | 5.7 | 4.6 |
| Lancer | 50 | 5.7 | 5.3 | 3.7 | 5.0 | 4.7 | 5.0 | 4.7 | 4.3 | 5.0 | 4.6 |
| Tomahawk RT | 43 | 6.3 | 5.3 | 3.3 | 5.0 | 4.3 | 5.0 | 4.7 | 5.0 | 5.0 | 4.6 |

| Cultivar/ Experimental Number | % Estab. | Genetic Color | Texture | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | April | May | June | July | Aug. | Sept. | Oct. | Avg. |
| ATF 586 | 37 | 6.0 | 5.0 | 3.0 | 4.7 | 4.7 | 5.0 | 4.7 | 4.7 | 5.3 | 4.6 |
| CIS-TF-60 | 40 | 8.0 | 6.0 | 3.0 | 5.0 | 4.3 | 4.7 | 4.7 | 5.0 | 5.3 | 4.6 |
| Guardian-21 (Roberts DOL) | 35 | 6.0 | 5.7 | 3.0 | 4.7 | 4.7 | 5.3 | 4.7 | 4.7 | 5.0 | 4.6 |
| JT-12 | 42 | 7.0 | 6.7 | 3.3 | 5.0 | 4.0 | 5.0 | 5.0 | 5.0 | 4.7 | 4.6 |
| JT-6 | 33 | 7.3 | 5.3 | 2.7 | 4.7 | 5.0 | 4.7 | 5.0 | 4.7 | 5.0 | 4.5 |
| Pick-00-AFA | 47 | 5.7 | 5.7 | 3.3 | 5.0 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.5 |
| K01-8015 | 38 | 5.7 | 5.3 | 2.3 | 5.0 | 4.7 | 5.0 | 5.0 | 4.7 | 5.0 | 4.5 |
| MRF 29 | 43 | 6.7 | 5.7 | 3.3 | 4.7 | 4.7 | 5.0 | 4.3 | 4.7 | 5.0 | 4.5 |
| Rebel Exeda | 40 | 6.0 | 5.3 | 3.0 | 4.7 | 4.7 | 5.0 | 5.0 | 4.0 | 4.7 | 4.4 |
| ATF 802 | 40 | 6.3 | 5.3 | 2.7 | 4.3 | 4.3 | 5.0 | 4.7 | 5.0 | 4.7 | 4.4 |
| CIS-TF-64 | 38 | 7.0 | 5.7 | 2.7 | 4.3 | 4.0 | 5.3 | 5.3 | 4.0 | 4.7 | 4.3 |
| UT-155 | 42 | 6.0 | 5.0 | 2.3 | 4.3 | 4.3 | 5.0 | 4.7 | 4.7 | 5.0 | 4.3 |
| Mustang 3 | 37 | 6.0 | 5.0 | 2.7 | 4.0 | 4.0 | 5.0 | 4.3 | 5.0 | 4.7 | 4.2 |
| Tracer | 35 | 7.0 | 5.0 | 3.0 | 4.0 | 4.0 | 4.7 | 4.7 | 4.3 | 4.7 | 4.2 |
| K01-8007 | 35 | 6.7 | 6.0 | 2.3 | 3.7 | 4.7 | 4.3 | 4.7 | 4.3 | 5.3 | 4.2 |
| T991 | 32 | 7.0 | 4.7 | 2.7 | 4.3 | 4.0 | 4.3 | 4.3 | 4.0 | 5.3 | 4.1 |
| Ky-31 E+ | 62 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.3 | 4.0 | 4.0 |
| SRX 805 | 33 | 8.0 | 5.0 | 2.7 | 4.3 | 4.7 | 4.7 | 4.7 | 3.3 | 4.0 | 4.0 |
| MRF 211 | 32 | 7.7 | 5.3 | 2.7 | 4.0 | 4.0 | 4.3 | 4.0 | 4.3 | 4.7 | 4.0 |
| NA-TDD | 33 | 7.7 | 6.0 | 2.7 | 4.0 | 3.7 | 4.7 | 4.3 | 4.0 | 4.3 | 4.0 |
| PST-5KI | 38 | 6.0 | 5.3 | 2.3 | 4.0 | 4.0 | 4.3 | 4.0 | 4.3 | 4.3 | 3.9 |
| *LSD*[2] | *12.3* | *1.1* | *1.0* | *1.1* | *1.0* | *1.1* | *1.2* | *1.2* | *1.5* | *1.3* | *0.9* |

[1] Ratings based on a scale of 0-9 with 9=best measure.
[2] To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

**TITLE:** 2000 National Kentucky Bluegrass Test

**OBJECTIVE:** To evaluate Kentucky bluegrass cultivars under Kansas conditions and submit data collected to the National Turfgrass Evaluation Program.

**PERSONNEL:** Linda R. Parsons, Jack D. Fry

**SPONSOR:** USDA National Turfgrass Evaluation Program

## INTRODUCTION:

Kentucky bluegrass is a cool-season turfgrass suitable for use in Kansas. It is dark to mid blue-green in color and has a relatively fine texture, which make an attractive lawn. Its rhizomatous nature contributes to its drought tolerance and allows it to withstand low maintenance conditions. Even though, without care, it may go dormant and turn brown in hot, dry periods, it recovers well from injury and can be considered a water-saving grass. We are interested in evaluating bluegrass cultivars suitable for home lawns, golf course roughs, and other areas that tolerate low maintenance conditions and yet retain a dark leaf color, fine texture, disease resistance, and good sward density.

## MATERIALS AND METHODS:

On 2 October 2000, we seeded 528 study plots (5 x 5 ft in a 220 x 60 ft grid) at the John C. Pair Horticultural Center in Wichita, KS with 173 Kentucky bluegrass cultivars and experimental numbers in a randomized complete block design. Seeding rate was 2.0 lb seed/1000 $ft^2$. Prior to seeding, we incorporated 13-13-13 NPK into the study plots at a rate of 1.0 lb/1000 $ft^2$. We fertilized the plots twice in 2002 at 1.0 lb N/1000 $ft^2$. Plots were mowed weekly during the growing season at 2.0 to 2.5 inches and clippings returned. We irrigated as necessary to prevent dormancy and controlled weeds, insects, and diseases only when they presented a threat to the trial. We rated turfgrass performance on a scale of 0=poorest, 6=acceptable, and 9=optimum measure.

## RESULTS:

We started off the 2002 growing season by looking at spring greenup and found that by 29 April the cultivars/experimental numbers B5-45, Chelsea, A96-427, A96-451, A97-1330, Allure, Pro Seeds - 453, and Royale (A97-1336) were the greenest (Table 1). We rated turf quality monthly throughout the growing season. Quality ratings were influenced by degree of coverage and weed infestation as well as turf color, texture, and density. The best overall performers were J-1420, DLF 76-9037, Everglade, Pick 113-3, Sonoma, and A97-1715. At summer's end, we looked at turf color and texture and found that Ba 84-140, Chicago II, Boomerang, A97-1409, and NA-K992 were the darkest green and that Kenblue, A97-857, Wellington, GO-9LM9, and Washington had the finest texture. We ended up the season by looking at percent living ground cover and found that Everglade, H92-203, Ba 81-058, Pick 113-3, A97-1715, and DLF 76-9037 were among the best.

Table 1. 2002 performance of Kentucky bluegrass cultivars at Wichita, KS[1].

| Cultivar/ Experimental Number | Spring Greenup | Genetic Color | Texture | % Fall Cover | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Apr | May | June | July | Aug | Sept | Oct | Avg |
| J-1420[2] | 5.0 | 7.0 | 6.0 | 94 | 5.0 | 6.0 | 5.7 | 6.3 | 6.3 | 5.7 | 6.7 | 6.0 |
| DLF 76-9037 | 6.0 | 5.7 | 6.0 | 95 | 6.3 | 5.7 | 4.7 | 6.3 | 6.7 | 5.7 | 5.0 | 5.8 |
| Everglade* | 5.0 | 7.7 | 6.0 | 97 | 4.7 | 6.0 | 4.7 | 6.3 | 6.3 | 6.3 | 6.0 | 5.8 |
| Pick 113-3 | 6.0 | 7.0 | 6.3 | 96 | 5.7 | 5.0 | 5.0 | 5.7 | 6.3 | 5.3 | 7.0 | 5.7 |
| Sonoma* | 6.3 | 7.3 | 5.7 | 93 | 6.0 | 5.3 | 5.0 | 6.0 | 6.3 | 5.3 | 6.0 | 5.7 |
| A97-1715 | 6.3 | 6.3 | 6.0 | 95 | 5.7 | 5.7 | 4.7 | 6.0 | 6.3 | 5.7 | 5.7 | 5.7 |
| A96-451 | 6.7 | 7.7 | 5.0 | 87 | 6.0 | 5.3 | 5.7 | 6.0 | 6.0 | 4.7 | 5.3 | 5.6 |
| J-2695 | 5.3 | 7.7 | 6.0 | 93 | 4.7 | 5.7 | 5.3 | 6.0 | 6.3 | 5.0 | 6.0 | 5.6 |
| J-1648 | 5.7 | 7.7 | 6.0 | 93 | 5.0 | 5.7 | 4.7 | 6.0 | 6.3 | 5.7 | 5.3 | 5.5 |
| J-1665 | 4.7 | 8.0 | 6.0 | 93 | 4.3 | 5.7 | 4.3 | 6.3 | 6.0 | 5.3 | 6.3 | 5.5 |
| Champagne* | 5.3 | 5.0 | 6.0 | 93 | 4.7 | 5.3 | 5.0 | 6.3 | 5.7 | 6.0 | 5.3 | 5.5 |
| Ba 81-058 | 5.7 | 7.7 | 6.0 | 96 | 5.7 | 5.0 | 4.7 | 5.7 | 5.3 | 5.7 | 6.0 | 5.4 |
| Unknown | 5.7 | 7.7 | 6.0 | 96 | 4.7 | 5.3 | 4.7 | 6.0 | 6.0 | 5.7 | 5.7 | 5.4 |
| Monte Carlo (A96-402)* | 6.3 | 7.3 | 4.3 | 89 | 6.7 | 6.3 | 5.0 | 5.3 | 5.7 | 4.7 | 4.0 | 5.4 |
| A97-1330 | 6.7 | 5.3 | 6.3 | 87 | 6.7 | 6.0 | 4.3 | 5.7 | 6.0 | 4.7 | 4.3 | 5.4 |
| SRX 26351 | 5.7 | 6.3 | 7.0 | 90 | 5.0 | 5.7 | 5.0 | 6.3 | 6.0 | 5.0 | 4.7 | 5.4 |
| A98-139 | 5.7 | 6.0 | 4.7 | 94 | 5.3 | 5.3 | 4.3 | 5.3 | 6.0 | 5.7 | 5.3 | 5.3 |
| BAR Pp 0566 | 5.7 | 7.7 | 5.3 | 93 | 5.3 | 5.0 | 4.3 | 5.7 | 6.0 | 5.3 | 5.7 | 5.3 |
| Eagleton* | 5.3 | 4.0 | 4.7 | 92 | 4.7 | 5.7 | 4.7 | 6.3 | 5.7 | 5.7 | 4.7 | 5.3 |
| Impact* | 5.7 | 7.7 | 5.7 | 88 | 5.7 | 5.3 | 4.7 | 5.7 | 5.3 | 4.7 | 6.0 | 5.3 |
| Pick 417 | 6.0 | 7.7 | 5.0 | 89 | 5.7 | 6.0 | 4.7 | 5.7 | 5.7 | 4.7 | 5.0 | 5.3 |
| A97-1409 | 6.3 | 8.3 | 6.0 | 82 | 6.3 | 5.0 | 5.3 | 6.0 | 5.3 | 4.7 | 4.3 | 5.3 |
| A98-304 | 5.7 | 4.7 | 5.7 | 91 | 5.7 | 5.7 | 4.3 | 6.0 | 5.7 | 5.3 | 4.3 | 5.3 |
| BAR Pp 0468 | 6.3 | 5.0 | 6.3 | 80 | 6.7 | 5.7 | 5.0 | 5.3 | 5.3 | 4.7 | 4.3 | 5.3 |
| Langara* | 6.0 | 6.0 | 5.3 | 91 | 5.7 | 5.0 | 4.7 | 5.3 | 6.0 | 5.0 | 5.3 | 5.3 |
| Misty* | 6.0 | 5.3 | 4.7 | 86 | 5.7 | 5.0 | 5.0 | 6.3 | 5.7 | 4.7 | 4.7 | 5.3 |
| PST-731 | 5.7 | 7.3 | 6.7 | 93 | 5.0 | 5.7 | 4.7 | 5.3 | 5.3 | 4.7 | 6.3 | 5.3 |

| Cultivar/<br>Experimental Number | Spring<br>Greenup | Genetic<br>Color | Texture | % Fall<br>Cover | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Apr | May | June | July | Aug | Sept | Oct | Avg |
| PST-B4-246 | 5.3 | 6.7 | 5.7 | 89 | 4.7 | 5.3 | 5.7 | 6.0 | 5.7 | 5.3 | 4.3 | 5.3 |
| Bedazzled* | 6.0 | 6.3 | 5.0 | 93 | 5.0 | 5.3 | 4.7 | 5.7 | 5.7 | 5.7 | 4.7 | 5.2 |
| H92-203 | 6.0 | 5.7 | 5.7 | 97 | 5.3 | 5.0 | 4.0 | 6.0 | 6.0 | 5.3 | 5.0 | 5.2 |
| SRX 2284 | 6.0 | 7.3 | 6.0 | 88 | 6.0 | 5.0 | 4.3 | 5.3 | 5.3 | 5.3 | 5.3 | 5.2 |
| Award* | 5.0 | 7.3 | 6.0 | 88 | 4.7 | 5.3 | 4.7 | 5.7 | 5.7 | 5.0 | 5.3 | 5.2 |
| Baritone* | 5.3 | 6.0 | 5.0 | 88 | 5.3 | 5.0 | 4.7 | 5.7 | 5.3 | 5.0 | 5.3 | 5.2 |
| DLF 76-9032 | 5.7 | 5.3 | 6.0 | 90 | 5.0 | 6.3 | 4.3 | 5.3 | 5.7 | 4.7 | 5.0 | 5.2 |
| Royale (A97-1336)* | 6.7 | 6.3 | 5.7 | 91 | 5.7 | 6.3 | 4.7 | 5.3 | 5.3 | 4.3 | 4.7 | 5.2 |
| B4-128A | 5.7 | 5.3 | 6.3 | 87 | 5.0 | 5.0 | 4.3 | 5.7 | 5.7 | 6.0 | 4.3 | 5.1 |
| Freedom II* | 5.7 | 8.0 | 6.7 | 82 | 5.3 | 6.3 | 4.7 | 5.3 | 5.0 | 4.7 | 4.7 | 5.1 |
| PST-B5-89 | 6.0 | 8.0 | 5.3 | 81 | 5.7 | 6.3 | 5.3 | 5.3 | 4.7 | 4.3 | 4.3 | 5.1 |
| Ascot* | 6.0 | 7.0 | 6.3 | 88 | 4.7 | 5.7 | 5.0 | 5.7 | 5.7 | 5.0 | 4.3 | 5.1 |
| B5-144 | 5.7 | 4.7 | 5.0 | 93 | 5.0 | 5.3 | 4.3 | 5.7 | 6.0 | 5.0 | 4.7 | 5.1 |
| Bordeaux* | 5.7 | 7.3 | 5.3 | 93 | 5.3 | 4.7 | 4.3 | 6.0 | 5.7 | 5.3 | 4.7 | 5.1 |
| Pro Seeds - 453 | 6.7 | 6.3 | 5.7 | 81 | 6.7 | 5.3 | 4.7 | 5.3 | 4.7 | 5.0 | 4.3 | 5.1 |
| A98-296 | 6.0 | 7.0 | 5.3 | 92 | 5.3 | 4.7 | 4.0 | 6.0 | 5.7 | 5.3 | 4.7 | 5.1 |
| BH 00-6002 | 5.3 | 5.0 | 5.0 | 90 | 4.7 | 4.3 | 4.3 | 5.7 | 6.0 | 5.3 | 5.3 | 5.1 |
| J-1513 | 6.3 | 7.7 | 6.7 | 87 | 5.0 | 6.0 | 5.0 | 5.3 | 5.3 | 4.3 | 4.7 | 5.1 |
| Mallard (A97-1439)* | 6.0 | 7.7 | 5.3 | 76 | 5.3 | 5.0 | 5.0 | 5.3 | 5.3 | 5.0 | 4.7 | 5.1 |
| A98-1275 | 5.7 | 6.7 | 5.0 | 77 | 5.3 | 5.7 | 4.7 | 5.7 | 5.3 | 4.3 | 4.7 | 5.1 |
| Ba 82-288 | 5.7 | 7.0 | 5.3 | 87 | 5.3 | 5.0 | 4.7 | 5.3 | 5.3 | 5.0 | 5.0 | 5.1 |
| H94-293 | 5.3 | 6.7 | 5.7 | 91 | 4.3 | 5.0 | 4.7 | 6.0 | 5.7 | 5.0 | 5.0 | 5.1 |
| J-2885 | 6.0 | 7.3 | 6.3 | 87 | 4.7 | 5.7 | 4.7 | 5.3 | 5.7 | 5.0 | 4.7 | 5.1 |
| PST-108-79 | 6.0 | 5.3 | 6.3 | 90 | 5.3 | 5.3 | 4.7 | 5.3 | 5.3 | 5.0 | 4.7 | 5.1 |
| SI A96-386 | 6.0 | 6.7 | 5.0 | 83 | 4.7 | 5.3 | 4.7 | 5.7 | 6.0 | 5.0 | 4.3 | 5.1 |
| SRX 27921 | 5.3 | 7.0 | 7.0 | 90 | 4.0 | 5.3 | 5.3 | 5.3 | 6.0 | 5.0 | 4.7 | 5.1 |
| B5-45 | 7.0 | 5.0 | 5.3 | 87 | 5.3 | 5.7 | 4.3 | 5.7 | 5.3 | 5.0 | 4.0 | 5.0 |
| Jewel* | 5.3 | 6.0 | 5.3 | 88 | 4.7 | 5.0 | 3.7 | 5.7 | 6.0 | 5.7 | 4.7 | 5.0 |

| Cultivar/ Experimental Number | Spring Greenup | Genetic Color | Texture | % Fall Cover | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Apr | May | June | July | Aug | Sept | Oct | Avg |
| Limousine* | 5.3 | 4.7 | 6.0 | 90 | 4.3 | 5.0 | 4.3 | 5.7 | 5.7 | 5.3 | 5.0 | 5.0 |
| PST-B5-125 | 5.3 | 7.3 | 6.3 | 88 | 5.3 | 5.0 | 5.0 | 5.7 | 5.3 | 4.7 | 4.3 | 5.0 |
| Rambo* | 5.7 | 6.3 | 6.0 | 84 | 5.3 | 6.0 | 4.3 | 5.7 | 5.0 | 4.3 | 4.7 | 5.0 |
| Alpine* | 6.0 | 6.0 | 6.0 | 88 | 5.7 | 5.3 | 4.7 | 5.0 | 5.3 | 5.0 | 4.0 | 5.0 |
| BAR Pp 0573 | 5.3 | 6.3 | 5.3 | 90 | 5.0 | 4.7 | 4.7 | 5.3 | 5.7 | 4.3 | 5.3 | 5.0 |
| Everest* | 5.3 | 8.0 | 5.7 | 84 | 5.3 | 5.7 | 4.3 | 5.7 | 5.3 | 4.3 | 4.3 | 5.0 |
| SRX 2114 | 5.7 | 6.7 | 5.7 | 83 | 4.7 | 5.3 | 4.7 | 5.7 | 5.3 | 4.7 | 4.7 | 5.0 |
| B3-171 | 5.7 | 6.0 | 5.7 | 87 | 5.7 | 5.0 | 4.0 | 5.0 | 5.7 | 4.7 | 4.7 | 5.0 |
| Boutique* | 5.3 | 7.7 | 5.3 | 73 | 5.0 | 4.3 | 4.3 | 5.3 | 5.7 | 4.3 | 5.7 | 5.0 |
| Midnight* | 5.7 | 7.3 | 5.3 | 81 | 5.3 | 5.7 | 4.7 | 5.0 | 5.0 | 4.3 | 4.7 | 5.0 |
| Shamrock* | 5.7 | 6.7 | 5.7 | 95 | 5.0 | 5.3 | 4.3 | 5.0 | 5.7 | 4.7 | 4.7 | 5.0 |
| A98-407 | 6.3 | 7.3 | 5.0 | 85 | 5.7 | 5.3 | 4.7 | 5.0 | 5.0 | 4.7 | 4.3 | 5.0 |
| Unique* | 5.7 | 5.3 | 6.0 | 81 | 6.0 | 4.7 | 4.0 | 5.7 | 5.3 | 4.7 | 4.3 | 5.0 |
| Coventry* | 6.3 | 5.0 | 5.0 | 92 | 4.7 | 5.3 | 4.3 | 6.0 | 5.0 | 4.7 | 4.3 | 4.9 |
| PST-1701 | 5.3 | 5.0 | 6.3 | 93 | 4.3 | 4.0 | 4.7 | 5.3 | 5.3 | 5.7 | 5.0 | 4.9 |
| Pp H 6370 | 5.3 | 5.7 | 7.3 | 86 | 4.7 | 4.3 | 4.7 | 5.7 | 5.3 | 4.7 | 5.0 | 4.9 |
| Serene* | 5.7 | 5.7 | 4.7 | 79 | 5.3 | 5.3 | 4.7 | 5.0 | 5.0 | 4.7 | 4.3 | 4.9 |
| B5-43 | 6.3 | 5.3 | 5.0 | 89 | 4.7 | 5.0 | 4.3 | 5.7 | 5.3 | 4.7 | 4.7 | 4.9 |
| Pp H 7832 | 5.3 | 6.7 | 5.3 | 89 | 4.7 | 5.0 | 4.3 | 5.3 | 5.3 | 4.7 | 5.0 | 4.9 |
| A93-200 | 6.3 | 5.3 | 5.7 | 94 | 4.7 | 4.7 | 4.0 | 5.3 | 5.7 | 5.0 | 4.7 | 4.9 |
| A96-427 | 6.7 | 6.0 | 5.7 | 74 | 5.0 | 5.7 | 4.7 | 5.0 | 5.0 | 4.3 | 4.3 | 4.9 |
| A98-881 | 5.7 | 6.0 | 6.0 | 89 | 5.0 | 4.3 | 4.3 | 5.3 | 5.3 | 4.7 | 5.0 | 4.9 |
| Bodacious* | 5.3 | 7.0 | 6.7 | 86 | 4.7 | 5.0 | 4.7 | 5.0 | 5.7 | 4.7 | 4.3 | 4.9 |
| PST-1QG-27 | 6.0 | 5.7 | 5.7 | 87 | 5.3 | 5.0 | 4.3 | 4.7 | 5.3 | 4.7 | 4.7 | 4.9 |
| Abbey* | 6.3 | 5.7 | 4.7 | 84 | 5.3 | 5.0 | 4.0 | 5.7 | 5.3 | 4.0 | 4.3 | 4.8 |
| Lily | 5.7 | 5.7 | 5.0 | 90 | 4.7 | 5.0 | 4.3 | 5.3 | 5.3 | 4.7 | 4.3 | 4.8 |
| PST-1BMY | 5.7 | 7.3 | 4.7 | 74 | 5.7 | 4.7 | 4.7 | 5.3 | 4.0 | 4.7 | 4.7 | 4.8 |
| PST-York Harbor 4 | 5.3 | 7.0 | 5.7 | 78 | 5.0 | 4.7 | 4.3 | 5.3 | 5.3 | 5.0 | 4.0 | 4.8 |

| Cultivar/ Experimental Number | Spring Greenup | Genetic Color | Texture | % Fall Cover | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Apr | May | June | July | Aug | Sept | Oct | Avg |
| 99AN-53 | 5.3 | 6.7 | 4.7 | 85 | 5.0 | 4.3 | 4.0 | 5.7 | 5.3 | 5.0 | 4.0 | 4.8 |
| Chateau* | 6.0 | 6.3 | 4.7 | 76 | 5.3 | 5.0 | 4.3 | 5.3 | 4.7 | 4.7 | 4.0 | 4.8 |
| J-2890 | 5.0 | 7.3 | 5.7 | 64 | 4.7 | 5.7 | 4.3 | 5.0 | 4.7 | 4.3 | 4.7 | 4.8 |
| Limerick | 5.3 | 5.3 | 5.7 | 89 | 4.3 | 5.0 | 4.3 | 5.7 | 5.3 | 4.3 | 4.3 | 4.8 |
| PST-222 | 6.3 | 8.0 | 4.3 | 74 | 5.3 | 5.0 | 4.3 | 5.3 | 5.0 | 4.3 | 4.0 | 4.8 |
| PST-B3-170 | 5.3 | 7.0 | 5.3 | 86 | 4.7 | 4.3 | 4.3 | 5.3 | 5.3 | 4.7 | 4.7 | 4.8 |
| Wildwood* | 5.3 | 6.7 | 6.7 | 80 | 4.7 | 4.7 | 4.7 | 5.3 | 5.0 | 4.3 | 4.7 | 4.8 |
| A97-857 | 4.7 | 4.0 | 8.7 | 89 | 4.0 | 4.3 | 4.0 | 5.3 | 5.7 | 5.3 | 4.3 | 4.7 |
| Ba 00-6001 | 6.0 | 6.3 | 6.0 | 83 | 4.7 | 5.3 | 4.0 | 4.7 | 5.0 | 4.7 | 4.7 | 4.7 |
| DLF 76-9036 | 5.3 | 6.3 | 4.3 | 84 | 5.0 | 4.3 | 4.0 | 5.3 | 5.3 | 4.7 | 4.3 | 4.7 |
| PST-H6-150 | 5.7 | 5.0 | 6.3 | 75 | 5.3 | 4.7 | 4.0 | 5.3 | 5.3 | 4.3 | 4.0 | 4.7 |
| A98-1028 | 6.3 | 6.3 | 5.7 | 79 | 5.0 | 5.7 | 4.3 | 4.7 | 4.7 | 4.0 | 4.3 | 4.7 |
| BAR Pp 0471 | 5.7 | 5.3 | 6.0 | 65 | 5.0 | 4.7 | 4.0 | 5.0 | 5.3 | 4.7 | 4.0 | 4.7 |
| Baron* | 5.3 | 6.3 | 5.0 | 86 | 4.7 | 4.7 | 4.0 | 5.0 | 5.0 | 4.7 | 4.7 | 4.7 |
| Baronie* | 6.0 | 5.7 | 5.7 | 85 | 5.0 | 5.3 | 4.0 | 5.0 | 4.7 | 4.3 | 4.3 | 4.7 |
| Blue Knight* | 5.3 | 7.7 | 6.0 | 84 | 3.7 | 5.0 | 4.7 | 5.7 | 5.0 | 4.3 | 4.3 | 4.7 |
| DLF 76-9034 | 6.0 | 5.0 | 5.0 | 86 | 4.3 | 5.3 | 4.0 | 5.0 | 5.0 | 5.0 | 4.0 | 4.7 |
| Pp H 6366 | 5.7 | 5.3 | 7.0 | 85 | 4.7 | 5.0 | 4.3 | 5.3 | 4.3 | 4.7 | 4.3 | 4.7 |
| Pp H 7929 | 6.3 | 6.7 | 5.7 | 85 | 4.3 | 5.3 | 4.7 | 5.3 | 4.7 | 4.3 | 4.0 | 4.7 |
| A98-183 | 5.3 | 7.3 | 4.7 | 79 | 4.3 | 4.7 | 4.3 | 5.3 | 4.3 | 5.0 | 4.7 | 4.7 |
| A98-365 | 6.0 | 7.3 | 4.7 | 81 | 5.0 | 5.3 | 4.3 | 4.7 | 4.7 | 4.7 | 3.7 | 4.6 |
| Liberator* | 5.0 | 7.3 | 5.7 | 82 | 4.7 | 5.3 | 4.7 | 4.7 | 4.3 | 4.3 | 4.3 | 4.6 |
| PST-H5-35 | 5.0 | 6.7 | 5.0 | 77 | 4.3 | 5.0 | 4.3 | 5.3 | 5.0 | 4.0 | 4.3 | 4.6 |
| Pick 453 | 5.7 | 7.3 | 5.3 | 61 | 5.0 | 4.7 | 4.0 | 5.3 | 5.0 | 4.3 | 4.0 | 4.6 |
| Quantum Leap* | 5.3 | 8.0 | 6.0 | 67 | 5.0 | 5.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.7 | 4.6 |
| Chelsea* | 7.0 | 5.0 | 7.3 | 92 | 4.3 | 4.7 | 4.0 | 5.0 | 5.0 | 4.7 | 4.7 | 4.6 |
| BH 00-6003 | 6.3 | 8.0 | 6.3 | 62 | 5.0 | 5.3 | 4.3 | 5.0 | 4.3 | 4.3 | 3.7 | 4.6 |
| Blackstone* | 4.7 | 7.3 | 5.3 | 70 | 5.0 | 4.7 | 4.7 | 5.0 | 5.0 | 3.3 | 4.3 | 4.6 |

| Cultivar/ Experimental Number | Spring Greenup | Genetic Color | Texture | % Fall Cover | Quality Apr | May | June | July | Aug | Sept | Oct | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chicago II* | 5.0 | 8.7 | 5.0 | 73 | 4.7 | 4.7 | 4.3 | 5.0 | 4.7 | 4.3 | 4.3 | 4.6 |
| Fairfax* | 5.3 | 5.7 | 4.7 | 89 | 4.3 | 4.7 | 4.0 | 5.0 | 5.0 | 4.7 | 4.3 | 4.6 |
| HV 140 | 6.0 | 5.7 | 7.3 | 76 | 5.0 | 5.0 | 4.7 | 4.7 | 4.7 | 4.0 | 4.0 | 4.6 |
| Julius* | 6.0 | 4.3 | 6.0 | 79 | 5.0 | 5.3 | 4.0 | 4.7 | 4.7 | 4.3 | 4.0 | 4.6 |
| Marquis* | 6.0 | 5.7 | 4.7 | 86 | 5.0 | 4.0 | 3.7 | 5.0 | 5.0 | 4.7 | 4.7 | 4.6 |
| IB7-308 | 5.7 | 8.0 | 5.0 | 61 | 5.3 | 5.3 | 4.7 | 4.7 | 4.7 | 3.3 | 4.0 | 4.6 |
| Julia* | 5.3 | 6.0 | 5.3 | 60 | 5.0 | 5.0 | 4.3 | 5.0 | 4.7 | 4.0 | 3.7 | 4.5 |
| PST-161 | 5.7 | 6.7 | 4.7 | 79 | 4.7 | 5.3 | 4.0 | 4.3 | 4.3 | 4.3 | 4.7 | 4.5 |
| SRX 2394 | 5.3 | 6.3 | 5.3 | 82 | 4.0 | 4.7 | 4.3 | 5.0 | 5.3 | 4.7 | 3.7 | 4.5 |
| Rita* | 5.3 | 7.3 | 5.3 | 73 | 5.0 | 4.3 | 4.0 | 5.0 | 5.0 | 3.7 | 4.3 | 4.5 |
| Allure* | 6.7 | 5.7 | 5.3 | 77 | 4.3 | 5.3 | 4.3 | 5.0 | 4.0 | 4.0 | 4.0 | 4.4 |
| Hallmark* | 5.7 | 6.3 | 6.3 | 69 | 5.3 | 5.0 | 4.0 | 5.0 | 4.3 | 3.7 | 3.7 | 4.4 |
| North Star* | 4.7 | 6.3 | 6.0 | 67 | 3.7 | 4.7 | 4.3 | 5.0 | 5.3 | 4.3 | 3.7 | 4.4 |
| Washington* | 5.0 | 4.3 | 7.7 | 87 | 4.0 | 4.0 | 4.0 | 5.0 | 5.0 | 5.0 | 4.0 | 4.4 |
| A96-742 | 4.7 | 5.0 | 5.3 | 88 | 4.3 | 4.3 | 4.0 | 5.0 | 5.0 | 4.3 | 4.0 | 4.4 |
| Brooklawn* | 5.7 | 6.7 | 5.7 | 69 | 5.0 | 4.7 | 4.0 | 5.0 | 4.3 | 3.7 | 4.3 | 4.4 |
| Cabernet* | 5.3 | 4.7 | 6.0 | 78 | 4.0 | 5.0 | 4.3 | 4.3 | 4.7 | 4.7 | 4.0 | 4.4 |
| Princeton 105* | 5.3 | 7.0 | 4.3 | 78 | 5.0 | 5.0 | 4.3 | 4.3 | 4.7 | 3.7 | 4.0 | 4.4 |
| Ba 84-140 | 5.3 | 9.0 | 4.0 | 69 | 4.7 | 5.3 | 4.7 | 4.0 | 4.7 | 3.7 | 3.7 | 4.4 |
| Wellington* | 5.3 | 4.0 | 8.3 | 92 | 4.3 | 4.0 | 3.3 | 4.7 | 5.3 | 5.0 | 4.0 | 4.4 |
| J-2487 | 5.3 | 8.0 | 6.0 | 67 | 4.3 | 4.3 | 4.3 | 4.7 | 4.3 | 4.0 | 4.3 | 4.3 |
| Jefferson* | 5.3 | 5.3 | 6.0 | 70 | 4.7 | 4.7 | 3.7 | 4.7 | 4.7 | 4.0 | 4.0 | 4.3 |
| Kenblue* | 5.3 | 4.0 | 9.0 | 87 | 4.3 | 4.0 | 3.7 | 4.7 | 5.3 | 4.3 | 4.0 | 4.3 |
| Raven* | 6.0 | 5.7 | 4.7 | 67 | 4.7 | 4.7 | 3.7 | 4.7 | 4.7 | 4.0 | 4.0 | 4.3 |
| Apollo* | 5.7 | 5.3 | 5.7 | 70 | 4.7 | 4.7 | 4.0 | 4.7 | 4.3 | 4.0 | 3.7 | 4.3 |
| Bartitia* | 5.3 | 6.0 | 5.0 | 81 | 4.3 | 4.3 | 3.7 | 5.0 | 4.7 | 4.3 | 3.7 | 4.3 |
| Odyssey* | 5.0 | 7.7 | 5.7 | 77 | 4.3 | 4.7 | 4.0 | 4.3 | 4.3 | 4.3 | 4.0 | 4.3 |
| PST-604 | 5.7 | 7.3 | 4.3 | 72 | 4.7 | 4.7 | 4.0 | 4.7 | 4.3 | 4.0 | 3.7 | 4.3 |

| Cultivar/ Experimental Number | Spring Greenup | Genetic Color | Texture | % Fall Cover | Quality | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | | | Apr | May | June | July | Aug | Sept | Oct | Avg |
| Pp H 7097 | 5.3 | 7.3 | 5.7 | 61 | 4.0 | 4.7 | 3.7 | 5.3 | 5.0 | 3.3 | 4.0 | 4.3 |
| Bariris* | 5.3 | 6.7 | 5.0 | 53 | 4.7 | 5.3 | 3.7 | 5.0 | 4.3 | 3.3 | 3.3 | 4.2 |
| Envicta* | 5.3 | 5.7 | 4.7 | 71 | 4.3 | 4.7 | 3.7 | 4.7 | 4.7 | 4.0 | 3.7 | 4.2 |
| J-1515 | 5.0 | 8.0 | 5.3 | 67 | 4.7 | 4.7 | 4.0 | 4.7 | 4.0 | 3.3 | 4.3 | 4.2 |
| Rugby II* | 4.7 | 7.7 | 6.0 | 79 | 4.0 | 5.3 | 4.3 | 4.3 | 4.0 | 3.7 | 4.0 | 4.2 |
| A98-739 | 5.7 | 7.0 | 6.7 | 74 | 4.3 | 5.0 | 4.0 | 4.3 | 4.0 | 3.7 | 4.0 | 4.2 |
| GO-9LM9 | 5.0 | 4.3 | 7.7 | 79 | 4.0 | 4.0 | 3.7 | 4.3 | 4.7 | 4.7 | 4.0 | 4.2 |
| PST-1804 | 4.7 | 5.3 | 6.0 | 61 | 4.7 | 4.0 | 4.0 | 4.3 | 4.3 | 4.0 | 4.0 | 4.2 |
| Blue Ridge (A97-1449)* | 5.7 | 8.0 | 4.0 | 54 | 4.3 | 5.0 | 4.3 | 4.3 | 4.0 | 3.3 | 3.7 | 4.1 |
| CVB-20631 | 4.7 | 6.0 | 5.7 | 81 | 3.7 | 4.0 | 4.3 | 4.3 | 4.7 | 4.3 | 3.3 | 4.1 |
| B3-185 | 4.7 | 5.0 | 6.0 | 59 | 4.3 | 4.0 | 4.0 | 4.0 | 4.3 | 3.7 | 4.0 | 4.0 |
| Goldrush* | 5.7 | 6.3 | 4.7 | 59 | 5.0 | 4.7 | 3.3 | 4.0 | 4.3 | 3.3 | 3.7 | 4.0 |
| NA-K991 | 4.3 | 7.0 | 4.7 | 48 | 4.3 | 4.3 | 4.3 | 4.7 | 4.3 | 3.3 | 3.0 | 4.0 |
| Showcase* | 4.7 | 5.7 | 6.7 | 63 | 4.0 | 4.3 | 3.7 | 4.3 | 4.3 | 4.0 | 3.7 | 4.0 |
| A96-739 | 5.3 | 7.3 | 4.7 | 62 | 5.0 | 4.7 | 3.7 | 4.7 | 4.0 | 3.0 | 3.0 | 4.0 |
| Ba 83-113 | 5.7 | 8.0 | 5.3 | 58 | 4.3 | 4.3 | 3.7 | 4.3 | 4.0 | 3.7 | 3.7 | 4.0 |
| Boomerang* | 5.3 | 8.5 | 6.3 | 37 | 4.7 | 5.0 | 4.0 | 4.3 | 4.3 | 2.7 | 3.0 | 4.0 |
| Moonlight* | 5.7 | 8.0 | 4.7 | 46 | 5.7 | 5.3 | 3.7 | 3.7 | 3.3 | 3.0 | 3.0 | 4.0 |
| Brilliant* | 6.0 | 5.3 | 6.0 | 50 | 5.0 | 5.0 | 4.0 | 4.3 | 3.7 | 2.7 | 3.0 | 4.0 |
| SRX OG245 | 5.3 | 6.3 | 5.7 | 68 | 4.3 | 4.0 | 3.7 | 4.0 | 4.0 | 3.7 | 3.7 | 3.9 |
| NuGlade* | 5.0 | 6.7 | 6.0 | 65 | 4.3 | 4.7 | 3.7 | 4.0 | 3.7 | 3.3 | 3.7 | 3.9 |
| Total Eclipse* | 5.0 | 7.0 | 5.0 | 57 | 4.7 | 4.7 | 3.7 | 3.3 | 3.7 | 3.3 | 3.7 | 3.9 |
| J-1838 | 4.7 | 7.3 | 6.0 | 55 | 4.0 | 4.7 | 3.3 | 3.3 | 4.3 | 3.7 | 3.7 | 3.9 |
| J-2561 | 4.7 | 7.5 | 6.0 | 43 | 4.0 | 4.7 | 4.0 | 3.7 | 3.7 | 3.0 | 3.7 | 3.8 |
| Barzan* | 4.3 | 6.0 | 6.0 | 53 | 3.7 | 3.7 | 3.7 | 4.7 | 4.3 | 2.7 | 3.7 | 3.8 |
| J-1368 | 4.7 | 8.0 | 6.0 | 59 | 3.7 | 4.3 | 3.7 | 3.7 | 4.0 | 3.3 | 3.3 | 3.7 |
| H92-558 | 5.3 | 7.0 | 5.3 | 28 | 4.7 | 5.0 | 3.7 | 4.3 | 3.7 | 2.3 | 2.0 | 3.7 |
| A97-1432 | 5.7 | 7.3 | 5.3 | 58 | 4.0 | 4.7 | 3.3 | 3.7 | 3.0 | 3.3 | 3.3 | 3.6 |

| Cultivar/ Experimental Number | Spring Greenup | Genetic Color | Texture | % Fall Cover | Quality | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Apr | May | June | July | Aug | Sept | Oct | Avg |
| HV 238 | 5.0 | 6.7 | 5.3 | 45 | 4.3 | 4.0 | 3.7 | 4.0 | 3.3 | 2.3 | 3.3 | 3.6 |
| A97-1567 | 4.7 | 7.3 | 5.0 | 39 | 4.0 | 4.0 | 3.0 | 4.0 | 3.3 | 2.7 | 3.7 | 3.5 |
| J-1880 | 5.0 | 7.0 | 6.0 | 38 | 4.0 | 4.7 | 3.3 | 3.3 | 3.0 | 2.7 | 3.7 | 3.5 |
| Pick-232 | 5.0 | 7.0 | 5.7 | 36 | 4.7 | 4.7 | 3.0 | 3.3 | 2.7 | 2.7 | 2.7 | 3.4 |
| Arcadia* | 4.3 | 8.0 | 5.3 | 35 | 4.0 | 4.3 | 3.0 | 3.3 | 3.0 | 2.7 | 2.3 | 3.2 |
| NA-K992 | 4.7 | 8.3 | 6.0 | 31 | 4.0 | 3.3 | 2.7 | 3.3 | 2.7 | 2.0 | 2.3 | 2.9 |
| *LSD*[3] | *1.2* | *1.0* | *1.1* | *37.9* | *1.3* | *1.2* | *1.3* | *1.9* | *2.0* | *2.1* | *2.1* | *1.4* |

[1] Ratings based on a scale of 0-9 with 9=best quality.
[2] Cultivars marked with "*" were commercially available in 2002.
[3] To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

**TITLE:** Bentgrass Cultivar Evaluation for Putting Greens

**OBJECTIVE:** Evaluate new and traditional bentgrass cultivars under putting green conditions in Kansas.

**PERSONNEL:** Jack Fry

**SPONSOR:** National Turfgrass Evaluation Program

**MATERIALS AND METHODS:**

Twenty-six creeping bentgrass and three velvet bentgrass cultivars were seeded in September 1998 at 1.5 lbs/1000 $ft^2$ at the Rocky Ford Turfgrass Research Center in Manhattan. Three plots of each cultivar were arranged in a randomized complete block design with three replicates. Plots were mowed 6 days weekly at 5/32 inches. Insecticides and fungicides were applied as needed. Plots were rated for winter desiccation injury in early spring, and quality from April to October. All ratings were done visually on a 0 to 9 scale, where 0 = worst and 9 = best.

**RESULTS:**

Cultivars that had significantly worse winter desiccation injury than the highest rated cultivars were Penn A-1, Providence, Penn A-4, and ABT-CRB-1.

Differences in turf quality were observed in May, July, September, and October. In May, the highest rated cultivars (L-93 and SRX 1NJH) had better quality than Providence, Penn A-4, and ABT-CRB-1. In July L-93 received the highest score, and was significantly better than Bavaria, Penn A-4, and ABT-CRB-1. In September cultivars that were statistically lower than L-93 were Pennlinks, SR 1119, Penncross, SRX 1BPAA, Brighton, Century, Imperial, Vesper, PICK CB 13-94, SYN 96-2, Bavaria, Penn A-4, and ABT-CRB-1. In October Penn A-1, SYN 96-2, Penn A-4, and ABT-CRB-1 were statistically lower than the highest rated cultivars, L-93 and SRX 1NJH.

Table 1. Winterkill and turf quality of creeping bentgrass cultivars at Manhattan, KS in 2002.[1]

| Cultivar | Winter desiccation | Quality[2] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | April | May | June | July | Aug | Sept | Oct | Mean |
| L-93 | 7.0 | 5.3 | 5.0 | 6.7 | 7.7 | 7.3 | 7.3 | 7.0 | 6.6 |
| SRX 1NJH | 7.0 | 3.3 | 5.0 | 5.7 | 7.3 | 6.0 | 6.0 | 7.0 | 5.8 |
| Pennlinks | 6.3 | 5.0 | 4.3 | 5.3 | 7.3 | 6.3 | 5.0 | 6.3 | 5.7 |
| PST-A2E | 5.3 | 4.3 | 3.7 | 5.3 | 7.7 | 6.3 | 6.3 | 5.3 | 5.6 |
| Penn G-6 | 6.3 | 3.3 | 4.3 | 5.3 | 7.3 | 6.7 | 5.3 | 6.3 | 5.5 |
| SR 1119 | 6.0 | 4.7 | 4.0 | 5.0 | 6.7 | 6.0 | 4.7 | 6.0 | 5.3 |
| SYN 96-3 | 5.0 | 4.0 | 4.0 | 5.3 | 7.0 | 6.3 | 5.3 | 5.0 | 5.3 |
| Bengal (BAR AS 8FUS2) | 5.7 | 4.0 | 4.0 | 5.0 | 6.3 | 6.0 | 5.7 | 5.7 | 5.2 |
| Crenshaw | 6.7 | 4.3 | 4.3 | 5.0 | 7.0 | 5.3 | 4.0 | 6.7 | 5.2 |
| ISI AP-5 | 5.7 | 4.3 | 4.7 | 4.7 | 6.7 | 6.0 | 4.7 | 5.7 | 5.2 |
| Penn G-1 | 5.3 | 4.0 | 4.3 | 4.7 | 6.0 | 6.3 | 5.7 | 5.3 | 5.2 |
| BAR CB 8US3 | 5.7 | 3.7 | 3.7 | 5.3 | 6.0 | 6.0 | 5.3 | 5.7 | 5.1 |
| SR 7200 | 5.0 | 4.0 | 3.7 | 4.7 | 7.0 | 6.0 | 5.7 | 5.0 | 5.1 |
| SRX 1BPAA | 6.0 | 4.0 | 4.0 | 5.0 | 6.0 | 5.7 | 5.0 | 6.0 | 5.1 |
| Backspin | 4.7 | 2.7 | 3.7 | 5.0 | 7.0 | 6.0 | 5.7 | 4.7 | 5.0 |
| Brighton (SRX 1120) | 5.0 | 3.7 | 4.0 | 5.0 | 6.7 | 6.0 | 5.0 | 5.0 | 5.0 |
| Century | 6.0 | 3.7 | 3.7 | 5.0 | 7.0 | 5.7 | 4.3 | 6.0 | 5.0 |
| Imperial | 5.3 | 4.0 | 3.3 | 5.0 | 7.0 | 6.3 | 4.0 | 5.3 | 5.0 |
| Penn A-1 | 3.0 | 3.7 | 4.0 | 4.7 | 6.7 | 6.7 | 6.0 | 3.0 | 5.0 |
| Penn A-2 | 4.7 | 4.0 | 3.3 | 5.0 | 6.3 | 6.0 | 6.0 | 4.7 | 5.0 |
| SYN 96-1 | 4.0 | 2.0 | 4.0 | 4.7 | 8.0 | 6.3 | 5.7 | 4.0 | 5.0 |
| Vesper (Pick MVB) | 5.3 | 2.7 | 3.7 | 5.0 | 7.0 | 6.0 | 4.7 | 5.3 | 4.9 |
| Pick CB 13-94 | 4.3 | 3.7 | 3.3 | 4.7 | 6.0 | 5.3 | 4.7 | 4.3 | 4.6 |
| SYN 96-2 | 4.0 | 3.3 | 3.7 | 4.7 | 7.0 | 5.3 | 4.3 | 4.0 | 4.6 |
| Providence | 3.7 | 3.3 | 2.7 | 4.7 | 5.7 | 5.7 | 5.7 | 3.7 | 4.5 |
| Bavaria | 4.3 | 3.7 | 3.3 | 4.0 | 5.3 | 5.3 | 4.3 | 4.3 | 4.3 |
| Penn A-4 | 3.3 | 3.3 | 3.0 | 4.0 | 5.3 | 4.7 | 4.3 | 3.3 | 4.0 |
| ABT-CRB-1 | 2.0 | 1.7 | 2.0 | 3.3 | 4.7 | 4.3 | 4.3 | 2.0 | 3.2 |
| CV | 28.2 | 36.8 | 21.2 | 17.9 | 15.2 | 15.2 | 19.1 | 28.2 | 16.4 |
| LSD[2] | 3.1 | NS[3] | 1.8 | NS | 2.3 | NS | 2.2 | 3.1 | 2.0 |

[1]Ratings based on scale of 0 to 9, 9 = best.
[2]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.
[3]NS, No significant statistical differences among entries.

**TITLE:** Fineleaf Fescue Cultivar Trial

**OBJECTIVE:** To evaluate fine leaf fescue under Kansas conditions and submit data collected to the National Turfgrass Evaluation Program.

**PERSONNEL:** Alan Zuk

**SPONSOR:** USDA National Turfgrass Evaluation Program

**INTRODUCTION:**

Fineleaf fescues are shade-tolerant cool-season grasses with a slow, nonaggressive growth habit but a high density upon establishment. Blade width is usually narrower than 2 mm. Leaf curling often occurs during dry periods and can cause a wiry texture. They also do not tolerate wet, poorly drained soils, are susceptible to summer heat stress and various diseases, have fair wear tolerance, and fair to poor recuperative potential. Fineleaf fescues are better adapted to northern climates and often are thinned severely by our hot summers.

**MATERIALS AND METHODS:**

Seventy nine fineleaf fescue cultivars were seeded at the Rocky Ford Turfgrass Research Center in September 1998. The trial was mowed at 3 inches and fertilized with 3 lbs N/1000 $ft^2$ per year. Greenup, leaf texture, spring density and quality from April thru September were visually rated on a 0 to 9 scale, 9 = best. Analysis of variance (ANOVA) procedure was used to analyze the data. Means were separated using the Waller-Duncan K-ratio t test.

**RESULTS:**

Twenty six cultivars had an average greenup rating of 8 or higher, including Silhouette, ABT-CHW-1, ABT-CHW-2, Hardtop, Osprey, Intrigue, Jamestown II and Berkshire.

Nineteen cultivars had an average genetic leaf texture rating of 9, including Eureka II, Hardtop, Berkshire, Minotaur, Defiant, Jasper II, Stonehenge and Chariot.

Eleven cultivars had an average spring density rating of 9, including Magic, Oxford, SR 3200, Scaldis, Stonehenge, Pick FF A-97, Attila (E) and Nordic (E).

Two cultivars had an average mean quality rating of 5 or higher, including SR 5210 and Pathfinder.

Table 1. Performance of fineleaf fescue cultivars under lawn conditions at Manhattan, KS in 2002.

| | | | | Quality[1] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cultivar | Green up | Leaf Texture | Spring Density | Apr. | May | June | July | Aug. | Sept. | Mean |
| Navigator | 7.3 | 8.3 | 8.7 | 8.7 | 8.3 | 5.7 | 3.0 | 2.0 | 2.0 | 4.9 |
| Berkshire | 8.0 | 9.0 | 8.0 | 8.7 | 7.3 | 5.7 | 3.3 | 2.0 | 2.0 | 4.8 |
| Nordic | 7.3 | 9.0 | 9.0 | 7.7 | 7.3 | 5.0 | 3.3 | 2.0 | 2.0 | 4.6 |
| ABT-CR-2 | 7.0 | 8.7 | 8.0 | 8.7 | 8.0 | 5.7 | 3.0 | 2.0 | 2.3 | 4.9 |
| Jasper II | 7.7 | 9.0 | 8.3 | 8.7 | 8.3 | 5.3 | 2.3 | 2.0 | 2.0 | 4.8 |
| Pick FF A-97 | 7.0 | 9.0 | 9.0 | 8.3 | 7.3 | 6.0 | 3.3 | 2.0 | 2.0 | 4.8 |
| MB-63 | 7.3 | 8.7 | 8.7 | 8.7 | 7.7 | 5.7 | 2.7 | 2.0 | 2.0 | 4.8 |
| PST-4FR | 8.0 | 8.3 | 8.0 | 8.3 | 8.0 | 5.3 | 3.0 | 2.0 | 2.0 | 4.8 |
| Stonehenge | 7.7 | 9.0 | 9.0 | 8.7 | 6.7 | 5.0 | 3.0 | 2.0 | 2.0 | 4.6 |
| Attila E | 7.7 | 9.0 | 9.0 | 8.7 | 6.3 | 6.0 | 3.0 | 2.0 | 2.3 | 4.7 |
| Shademark | 6.7 | 8.7 | 8.0 | 8.0 | 8.3 | 5.0 | 3.0 | 2.0 | 2.0 | 4.7 |
| Bridgeport | 7.3 | 9.0 | 8.7 | 8.3 | 8.0 | 4.7 | 3.0 | 2.0 | 2.0 | 4.7 |
| ABT-CR-3 | 7.0 | 8.0 | 8.3 | 7.3 | 7.7 | 5.0 | 2.7 | 2.0 | 2.3 | 4.5 |
| BAR CHF 8 FUS 2 | 7.3 | 9.0 | 8.7 | 8.3 | 8.3 | 5.3 | 3.0 | 2.3 | 2.0 | 4.9 |
| Reliant II | 7.3 | 8.7 | 7.7 | 8.3 | 6.7 | 5.7 | 3.0 | 2.0 | 2.0 | 4.6 |
| SR 5210 | 8.0 | 8.3 | 9.0 | 9.0 | 9.0 | 6.0 | 3.0 | 2.3 | 2.3 | 5.2 |
| Longfellow II | 8.0 | 7.7 | 8.7 | 8.3 | 8.0 | 5.3 | 3.0 | 2.0 | 2.0 | 4.8 |
| Cindy Lou | 8.0 | 8.7 | 8.3 | 8.0 | 8.3 | 5.0 | 3.0 | 2.3 | 2.3 | 4.8 |
| Magic | 7.7 | 8.7 | 9.0 | 9.0 | 8.0 | 5.3 | 3.0 | 2.0 | 2.0 | 4.9 |
| ABT-HF-2 | 8.0 | 9.0 | 9.0 | 8.0 | 7.0 | 5.7 | 3.3 | 2.0 | 2.0 | 4.7 |
| PST-4HM | 8.0 | 7.7 | 8.3 | 8.0 | 7.0 | 5.7 | 3.0 | 2.0 | 2.0 | 4.6 |
| Chariot | 8.0 | 9.0 | 8.7 | 9.0 | 7.0 | 5.3 | 3.0 | 2.0 | 2.3 | 4.8 |
| Oxford | 8.0 | 9.0 | 9.0 | 9.0 | 7.7 | 5.7 | 3.0 | 2.0 | 2.0 | 4.9 |
| Aberdeen | 7.0 | 8.7 | 8.3 | 8.0 | 8.7 | 5.0 | 3.0 | 2.0 | 2.0 | 4.8 |
| ABT-CHW-1 | 8.3 | 8.3 | 8.7 | 8.3 | 8.0 | 4.0 | 3.0 | 2.0 | 2.0 | 4.6 |
| Wrigley | 7.0 | 8.3 | 8.7 | 8.3 | 8.0 | 5.7 | 3.0 | 2.0 | 2.3 | 4.9 |
| Scaldis | 8.0 | 8.7 | 9.0 | 8.7 | 8.0 | 5.7 | 3.0 | 2.3 | 2.0 | 4.9 |
| Heron | 7.7 | 8.7 | 8.7 | 8.0 | 7.3 | 4.3 | 3.0 | 2.0 | 2.3 | 4.5 |
| Sandpiper | 7.7 | 8.3 | 8.7 | 8.3 | 8.3 | 5.0 | 3.0 | 2.0 | 2.0 | 4.8 |
| Treazure | 7.3 | 8.3 | 7.7 | 8.3 | 8.0 | 5.3 | 3.0 | 2.0 | 2.0 | 4.8 |

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|---|---|---|---|---|---|---|---|---|---|---|
| Pathfinder | 7.7 | 7.3 | 7.3 | 9.0 | 8.7 | 5.7 | 3.0 | 2.0 | 2.0 | 5.1 |
| SRX 52961 | 8.0 | 7.7 | 8.3 | 8.0 | 8.0 | 5.0 | 3.0 | 2.3 | 2.0 | 4.7 |
| Culombra | 7.3 | 8.7 | 8.3 | 8.3 | 8.0 | 5.7 | 3.0 | 2.0 | 2.0 | 4.8 |
| ABT-HF1 | 7.3 | 9.0 | 8.3 | 8.0 | 7.3 | 5.7 | 3.3 | 2.0 | 2.0 | 4.7 |
| SRX 3961 | 8.0 | 8.7 | 8.3 | 8.0 | 7.7 | 5.0 | 3.0 | 2.0 | 2.0 | 4.6 |
| Salsa | 7.0 | 7.7 | 7.3 | 7.7 | 7.3 | 5.0 | 2.7 | 2.0 | 2.0 | 4.4 |
| Eureka II | 7.3 | 9.0 | 8.3 | 7.3 | 7.3 | 5.0 | 3.0 | 2.0 | 2.3 | 4.5 |
| Shademaster II | 8.0 | 8.0 | 8.7 | 8.7 | 8.0 | 4.7 | 3.0 | 2.0 | 2.3 | 4.8 |
| Ambassador | 7.7 | 7.7 | 7.3 | 8.0 | 8.3 | 5.0 | 2.7 | 2.0 | 2.0 | 4.7 |
| Inverness | 8.0 | 7.3 | 8.0 | 8.0 | 7.7 | 5.7 | 2.7 | 2.0 | 2.0 | 4.7 |
| Discovery | 7.7 | 8.0 | 8.3 | 8.3 | 7.3 | 4.7 | 2.7 | 2.0 | 2.0 | 4.5 |
| ABT-HF-4 | 7.7 | 9.0 | 8.7 | 8.0 | 6.7 | 4.7 | 3.0 | 2.0 | 2.3 | 4.4 |
| ABT-CHW-2 | 8.3 | 7.7 | 8.3 | 8.3 | 7.7 | 5.3 | 3.0 | 2.0 | 2.0 | 4.7 |
| Pick FRC A-93 | 8.0 | 7.0 | 8.3 | 7.7 | 7.7 | 5.3 | 3.0 | 2.0 | 2.0 | 4.6 |
| Osprey | 8.0 | 8.7 | 8.3 | 8.3 | 7.7 | 5.0 | 3.0 | 2.0 | 2.0 | 4.7 |
| Florentine | 7.0 | 8.7 | 7.7 | 7.7 | 8.0 | 4.7 | 3.0 | 2.0 | 2.3 | 4.6 |
| PST-4MB | 7.7 | 9.0 | 8.7 | 8.3 | 7.0 | 5.0 | 3.0 | 2.0 | 2.0 | 4.6 |
| ABT-HF-3 | 7.0 | 9.0 | 9.0 | 7.7 | 6.7 | 4.0 | 3.0 | 2.0 | 2.0 | 4.2 |
| MB-82 | 8.0 | 8.7 | 8.7 | 8.0 | 6.7 | 5.0 | 3.0 | 2.0 | 2.0 | 4.4 |
| Hardtop | 8.0 | 9.0 | 8.3 | 8.0 | 7.3 | 5.0 | 3.0 | 2.0 | 2.0 | 4.6 |
| Bargena III | 7.0 | 8.7 | 7.0 | 7.3 | 7.7 | 4.7 | 3.0 | 2.3 | 2.0 | 4.5 |
| DGSC 94 | 7.0 | 7.5 | 8.5 | 8.0 | 8.0 | 5.5 | 3.0 | 2.0 | 2.0 | 4.8 |
| Rose | 7.0 | 8.0 | 8.0 | 7.7 | 8.7 | 4.3 | 3.0 | 2.0 | 2.0 | 4.6 |
| Minotaur | 7.0 | 9.0 | 8.3 | 7.0 | 6.0 | 4.7 | 3.3 | 2.0 | 2.3 | 4.2 |
| SR 3200 | 7.3 | 8.0 | 9.0 | 7.7 | 7.3 | 3.0 | 3.0 | 2.0 | 2.0 | 4.2 |
| Rescue 911 | 7.7 | 8.3 | 8.0 | 7.3 | 7.7 | 4.7 | 3.0 | 2.0 | 2.0 | 4.4 |
| ABT-CHW-3 | 7.3 | 8.3 | 7.3 | 7.7 | 8.3 | 4.3 | 3.0 | 2.0 | 2.0 | 4.6 |
| ASC 082 | 8.0 | 7.7 | 8.3 | 8.7 | 8.0 | 5.3 | 3.0 | 2.0 | 2.0 | 4.8 |
| Bighorn | 7.0 | 8.3 | 8.7 | 7.3 | 6.3 | 3.3 | 3.0 | 2.0 | 2.0 | 4.0 |
| Silhouette | 8.3 | 7.7 | 8.3 | 8.0 | 7.7 | 4.0 | 3.0 | 2.0 | 2.0 | 4.4 |
| Brittany | 7.7 | 8.7 | 8.0 | 8.0 | 7.7 | 5.3 | 3.0 | 2.0 | 2.0 | 4.7 |
| SR 5100 | 8.0 | 7.0 | 8.3 | 7.3 | 8.3 | 4.3 | 3.0 | 2.0 | 2.0 | 4.5 |
| Quatro | 7.7 | 8.3 | 8.0 | 7.7 | 6.7 | 5.3 | 3.0 | 2.0 | 2.0 | 4.4 |
| ASR 049 | 7.3 | 8.0 | 8.3 | 8.0 | 8.0 | 5.3 | 3.0 | 2.0 | 2.3 | 4.8 |

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|---|---|---|---|---|---|---|---|---|---|---|
| Jamestown II | 8.0 | 7.7 | 7.7 | 7.3 | 7.7 | 4.3 | 3.0 | 2.0 | 2.0 | 4.4 |
| Scaldis II | 7.7 | 8.7 | 8.3 | 7.7 | 7.0 | 4.3 | 3.0 | 2.0 | 2.3 | 4.4 |
| Defiant | 7.7 | 9.0 | 8.3 | 8.0 | 7.7 | 5.3 | 3.0 | 2.0 | 2.0 | 4.7 |
| Intrigue | 8.0 | 6.7 | 7.3 | 7.7 | 9.0 | 4.7 | 3.0 | 2.0 | 2.0 | 4.7 |
| Tiffany | 7.7 | 9.0 | 8.0 | 7.3 | 7.3 | 4.3 | 3.0 | 2.0 | 2.0 | 4.3 |
| Boreal | 7.7 | 7.0 | 7.7 | 7.0 | 6.7 | 4.3 | 3.0 | 2.0 | 2.0 | 4.2 |
| SR 6000 | 7.7 | 7.7 | 7.7 | 7.3 | 6.3 | 4.3 | 3.0 | 2.0 | 2.0 | 4.2 |
| Common Creeping | 6.7 | 7.3 | 7.7 | 7.3 | 7.7 | 4.0 | 2.3 | 2.0 | 2.0 | 4.2 |
| BAR SCF 8 FUS 3 | 7.7 | 8.3 | 7.3 | 7.0 | 7.3 | 5.7 | 3.3 | 2.0 | 2.3 | 4.6 |
| Shadow II | 7.3 | 7.7 | 6.0 | 6.0 | 6.3 | 4.3 | 3.0 | 2.0 | 2.0 | 3.9 |
| Dawson E+ | 7.0 | 8.0 | 7.3 | 6.7 | 7.3 | 6.3 | 3.3 | 2.0 | 2.0 | 4.6 |
| ASC 172 | 8.0 | 8.5 | 7.5 | 7.5 | 7.5 | 4.0 | 3.0 | 2.0 | 2.0 | 4.3 |
| Banner III | 7.7 | 7.3 | 7.3 | 7.0 | 7.3 | 3.7 | 3.0 | 2.0 | 2.0 | 4.2 |
| Seabreeze | 7.5 | 8.0 | 6.5 | 6.5 | 5.5 | 6.0 | 3.0 | 2.0 | 2.0 | 4.2 |
| ACF 083 | 6.7 | 5.3 | 6.7 | 6.0 | 5.7 | 4.3 | 3.0 | 2.0 | 2.0 | 3.8 |
| *Minimum Significant Difference*[2] | 3.4 | 2.2 | 2.1 | 2.0 | 1.5 | 2.0 | 1.0 | 0.7 | 1.3 | 0.6 |

[1]Quality rated on a scale of 0-9 with 9 = best.
[2]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding minimum significant difference value.

**TITLE:** 1999 National Perennial Ryegrass Test

**OBJECTIVES:** To evaluate perennial ryegrass cultivars under Kansas conditions

**PERSONNEL**: Jinmin Fu and Jack Fry

**SPONSOR**: National Turfgrass Evaluation Program

**INTRODUCTION**:

Perennial ryegrass is a cool-season turfgrass widely used in Kansas for golf course fairways and tees, and sports turfs. There exists significant differences in genetic color, disease susceptibility, and visual quality among cultivars. Identifying best performing cultivars in our climate is valuable to seed suppliers, golf course superintendents, and sports turf managers.

**MATERIALS AND METHODS**:

This trial began on 17 September 1999 with the establishment of 134 cultivars of perennial ryegrass at the Rocky Ford Turfgrass Research Center. The turf was maintained at a 0.5 inch mowing height and fertilized with 1 lb N/1000 $ft^2$/yr in May, September and November, and irrigated to prevent drought stress.

Cultivars were evaluated for turf quality each month of the growing season. Genetic color, dollar spot, and visual quality were rated on a 0 to 9 scale: 9 = best, 6 = lowest acceptable, and 0 = poorest. Values listed under each month in Table 1 are the averages of ratings made on three replicated plots.

**RESULTS**:

*Genetic Color.* Cultivars in the highest group were Mach 1 (Roberts-627), UT-1000(ABT-99-4.709), CIS-PR-84 and HAWKERE (SRX 4RHT), although they were not significantly different from many other cultivars. Premier II, DP 17-9496, and Linn had the poorest color ratings.

*Leaf texture.* Manhattan 4 and SR 4420 had the highest leaf texture ratings (8.0). The cultivar with coarsest leaf texture was Linn with 2.0 rating. The leaf texture for other cultivars ranged from 4.7 to 7.7.

*Dollar spot.* There were no significant differences in dollar spot among cultivars, although the ratings ranged from 4.0 - 9.0. This indicated that there was a lot of variation in dollar spot among replicates.

*Turf quality.* Differences were observed in all months except May, August, and September. Regarding the overall mean, cultivars that had significantly lower quality than others were Fore, Linn and Monterey II (JR-187). There was no significant difference in turf quality among other cultivars.

Table 1. Genetic color, leaf texture, dollar spot, and turf quality of perennial ryegrass cultivars at Manhattan, KS in 2002.

| | | | | Turf quality[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Selection | Genetic color | Leaf texture | Dollar spot | Apr | May | Jun | Jul | Aug | Sep | Nov | Mean |
| Racer | 6.7 | 6.7 | 6.3 | 8.3 | 7.7 | 6.7 | 7.7 | 7.0 | 6.3 | 8.0 | 7.4 |
| Pennant II | 7.0 | 6.7 | 7.3 | 8.7 | 9.0 | 6.7 | 5.0 | 6.3 | 7.0 | 8.0 | 7.2 |
| ABT-99-4.721 | 7.7 | 7.7 | 6.7 | 7.7 | 8.7 | 7.0 | 6.0 | 6.0 | 6.3 | 8.3 | 7.1 |
| Charger II | 6.0 | 7.3 | 8.3 | 8.7 | 7.7 | 6.0 | 6.0 | 6.0 | 7.0 | 8.3 | 7.1 |
| Grand Slam (PST-2L96) | 7.3 | 7.7 | 8.0 | 7.3 | 8.7 | 6.3 | 5.7 | 6.3 | 7.3 | 8.3 | 7.1 |
| ABT-99-4.339 | 7.0 | 7.0 | 6.3 | 7.3 | 8.3 | 6.3 | 6.7 | 6.0 | 6.0 | 8.0 | 7.0 |
| Churchill | 7.3 | 7.0 | 6.3 | 8.3 | 8.3 | 6.3 | 6.0 | 5.3 | 5.7 | 8.7 | 7.0 |
| Hawkeye (SRX 4RHT) | 8.0 | 7.7 | 8.3 | 7.3 | 8.3 | 6.3 | 5.0 | 5.7 | 7.7 | 8.7 | 7.0 |
| Inspire (R8000) | 7.7 | 7.3 | 6.0 | 7.7 | 8.0 | 6.3 | 6.7 | 6.0 | 6.3 | 8.0 | 7.0 |
| LPR 98-144 | 6.7 | 7.7 | 8.0 | 8.0 | 8.0 | 6.0 | 6.3 | 6.0 | 6.7 | 8.0 | 7.0 |
| Manhattan 3 | 6.7 | 8.0 | 7.7 | 7.7 | 8.0 | 6.3 | 6.7 | 6.0 | 6.3 | 8.0 | 7.0 |
| SR 4220 (SRX4801) | 7.3 | 7.7 | 8.0 | 7.0 | 7.7 | 6.3 | 6.3 | 6.3 | 7.0 | 8.0 | 70 |
| Admire (JR-151) | 6.3 | 7.7 | 6.3 | 8.0 | 8.0 | 6.3 | 6.0 | 6.0 | 6.0 | 8.0 | 6.9 |
| Cabo (CIS-PR-80) | 7.0 | 6.7 | 6.3 | 7.3 | 8.3 | 6.7 | 5.7 | 6.0 | 6.0 | 8.0 | 6.9 |
| Pizzazz | 7.7 | 7.7 | 7.7 | 7.7 | 8.7 | 6.7 | 5.3 | 6.3 | 6.0 | 7.7 | 6.9 |
| Terradyne (A5C) | 7.7 | 6.0 | 6.7 | 8.3 | 8.3 | 6.3 | 5.7 | 5.7 | 6.0 | 7.7 | 6.9 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blazer IV (Pick MDR) | 7.3 | 7.0 | 7.3 | 7.3 | 8.3 | 6.0 | 5.7 | 6.3 | 5.7 | 7.0 | 6.8 |
| Courage (MB 410) | 7.3 | 7.3 | 8.7 | 6.7 | 8.3 | 6.3 | 6.0 | 6.3 | 6.3 | 7.7 | 6.8 |
| Applaud (Pennington-11301) | 7.7 | 7.3 | 5.7 | 7.3 | 9.0 | 6.3 | 5.7 | 5.7 | 5.7 | 7.0 | 6.7 |
| APR 1232 | 6.0 | 7.3 | 6.7 | 8.0 | 8.3 | 5.0 | 5.3 | 6.3 | 6.0 | 7.7 | 6.7 |
| APR 776 | 6.0 | 7.0 | 6.7 | 7.7 | 7.7 | 6.0 | 6.0 | 6.3 | 6.0 | 7.3 | 6.7 |
| SRX 4120 | 6.3 | 7.3 | 7.0 | 7.3 | 7.7 | 6.3 | 6.3 | 5.7 | 6.0 | 7.3 | 6.7 |
| Headstart | 6.0 | 7.0 | 7.0 | 7.3 | 8.0 | 6.0 | 5.0 | 5.7 | 6.7 | 7.3 | 6.6 |
| Palmer III | 7.0 | 7.3 | 6.3 | 7.7 | 8.3 | 5.7 | 5.7 | 5.0 | 6.0 | 7.7 | 6.6 |
| Pinnacle II (BAR 9 B2) | 7.3 | 6.7 | 6.0 | 6.3 | 7.7 | 6.0 | 5.7 | 5.7 | 6.7 | 8.3 | 6.6 |
| PST-2M4 | 6.3 | 6.7 | 8.3 | 8.0 | 8.3 | 5.3 | 4.0 | 5.7 | 7.3 | 7.7 | 6.6 |
| PST-2SBE | 6.7 | 6.7 | 8.3 | 8.0 | 8.3 | 5.3 | 4.0 | 5.7 | 7.3 | 7.7 | 6.6 |
| Stellar (CIS-PR-72) | 7.3 | 7.0 | 6.7 | 7.0 | 8.0 | 6.0 | 6.0 | 5.7 | 6.0 | 7.3 | 6.6 |
| Ascend | 6.3 | 6.7 | 6.3 | 6.7 | 7.3 | 6.0 | 6.0 | 6.0 | 6.0 | 7.3 | 6.6 |
| Charismatic (LTP 98-501) | 7.3 | 7.3 | 5.0 | 7.3 | 8.0 | 6.3 | 5.0 | 5.3 | 6.3 | 7.0 | 6.5 |
| Affirmed | 7.0 | 6.7 | 6.7 | 6.7 | 8.0 | 6.3 | 5.3 | 5.7 | 6.0 | 7.0 | 6.4 |
| APR 1233 | 5.7 | 5.7 | 7.7 | 7.0 | 7.7 | 6.0 | 5.3 | 6.0 | 6.0 | 7.0 | 6.4 |
| Brightstar SLT (PST-2A6B) | 7.3 | 6.3 | 5.3 | 7.3 | 7.7 | 6.3 | 5.7 | 55.3 | 5.7 | 7.0 | 6.4 |
| Cathedral II | 7.0 | 7.0 | 6.7 | 7.3 | 7.7 | 5.7 | 6.0 | 5.3 | 5.3 | 7.3 | 6.4 |
| DLF-LDD | 7.0 | 6.7 | 8.7 | 7.7 | 7.3 | 5.7 | 4.3 | 5.7 | 7.0 | 7.3 | 6.4 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| Elfkin | 7.0 | 6.7 | 7.3 | 7.3 | 8.3 | 5.3 | 5.3 | 5.0 | 6.3 | 7.3 | 6.4 |
| Pick PR B-97 | 7.7 | 7.3 | 6.7 | 7.7 | 8.7 | 6.0 | 5.3 | 5.0 | 6.0 | 6.3 | 6.4 |
| Seville II | 7.7 | 7.3 | 7.3 | 6.3 | 8.0 | 5.7 | 5.0 | 6.3 | 6.0 | 7.3 | 6.4 |
| SR 4420 (SRX 4820) | 7.0 | 8.0 | 6.7 | 7.0 | 8.3 | 6.0 | 5.3 | 6.0 | 5.0 | 7.3 | 6.4 |
| Superstar (EP57) | 7.7 | 7.3 | 4.7 | 8.0 | 8.3 | 6.3 | 4.3 | 5.0 | 5.7 | 7.0 | 6.4 |
| ABT-99-4.815 | 6.3 | 7.0 | 4.7 | 7.3 | 8.0 | 6.3 | 5.7 | 5.3 | 5.0 | 6.7 | 6.3 |
| Affinity | 5.3 | 6.3 | 5.7 | 6.7 | 7.0 | 5.3 | 6.0 | 5.7 | 6.0 | 7.3 | 6.3 |
| Catalina | 6.7 | 7.0 | 7.0 | 6.3 | 7.7 | 5.7 | 5.0 | 6.3 | 6.0 | 7.3 | 6.3 |
| Gallery (MB 412) | 7.7 | 7.3 | 6.3 | 7.0 | 8.3 | 6.0 | 5.3 | 5.7 | 5.3 | 6.3 | 6.3 |
| Gator 3 (CIS-PR-85) | 7.3 | 6.7 | 6.7 | 7.3 | 8.0 | 6.0 | 4.7 | 5.3 | 5.7 | 7.0 | 6.3 |
| Line Drive | 7.0 | 7.0 | 5.0 | 6.0 | 8.0 | 6.3 | 6.0 | 4.7 | 6.0 | 7.0 | 6.3 |
| ABT-99-4.155 | 6.3 | 6.7 | 6.7 | 6.7 | 7.7 | 5.7 | 5.7 | 5.7 | 5.3 | 7.0 | 6.2 |
| All Star2 (CIS-PR-78) | 7.3 | 7.0 | 7.0 | 7.3 | 8.3 | 5.7 | 5.0 | 4.7 | 5.3 | 7.0 | 6.2 |
| DP 17-9391 | 5.0 | 7.0 | 6.7 | 6.3 | 7.3 | 6.0 | 6.7 | 5.0 | 5.3 | 7.0 | 6.2 |
| ABT-99-4.464 | 6.7 | 6.7 | 4.7 | 7.3 | 7.7 | 5.7 | 6.3 | 5.3 | 4.3 | 6.31 | 6.1 |
| DP LP-1 | 6.0 | 6.0 | 6.0 | 6.7 | 7.3 | 5.7 | 5.3 | 5.0 | 5.7 | 7.0 | 6.1 |
| Edge | 6.0 | 6.5 | 6.0 | 7.5 | 7.0 | 5.0 | 4.5 | 5.0 | 6.5 | 7.0 | 6.1 |
| LPR 98-143 | 5.7 | 6.3 | 5.0 | 6.7 | 7.3 | 5.7 | 5.0 | 4.7 | 5.7 | 7.7 | 6.1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Nexus | 7.7 | 6.3 | 6.7 | 7.0 | 7.7 | 6.0 | 4.7 | 5.3 | 5.0 | 7.0 | 6.1 |
| Pentium (NJ-6401) | 7.0 | 7.3 | 8.3 | 7.0 | 8.0 | 6.0 | 3.7 | 5.3 | 6.0 | 7.0 | 6.1 |
| BY-100 | 6.0 | 5.7 | 5.7 | 6.3 | 7.3 | 5.7 | 5.7 | 4.7 | 5.3 | 7.0 | 6.0 |
| Calypso II | 6.0 | 7.3 | 5.3 | 7.7 | 8.0 | 5.7 | 4.3 | 5.0 | 5.0 | 6.3 | 6.0 |
| CIS-PR-84 | 8.0 | 6.7 | 4.7 | 7.0 | 8.0 | 5.7 | 6.3 | 4.3 | 4.7 | 6.3 | 6.0 |
| Pacesetter (6011) | 7.0 | 6.7 | 7.0 | 6.7 | 7.3 | 5.3 | 5.3 | 5.0 | 5.7 | 7.0 | 6.0 |
| Panther | 6.3 | 6.7 | 4.7 | 6.0 | 7.7 | 5.3 | 5.7 | 4.7 | 5.0 | 7.3 | 6.0 |
| Paragon | 7.3 | 6.7 | 6.3 | 7.7 | 7.7 | 6.0 | 4.7 | 4.7 | 5.0 | 6.7 | 6.0 |
| PST-2LA | 6.7 | 6.7 | 7.7 | 6.7 | 7.7 | 5.3 | 4.0 | 5.0 | 6.0 | 7.7 | 6.0 |
| Splendid (MB 411) | 7.0 | 7.0 | 6.7 | 6.7 | 7.7 | 5.7 | 3.7 | 4.7 | 6.0 | 7.3 | 6.0 |
| Summerset (MB413) | 7.3 | 7.0 | 7.7 | 7.3 | 7.7 | 5.3 | 4.0 | 4.7 | 5.7 | 7.3 | 6.0 |
| Wilmington | 7.7 | 7.0 | 6.7 | 7.0 | 8.0 | 6.0 | 5.0 | 4.3 | 5.3 | 6.3 | 6.0 |
| ABT-99-4.600 | 6.7 | 7.0 | 7.7 | 7.0 | 7.3 | 6.0 | 4.0 | 5.0 | 5.3 | 6.3 | 5.9 |
| ABT-99.4.834 | 7.7 | 6.3 | 5.0 | 6.7 | 7.3 | 6.0 | 5.0 | 4.3 | 5.3 | 6.3 | 5.9 |
| Allsport | 6.7 | 6.7 | 7.3 | 6.0 | 7.3 | 5.3 | 5.0 | 5.0 | 5.7 | 7.0 | 5.9 |
| CAS-LP84 | 7.3 | 6.3 | 5.0 | 7.0 | 7.0 | 5.3 | 5.7 | 5.3 | 4.7 | 6.3 | 5.9 |
| Catalina II (PST-CATS) | 7.0 | 6.3 | 8.0 | 7.3 | 7.7 | 5.0 | 4.0 | 4.0 | 6.0 | 7.3 | 5.9 |
| CIS-PR-75 | 7.7 | 6.0 | 8.3 | 6.0 | 8.0 | 5.0 | 3.3 | 5.0 | 6.3 | 7.3 | 5.9 |
| Icon (MB 414) | 7.3 | 6.0 | 5.0 | 6.0 | 7.7 | 6.0 | 6.0 | 5.0 | 4.7 | 6.0 | 5.9 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| LTP-ME | 7.0 | 6.0 | 6.0 | 7.7 | 7.7 | 5.0 | 4.0 | 5.0 | 5.7 | 6.3 | 5.9 |
| Majesty | 7.0 | 6.7 | 7.0 | 7.7 | 8.0 | 5.0 | 5.3 | 4.0 | 5.0 | 6.0 | 5.9 |
| PST-2JH | 6.7 | 6.3 | 7.0 | 7.0 | 7.7 | 5.7 | 4.3 | 4.7 | 5.0 | 6.7 | 5.9 |
| Racer II (Piack RC2) | 6.7 | 6.3 | 6.7 | 6.3 | 7.0 | 5.7 | 5.0 | 5.0 | 5.3 | 7.0 | 5.9 |
| ABT-99-4.625 | 7.0 | 6.0 | 8.3 | 6.0 | 6.3 | 5.3 | 4.7 | 5.3 | 5.7 | 7.0 | 5.8 |
| APR 1235 | 7.0 | 5.7 | 6.3 | 6.3 | 6.7 | 5.0 | 5.7 | 5.3 | 5.3 | 6.0 | 5.8 |
| Brightstar II | 7.3 | 6.7 | 7.3 | 7.0 | 8.0 | 5.3 | 4.0 | 4.0 | 5.7 | 6.7 | 5.8 |
| Pleasure XL | 7.0 | 6.0 | 6.7 | 7.0 | 6.7 | 4.7 | 5.0 | 5.0 | 5.3 | 6.7 | 5.8 |
| ABT-99-4.965 | 7.3 | 6.3 | 5.7 | 7.0 | 8.0 | 5.3 | 5.0 | 4.0 | 4.7 | 6.0 | 5.7 |
| MP103 | 7.3 | 7.0 | 7.3 | 6.7 | 7.0 | 5.0 | 4.0 | 4.7 | 5.7 | 7.0 | 5.7 |
| Paradigm (APR 1236) | 6.7 | 5.7 | 6.3 | 6.0 | 7.7 | 5.3 | 4.7 | 4.7 | 5.3 | 6.3 | 5.7 |
| Pick PR 1-94 | 7.3 | 6.3 | 6.0 | 6.7 | 7.7 | 5.3 | 4.7 | 4.3 | 4.7 | 6.7 | 5.7 |
| Pick Prngs | 6.7 | 7.7 | 7.7 | 7.0 | 8.3 | 5.0 | 3.3 | 4.7 | 5.3 | 6.3 | 5.7 |
| Promise | 7.3 | 6.7 | 7.7 | 6.0 | 8.0 | 5.7 | 4.0 | 4.3 | 5.3 | 6.3 | 5.7 |
| APR 1234 | 6.0 | 5.7 | 6.3 | 6.7 | 7.0 | 5.0 | 4.3 | 5.0 | 5.7 | 5.3 | 5.6 |
| Citation Fore (PST-2BR) | 7.7 | 6.3 | 7.3 | 7.0 | 7.3 | 5.3 | 4.3 | 5.0 | 4.3 | 6.0 | 5.6 |
| EPD | 7.0 | 6.3 | 6.7 | 6.0 | 7.3 | 5.7 | 4.7 | 4.3 | 4.7 | 6.7 | 5.7 |
| Exacta | 7.0 | 6.3 | 7.0 | 6.0 | 6.7 | 4.7 | 4.7 | 5.3 | 5.7 | 6.3 | 5.6 |
| Fiesta 3 | 7.0 | 6.7 | 7.3 | 6.3 | 7.3 | 5.0 | 4.,0 | 4.7 | 5.0 | 7.0 | 5.6 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kokomo (CIS-PR-69) | 7.0 | 5.7 | 8.3 | 6.7 | 6.7 | 5.3 | 4.0 | 4.7 | 5.3 | 6.7 | 5.6 |
| Passport | 5.7 | 5.3 | 8.3 | 6.0 | 6.7 | 5.0 | 5.0 | 5.3 | 5.0 | 6.0 | 5.6 |
| PST-2CRR | 7.0 | 6.7 | 7.0 | 7.3 | 7.7 | 5.3 | 4.0 | 4.0 | 4.7 | 6.3 | 5.6 |
| PST-2RT | 7.0 | 6.0 | 8.3 | 5.3 | 6.7 | 5.0 | 5.0 | 5.0 | 5.3 | 6.7 | 5.6 |
| WVPB-R-82 | 6.0 | 6.3 | 7.0 | 6.3 | 7.7 | 5.0 | 4.7 | 4.7 | 5.0 | 6.0 | 5.6 |
| DP 17-9069 | 5.3 | 6.3 | 5.7 | 6.3 | 6.7 | 4.7 | 5.0 | 4.3 | 5.7 | 6.0 | 5.5 |
| MP107 | 7.3 | 6.7 | 5.3 | 7.0 | 8.0 | 5.7 | 3.7 | 3.3 | 5.0 | 6.0 | 5.5 |
| Prowler (APR 777) | 5.7 | 5.3 | 8.0 | 6.3 | 6.7 | 5.3 | 4.7 | 5.0 | 5.0 | 5.7 | 5.5 |
| Radiant | 7.7 | 6.7 | 5.7 | 6.0 | 7.3 | 5.3 | 5.3 | 4.7 | 4.3 | 5.7 | 5.5 |
| Skyhawk | 7.7 | 6.3 | 5.3 | 6.0 | 7.7 | 5.3 | 5.3 | 4.3 | 4.3 | 5.3 | 5.5 |
| WVPG-R-84 | 5.7 | 5.7 | 7.0 | 6.3 | 7.3 | 5.0 | 4.3 | 4.7 | 5.0 | 5.7 | 5.5 |
| APR 1231 | 7.0 | 7.0 | 8.3 | 6.0 | 7.7 | 5.0 | 3.3 | 4.0 | 5.7 | 6.0 | 5.4 |
| APR 1237 | 6.7 | 6.3 | 5.3 | 6.3 | 7.3 | 5.3 | 4.3 | 4.7 | 4.3 | 5.7 | 5.4 |
| KOOS R-71 | 6.0 | 5.0 | 6.3 | 6.3 | 7.0 | 5.0 | 4.7 | 4.3 | 4.7 | 6.0 | 5.4 |
| Secretariat | 6.0 | 5.3 | 5.7 | 5.7 | 6.7 | 5.0 | 5.0 | 4.7 | 4.7 | 6.3 | 5.4 |
| Amazing (B1) | 7.7 | 7.3 | 7.0 | 6.7 | 8.0 | 5.0 | 4.0 | 4.0 | 4.0 | 5.3 | 5.3 |
| Barlennium | 7.7 | 6.3 | 6.3 | 6.3 | 7.0 | 5.0 | 5.0 | 2.7 | 5.0 | 6.0 | 5.3 |
| JR-128 | 6.3 | 7.3 | 5.0 | 6.7 | 7.3 | 5.3 | 4.7 | 3.7 | 4.3 | 5.3 | 5.3 |
| MDP | 7.7 | 6.0 | 7.0 | 6.0 | 8.0 | 4.7 | 3.3 | 3.7 | 5.0 | 6.3 | 5.3 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Premier II | 6.7 | 4.7 | 6.7 | 5.3 | 6.3 | 5.0 | 5.0 | 4.7 | 4.7 | 6.0 | 5.3 |
| Salinas (PST-2SLX) | 7.3 | 7.7 | 6.7 | 6.0 | 8.3 | 5.0 | 4.3 | 4.0 | 4.0 | 5.7 | 5.3 |
| Yatsugreen | 6.0 | 6.0 | 5.7 | 6.7 | 7.0 | 5.0 | 5.0 | 4.3 | 4.3 | 4.7 | 5.3 |
| Divine | 6.7 | 6.0 | 7.0 | 6.3 | 7.3 | 4.7 | 4.3 | 3.7 | 4.7 | 5.7 | 5.2 |
| Phantom | 7.3 | 6.3 | 8.3 | 6.7 | 7.3 | 4.3 | 3.3 | 3.7 | 5.3 | 6.0 | 5.2 |
| Buccaneer | 6.0 | 5.3 | 6.7 | 6.0 | 6.7 | 4.7 | 4.0 | 4.3 | 4.7 | 5.3 | 5.1 |
| MP88 | 7.0 | 6.7 | 8.3 | 5.0 | 7.0 | 5.3 | 4.0 | 3.7 | 5.0 | 6.0 | 5.1 |
| Prosport (AG-p981) | 6.7 | 6.7 | 6.3 | 6.3 | 7.0 | 4.7 | 3.7 | 4.0 | 5.0 | 5.3 | 5.1 |
| ABT-99-4.560 | 7.3 | 5.0 | 8.0 | 5.0 | 6.3 | 5.0 | 4.3 | 4.0 | 4.7 | 5.7 | 5.0 |
| Manhattan 4 (PST-2CRL) | 7.0 | 6.3 | 5.3 | 4.7 | 7.3 | 5.0 | 4.3 | 3.7 | 4.3 | 5.3 | 5.0 |
| Mepy | 6.3 | 5.3 | 7.3 | 6.0 | 7.0 | 4.3 | 3.7 | 4.7 | 4.3 | 5.3 | 5.0 |
| Pick EX2 | 6.7 | 5.0 | 7.7 | 5.3 | 7.0 | 5.0 | 2.7 | 4.3 | 5.0 | 5.7 | 5.0 |
| UT-1000 (ABT-99-4.709) | 8.0 | 6.7 | 8.0 | 5.7 | 7.7 | .7 | 3.7 | 4.0 | 4.3 | 5.0 | 5.0 |
| EP53 | 6.7 | 5.7 | 8.0 | 6.0 | 7.0 | 4.3 | 2.3 | 3.7 | 5.0 | 6.0 | 4.9 |
| Mach 1 (Roberts-627) | 8.0 | 5.7 | 9.0 | 6.0 | 7.0 | 5.0 | 2.7 | 4.0 | 4.0 | 5.3 | 4.9 |
| SR 4500 | 6.7 | 5.3 | 7.3 | 5.7 | 6.7 | 4.3 | 3.7 | 3.7 | 4.3 | 6.0 | 4.9 |
| ABT-99-4.724 | 7.7 | 6.3 | 8.3 | 6.3 | 6.3 | 4.7 | 3.3 | 4.3 | 3.7 | 5.0 | 4.8 |
| Pick PR QH-97 | 7.3 | 6.0 | 8.3 | 6.3 | 7.3 | 3.3 | 3.3 | 3.7 | 4.0 | 5.7 | 4.8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DP 17-9496 | 4.3 | 4.7 | 6.0 | 5.7 | 7.0 | 4.0 | 5.0 | 3.7 | 4.3 | 3.3 | 4.7 |
| Premier | 6.3 | 5.3 | 4.0 | 5.7 | 6.3 | 4.7 | 4.3 | 2.7 | 3.7 | 4.3 | 4.5 |
| Monterey II (JR-187) | 7.0 | 5.7 | 7.3 | 4.7 | 6.3 | 4.7 | 3.0 | 3.7 | 4.0 | 4.7 | 4.4 |
| Linn | 3.0 | 2.0 | 8.0 | 2.7 | 4.3 | 2.3 | 1.0 | 1.0 | 1.3 | 2.0 | 2.1 |
| LSD[2] | 0.9 | 1.4 | NS | 3.2 | NS | 2.5 | 4.8 | NS | NS | 4.2 | 2.8 |

[1]Quality rated on a scale of 0-9 w/9 = best.
[2]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding minimum significant difference value. NS = No statistical difference.

**TITLE:** Bermudagrass Cultivar Trial

**LOCATION:** Wichita, Kansas City

**OBJECTIVE:** To evaluate bermudagrass under Kansas conditions.

**PERSONNEL:** Matt Fagerness and Linda Parsons

**SPONSOR:** USDA National Turfgrass Evaluation Program

## INTRODUCTION:

Kansas represents the northern extremity in the central US where bermudagrass can be successfully grown as a perennial turfgrass species. It has a wide range of uses and is especially useful for athletic field turf. Historically, few cultivars have been available for Kansas growers that have both acceptable quality and adequate cold tolerance. New available cultivars must be regularly tested in our climate to determine their long-range suitability for use here in Kansas.

## MATERIALS AND METHODS:

Forty two cultivars of bermudagrass were planted at each of two locations in Kansas, one in Wichita and one in the Kansas City area. Areas were planted in June 2002 with three replications per cultivar. Twenty nine of these cultivars were seeded and 13 were vegetative. Vegetative varieties were plugged with 12-inch spacings. Starter fertilizer was applied at the time of planting at 1 lb N/1000 $ft^2$ and plots were irrigated as needed to promote good turf growth. During 2002, plots were evaluated for percent cover to assess the extent of initial turfgrass establishment. All plots were maintained at a mowing height of 1.5 inches.

## RESULTS:

Data presented in Table 1 are from the Wichita location. Results at this point in the trial are very similar between the two locations so Kansas City data are not presented. Not surprisingly, seeded cultivars had an early establishment advantage, due to their more uniform placement in plots. Many seeded cultivars reached near full cover by the end of summer and none achieved less than 60% coverage. Vegetative cultivars developed most rapidly in the latter part of summer and reached 50-70% cover by the end of the summer rating period. At this early point in this trial, it is not appropriate to speculate as to the performance of specific seeded or vegetative cultivars. Those cultivars that survive their first winter are expected to reach full cover by early in the 2003 growing season. The effects of winter conditions and turfgrass quality will continue to be evaluated during and beyond the 2003 growing season.

Table 1. Percent establishment of bermudagrass cultivars in Wichita, KS over a 2 month period in 2002.

| Cultivar | Seeded/Vegetative | 26-July | 27-Aug. | 27-Sep. |
|---|---|---|---|---|
| | | ----------------Percent establishment--------------- | | |
| Sunstar | Seeded | 65 | 94 | 95 |
| B-14 | Seeded | 52 | 78 | 91 |
| SWI-1003 | Seeded | 25 | 40 | 80 |
| SWI-1012 | Seeded | 10 | 27 | 78 |
| SWI-1014 | Seeded | 2 | 18 | 60 |
| SWI-1041 | Seeded | 20 | 45 | 89 |
| SWI-1044 | Seeded | 13 | 45 | 80 |
| SWI-1045 | Seeded | 23 | 43 | 89 |
| SWI-1046 | Seeded | 17 | 40 | 78 |
| Arizona Common | Seeded | 23 | 55 | 84 |
| NuMex Sahara | Seeded | 40 | 84 | 91 |
| Princess 77 | Seeded | 55 | 65 | 89 |
| Mohawk | Seeded | 48 | 78 | 88 |
| FMC-6 | Seeded | 85 | 92 | 95 |
| SWI-1001 | Seeded | 58 | 75 | 90 |
| Tift No. 3 | Vegetative | 33 | 25 | 71 |
| Tift No. 4 | Vegetative | 7 | 10 | 62 |
| Tifway | Vegetative | 8 | 15 | 53 |
| Midlawn | Vegetative | 10 | 35 | 72 |
| Tifsport | Vegetative | 11 | 22 | 63 |
| Sundevil | Seeded | 14 | 42 | 85 |
| Southern Star | Seeded | 23 | 48 | 85 |
| MS-Choice | Vegetative | 12 | 25 | 67 |

| | | | | |
|---|---|---|---|---|
| Riviera | Seeded | 5 | 23 | 67 |
| Transcontinental | Seeded | 14 | 70 | 87 |
| CIS-CD5 | Seeded | 23 | 53 | 83 |
| CIS-CD6 | Seeded | 11 | 32 | 80 |
| CIS-CD7 | Seeded | 15 | 48 | 89 |
| Panama | Seeded | 58 | 88 | 92 |
| SRX 9500 | Seeded | 42 | 68 | 89 |
| SR 9554 | Seeded | 63 | 87 | 94 |
| Yukon | Seeded | 45 | 43 | 75 |
| Aussie Green | Vegetative | 15 | 27 | 70 |
| GN-1 | Vegetative | 8 | 22 | 67 |
| OR 2002 | Vegetative | 10 | 23 | 67 |
| Ashmore | Vegetative | 8 | 13 | 50 |
| Patriot | Vegetative | 8 | 28 | 73 |
| OKC 70-18 | Vegetative | 7 | 10 | 53 |
| Celebration | Vegetative | 8 | 28 | 72 |
| Tift No. 1 | Seeded | 29 | 62 | 82 |
| Tift No. 2 | Seeded | 23 | 45 | 81 |
| PST-R68A | Seeded | 13 | 22 | 70 |
| LSD[1] 0.05 | | 10 | 13 | 14 |

[1]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding minimum significant difference value.

**TITLE:** Preventive Fall Fungicide Applications For Control of Large Patch Disease of Zoysiagrass

**OBJECTIVE:** To determine efficacy of various fungicides in the control of large patch.

**PERSONNEL:** Ned Tisserat

**SPONSORS:** Bayer Corporation, BASF Corporation, Dow AgroSciences and Syngenta Corporation

**MATERIALS AND METHODS:**

Fungicide plots were established on zoysiagrass 'Meyer' fairways at the Alvamar Country Club in Lawrence, KS. Turfgrass was mowed to a height of 0.5 inch, irrigated as needed and fertilized with approximately 2.5 lb N/1000 $ft^2$ annually. Fungicides were applied 8 Oct 01 with a $CO_2$-powered backpack sprayer with 8003 TeeJet flat fan nozzles at 20 psi in water equivalent to 2.2 gal per 1000 $ft^2$ Treatment plots were 10 x 12 ft and replicated four times in a randomized complete-block design. Plots were not irrigated for at least 12 hr after fungicide application. The percentage of plot area diseased was recorded on 24 Apr 02 after zoysiagrass resumed spring growth.

**RESULTS:**

A trace amount of large patch was evident in a few plots at the time of fungicide application in early Oct. However, no further development was noted in non-treated plots prior to fall dormancy. The winter was warm and dry. Large patch symptoms were apparent as soon as zoysiagrass resumed spring growth indicating that most fungal infection occurred sometime during winter dormancy. All fungicide treatments except Banner MAXX and Medallion reduced severity of large patch.

Table 1. Fungicide treatment and percent large spot in zoysiagrass.

| Treatment and rate/1000 $ft^2$ | % plot area damage |
|---|---|
| Heritage 50WG 0.4 oz + Primo MAXX 1.0 MEC 0.125 fl oz | 0.0 a* |
| ProStar 70WP 2.2 oz | 2.0 ab |
| Bayleton 50DF 1 oz | 3.0 abc |
| Honor 50WG 0.2 oz | 6.0 bcd |
| Endorse 2.5 WP 4 oz | 7.8 bcd |
| Heritage 50 WG 0.4 oz | 8.0 bcd |
| Insignia 20 WG 0.9 oz | 11.8 de |
| Medallion 50 WP 0.5 oz | 17.5 ef |
| Banner MAXX 1.2MEC 4 fl oz + Primo MAXX 10 MEC 0.125 fl oz | 21.3 ef |
| Banner MAXX 1.2 MEC 4 fl oz | 25.0 ef |
| No fungicide | 32.5 F |

*Means not followed by the same letter are significantly different (P = 0.05) by Fisher's LSD. Data received an arcsine square root transformation prior to analysis and then was back-transformed for presentation.

**TITLE:** Preventive Fungicide Applications for Control of Brown Patch and Dollar Spot on Creeping Bentgrass

**OBJECTIVE:** To determine efficacy of various fungicides in the control of brown patch and dollar spot on creeping bentgrass.

**PERSONNEL:** D. Settle, J. Fry and N. Tisserat

**SPONSORS:** Bayer Corporation, BASF Corporation, Dow AgroSciences and Syngenta Corporation

**MATERIALS AND METHODS:**

Fungicides were evaluated on an established stand of 'Penncross' creeping bentgrass on a sand-based putting green at the Rocky Ford Turf Research Center, Manhattan, KS. The turf was mowed to a height of 0.16 inch, irrigated as needed and fertilized with 4 lb N/1000 $ft^2$ annually. Applications were made at 2-, 3-, or 4-wk intervals beginning in June and continuing through September. Fungicides were applied with a $CO_2$-powered backpack sprayer with 8003 TeeJet nozzles at 20 psi in water equivalent to 2.7 gal/1000 $ft^2$. Plots were not irrigated for at least 12 hr after applications. Plots were 5 x 6 ft and arranged in a randomized complete-block design with four replications. Plots were rated weekly for the number of dollar spot infection centers, and the percentage plot area damaged (foliar necrosis) by brown patch.

**RESULTS**:

Dollar spot pressure was moderate to high throughout the growing season with the exception of a very hot, dry period from late July to early August. All treatments except Heritage, Daconil Ultrex, and the low rate of Insignia at 14-day intervals, or Insignia at 28-day intervals provided adequate dollar spot control. A moderate level of brown patch occurred in early August and in mid- to late-September. All fungicides reduced brown patch AUDPC compared to untreated plots, although applications of Emerald at 14- and 28-day intervals did not provide acceptable control of brown patch (>10% plot area blighted) on 13 Sept.

Table 1. Fungicide efficacy on 'Pencross' creeping bentgrass.

| | | Dollar spot (number infection centers/plot) | | | Brown patch (% plot area blighted | | |
|---|---|---|---|---|---|---|---|
| | Spray interval (days) | 15 Jul | 16 Aug | Dollar spot (AUDPC) | 13 Sep | Brown patch (AUDPC) | Acceptable visual quality (% dates rated)** |
| No fungicide | - | 108.1 a | 106.9 | 939 a | 36.7 a | 177 a | 12 h |
| Iprodione Pro @SE 4.0 fl oz. | 14 | 3.8 e | 0.0c | 7 f | 15.0 bcd | 38 bc | 89 cde |
| Daconil Ultrex 8.25 WDG 3.2 oz | 14 | 55.8 bcb | 37.0 | 266 cd | 11.3 bd | 54 bc | 50 g |
| Cleary's 3336 50 WP 4.0 oz | 14 | 0.0 e | 0.0 c | 7 f | 0.0 d | 1 c | 98 a |
| Chipco Signature 80WDG 4.0 oz + Chipco Triton 1.67SC 1.0 fl oz | 14 | 0.0 e | 0.0 c | 2 f | 10.0 bcd | 32 bc | 98 a |
| Insignia 20WG 0.9 oz alternating with Concorde 82.5DF 3.2 oz | 14 | 16.0 de | 0.0 c | 95 ef | 2.5 d | 4 c | 83 a-e |
| Insignia 20WG 0.9 oz alternating with Emerald 70WG 0.13 oz | 14 | 0.3 e | 1.3 c | 22 f | 0.0 d | 16 c | 98 a |
| Insignia 20WG 0.9 oz | 14 | 39.5 c | 0.0 c | 93 ef | 0.0 d | 2 c | 91 a-e |
| Insignia 20WG 0.5 oz | 14 | 71.3 b | 1.0 c | 183 de | 2.5 d | 31 bc | 62 fg |
| Insignia 20 WG 0.9 oz | 28 | 74.5 b | 34.8 b | 360 c | 5.0 cd | 18 c | 34 gh |
| Honor 50WG 0.2 oz | 14 | 0.3 e | 0.0 c | 7 f | 5.0 cd | 11 c | 96 ab |
| Honor 50WG 0.2 oz | 28 | 0.0 e | 0.0 c | 26 f | 0.0 d | 2 c | 94 a-d |
| Emerald 70 WG 0.13 oz | 14 | 0.0 e | 0.0 c | 8 f | 22.5 ab | 85 b | 87 b-e |
| Emerald 70WG 0.18 oz | 28 | 1.0 e | 0.0 c | 14 f | 20.0 bc | 89 b | 79 cde |
| Heritage 50WG 0.2 oz | 14 | 100.0 a | 114.3 a | 683 b | 0.0 d | 0 c | 10 h |
| Spectro 90 WDG 4.0 oz | 14 | 0.0 e | 0.0 c | 6 f | 0.0 d | 8 c | 96 abac |
| Chipco Signature 80WDG 4 oz. + Chipco 26GT 2SC 4.0 fl oz | 14 | 1.3 e | 0.0 c | 3 f | 10.0 bcd | 30 bc | 96 ab |
| Chipco Signature 80WDG 4.0 oz + Daconil Ultrex 82.5WDG 3.2 oz. | 14 | 38.3 cd | 13.5 c | 100 ef | 1.3 d | 5 c | 81 def |

*Area under disease progress curve (AUPDC). AUDPC value based on 14 weekly observations (1 Jun–16 Sep) for dollar spot and 9 rating periods (26 Jul–30 Sep) for brown patch. Means not followed by the same letter within the same column are significantly different ($P \leq 0.05$) by Fisher's protected LSD.

**Acceptable visual quality percentage was based on 13 weekly observations (21 Jun–23 Sep) of visual quality (0-9 scale, 9=best) where a rating of 6 or greater is considered acceptable. Means not followed by the same letter within the same column are significantly different ($P \leq 0.05$) by Fisher's protected LSD of arc sin transformed data.

**TITLE:** Evaluation of Plant Defense Activators for Dollar Spot and Brown Patch Suppression in 'Cobra' Creeping Bentgrass

**OBJECTIVE:** Evaluate plant defense activators ASM and BABA, applied alone, together, and in combination with reduced rate of chlorothalonil (Daconil) for suppression of dollar spot and brown patch in creeping bentgrass**.**

**PERSONNEL:** Qi Zhang, Jack Fry, and Ned Tisserat

**SPONSOR:** Kansas Turfgrass Foundation

**INTRODUCTION:**

Golf course superintendents in the transition zone routinely treat creeping bentgrass (*Agrostis palustris* Huds.) putting greens with fungicides to prevent damage from dollar spot *(Sclerotinia homoeocarpa* F. T. Bennett) and brown patch (*Rhizoctonia solani* Kuhn). For economic and environmental reasons, there is interest in reducing fungicide inputs on bentgrass. One of the alternatives to fungicide is the use of plant defense activators, which induce the systemic acquired (activated) resistance (SAR) mechanism in the plant, imparting a self-defense mechanism. Acibenzolar-S-methyl (ASM, Actigard, BTH) and *b*-aminobutyric acid (BABA) are the most widely used chemical plant defense activators to immunize plants.

**MATERIALS AND METHODS:**

This test was initiated on June 15, 2002, on a 'Cobra' creeping bentgrass at the Rocky Ford Turfgrass Research Center in Manhattan, Kansas. Turfgrass was mowed six days weekly at 5/32 inch and irrigated to provide 0.2 inch water daily. Fertilizers were applied at 1 lb N/1000 $ft^2$ in April, May, June, July, and September, 2002. The research area was aerified in September, 2002. Plant defense activators and chlorothalonil (CH) were applied on a 14-day interval with a $CO_2$-powered sprayer with 8003 TeeJet nozzles at 30 psi in water equivalent to 4 gal/1000 $ft^2$. Plots measuring 3.3 by 5 ft were arranged in a randomized complete block with four replications. Data were collected on turfgrass visual quality, number of *S. homoeocarpa* infection centers, size and number of *R. solani*.

**RESULTS:**

<u>Turfgrass Visual Quality</u>

Only the high rate of CH provided season-long acceptable quality; ASM+CH, and BABA (0.1 oz. 1000 $ft^{-2}$)+CH provided nearly acceptable quality (Table 1-1).

<u>Number of *S. homoeocarpa* infection centers</u>

'Cobra' treated with high rate of CH had a significantly lower number of dollar spots (AUDPC= 45) than all other treatments (Table 1-2). The number of dollar spots in the ASM+CH (AUDPC= 1765) was 38 times higher than high rate of CH, followed by BABA (0.1 oz/1000 $ft^2$) +CH (AUDPC= 2420), 53 times higher than high rate of CH. There was almost no difference between untreated plots and those receiving BABA alone.

<u>Brown Patch</u>

No brown patch occurred in 2002.

Results indicate that acceptable dollar spot control was not possible unless CH was applied at 4 oz/1000 $ft^2$. However, dollar spot suppression with CH applied at 1.6 oz/1000 $ft^2$ was significantly improved if either ASM or BABA were included in the mixture.

Table 1-1. 'Cobra' creeping bentgrass quality as influenced by plant defense activators and chlorothalonil at Manhattan, KS in 2002.

| Treatment | Application level (oz/1000 sq ft) | Turf quality[z] | | | | |
|---|---|---|---|---|---|---|
| | | June | July | Aug | Sep | Oct |
| Control | 0 | 4.5 | 4.3 e[y] | 3.5 f | 3.3 f | 3.5 e |
| chlorothalonil | 1.6 | 4.5 | 6.0 c | 5.3 cd | 4.8 de | 4.5 cd |
| chlorothalonil | 3.2 | 6.0 | 7.8 a | 8.0 a | 8.0 a | 8.0 a |
| BABA | 0.1 | 5.3 | 4.5 e | 4.3 e | 3.3 f | 3.8 de |
| BABA | 0.2 | 6.0 | 5.3 d | 4.8 de | 3.8 f | 4.8 c |
| BABA | 1.4 | 4.8 | 4.3 e | 3.5 f | 3.5 f | 3.5 e |
| BABA+ chlorothalonil | BABA (0.1) + chlorothalonil (1.6) | 6.0 | 6.8 b | 5.8 bc | 5.8 bc | 5.3 bc |
| BABA+ chlorothalonil | BABA (0.2)+ chlorothalonil (1.6) | 5.0 | 6.0 c | 5.3 cd | 5.0 cd | 4.8 c |
| BABA+ chlorothalonil | BABA (0.4)+ chlorothalonil (1.6) | 5.5 | 5.8 cd | 5.8 bc | 5.5 bcd | 5.3 bc |
| ASM | 0.02 | 6.0 | 5.8 cd | 5.0 d | 4.0 ef | 4.5 cd |
| ASM+ chlorothalonil | ASM (0.02)+ chlorothalonil (1.6) | 6.0 | 7.0 b | 6.3 b | 6.0 b | 6.0 b |
| ASM+BABA | ASM (0.02)+ BABA (0.2) | 5.8 | 6.0 c | 4.8 de | 4.0 ef | 4.8 c |
| | ANOVA | NS | * | * | * | * |

NS=Not significant, and * = significant difference at $P \leq 0.05$.

[z]Quality rated on a scale of 0 to 9, 0= dead, 7= acceptable for putting green, 9= best

[y] Means followed by the same letter in a column are not significantly different ($P \leq 0.05$)

Table 1-2. Number of *S. homoeocarpa* infection center in 'Cobra' creeping bentgrass as influenced by plant defense activators and chlorothalonil at Manhattan, KS in 2002.

| Treatment | Application level (oz/1000 sq ft) | AUDPC |
|---|---|---|
| Control | 0 | 4755 a[y] |
| chlorothalonil | 4 | 3160 c |
| chlorothalonil | 8 | 45 f |
| BABA | 0.42 | 4120 ab |
| BABA | 0.8 | 3465 bc |
| BABA | 1.6 | 4365 a |
| BABA+ chlorothalonil | BABA (0.4) + chlorothalonil (4) | 2420 de |
| BABA+ chlorothalonil | BABA (0.8)+ chlorothalonil (4) | 3065 cd |
| BABA+ chlorothalonil | BABA (1.6)+ chlorothalonil (4) | 2950 cd |
| ASM | 0.035 | 3485 bc |
| ASM+ chlorothalonil | ASM (0.035)+ chlorothalonil (4) | 1765 e |
| ASM+BABA | ASM (0.035)+ BABA (0.35) | 3390 c |
| | ANOVA | * |

NS,=Not significant, and * =significant difference at $P \leq 0.05$.

[y] Means followed by the same letter in a column are not significantly different ($P \leq 0.05$)

AUDPC= Area under the disease progression curve, using days as the horizontal axis.

**TITLE:** Evaluation of Calcium Silicate for Brown Patch Suppression in Tall Fescue

**OBJECTIVE:** Evaluate the effect of calcium silicate applied at two application rates, alone and in combination with reduced rate of flutolanil (Prostar) for suppression of brown patch in tall fescue.

**PERSONNEL:** Qi Zhang, Jack Fry, Kathie Lowe, and Ned Tisserat

**SPONSORS:** Kansas Turfgrass Foundation

## INTRODUCTION:

Tall fescue (*Festuca arundinacea* Schreb.) is one of the most widely used turfgrasses for home lawns in the transition zone because of its heat and drought resistance and ease of establishment; however, tall fescue is susceptible to brown patch. Environmental concerns, public safety and economic reasons have led lawn care operators to consider alternatives to fungicides for reducing diseases in tall fescue. One potential tool for reducing turfgrass fungicide inputs is the use of silicon (Si) fertilizers. Some diseases, such as dollar spot, brown patch, and grey leaf spot, have been reduced by up 30% when Si fertilizers were applied alone and up to 70% when they were applied with fungicides.

## MATERIALS AND METHODS:

'Tarheel' (brown patch resistant) and 'Bonsai 2000' (brown patch susceptible) tall fescue were seeded at 7 lb N/1000 $ft^2$ in September 2001 at the Rocky Ford Turfgrass Research Center in Manhattan, KS. Experimental design was a split-plot design with each whole plot 10 by 40 ft and sub-plot 7 by 10 ft. Treatments are shown in Table 2-1. Turfgrass was mowed at about 3.5 inches twice weekly. Irrigation was applied at about 0.6 inch every night to increase brown patch. Urea (46-0-0) was applied at 1 lb/1000 $ft^2$ in April, May and September 2002. CaSi (31% $SiO_2$, 22% Ca) was applied uniformly using a shaker bottle on 29 May and 10 October, 2002. Flutolanil was applied on a 21-day interval with a $CO_2$-powered sprayer with 8003 TeeJet nozzles at 30 psi in water equivalent to1.9 gal/1000 $ft^2$ from June through September. Plant tissue was sampled on 2 August and 10 October, 2002. Data were collected on turfgrass visual quality, spectral reflectance measurements, and nutrient concentrations in plant tissue.

## RESULTS:

### Turfgrass Visual Quality

No significant differences were observed in quality between tall fescue cultivars during the whole period (Table 1). In August and September 2002, quality of turf in untreated plots and those treated with CaSi was lower than turf receiving flutolanil at 1.1 or 2.2 oz/1000 $ft^2$. In late September, turfgrass recovered from brown patch.

### Brown Patch

Brown patch was first found in control and CaSi fertilizer alone treatments on 7 July 2002. About 2 to 5% of leaves were damaged at that time. Cultivars did not differ in AUDPC levels of brown patch (Table 2). Lowest brown patch AUDPC levels occurred in turf treated with flutolanil at either rate, followed by the control and CaSi at 50 lb/1000 $ft^2$. Turf treated with CaSi at 100 lb/1000 $ft^2$ had higher brown patch AUDPC level than turf in any other treatment.

Foliar nutrition

Cultivars exhibited no differences in Si and Ca concentrations on either 2 August or 10 October, 2002 (Table 3). On 2 August, Tarheel had a higher foliar N level than Bonsai 2000 (Table 4). No differences in foliar N, P, or K were observed among turf treated with CaSi or fungicides.

**SUMMARY:**

Results from the initial year of work indicate that there is little benefit to applying CaSi to tall fescue in order to improve brown patch resistance. Regardless of CaSi application rate, there no evidence of Si accumulation in tall fescue leaves.

Table 1. Tall fescue quality as influenced by CaSi and flutolanil at Manhattan, KS in 2002.

| Treatment | | Quality[z] | | | |
|---|---|---|---|---|---|
| | | July | August | Sep | Oct |
| Whole-plot | Bonsai 2000 | 6.4 | 6.4 | 7.4 | 8.0 |
| | Tar heel | 6.4 | 6.4 | 7.4 | 8.0 |
| Sub-plot | Control | 6.0 | 6.0 b[y] | 7.0 c | 8.0 |
| | CaSi (50 lbs) | 6.0 | 5.9 b | 7.0 c | 8.0 |
| | CaSi (100 lbs) | 6.0 | 5.8 b | 7.0 c | 8.0 |
| | CaSi (50 lbs) + flutolanil (1.1 oz) | 7.0 | 7.0 a | 7.8 b | 8.0 |
| | Flutolanil (2.2 oz.) | 7.0 | 7.1 a | 8.0 a | 8.0 |
| Analysis | Whole-plot | NS | NS | NS | NS |
| | Sub-plot | NS | * | * | NS |
| | Whole-plot * Sub-plot | NS | NS | NS | NS |

NS, *= Not significant, or significant difference at $P \leq 0.05$

[Y]Means followed by the same letter in a column are not significantly different ($P \leq 0.05$)

[z]Quality was rated on a scale of 0 to 9 where 0= dead, 6= acceptable for tall fescue home lawn, and 9= best.

Table 2. Brown patch in tall fescue as influenced by CaSi and flutolanil at Manhattan, KS in 2002.

| Treatment | | AUDPC |
|---|---|---|
| Whole-plot | Bonsai 2000 | 56.8 |
| | Tar heel | 49.6 |
| Sub-plot | Control | 77.0 b[y] |
| | CaSi (50 lbs) | 81.5 b |
| | CaSi (100 lbs) | 95.6 c |
| | CaSi (50 lbs)+ flutolanil (1.1 oz) | 9.4 a |
| | Flutolanil (2.2 oz.) | 2.5 a |
| Analysis | Whole-plot | NS |
| | Sub-plot | * |
| | Whole-plot * Sub-plot | NS |

NS = Not significant; * = significant difference at $P \leq 0.05$

[y]Means followed by the same letter in a column are not significantly different ($P \leq 0.05$)

AUDPC= Area under the disease progression curve, using days as the horizontal axis

Table 3. Si and Ca (ppm) in tall fescue plant tissue as influenced by CaSi and flutolanil at Manhattan, KS in 2002.

| Treatment | | 2 August | | 10 October | |
|---|---|---|---|---|---|
| | | Si | Ca | Si | Ca |
| Whole-plot | Bonsai 2000 | 23632 | 7541.7 | 18053 | 5638.0 |
| | Tar heel | 24857 | 8212.4 | 18100 | 5904.7 |
| Sub-plot | Control | 25500 | 8074.0 ab[y] | 18627 | 5004.5 b |
| | CaSi (50 lbs) | 22914 | 8221.4 a | 18871 | 7908.9 a |
| | CaSi (100 lbs) | 24681 | 7993.6 abc | 18445 | 6296.3 ab |
| | CaSi (50 lbs) +flutolanil (1.1 oz) | 24026 | 7600.4 bc | 17114 | 4739.38 b |
| | Flutolanil (2.2 oz.) | 24100 | 7495.9 c | 17324 | 4907.5 b |
| Analysis | Whole-plot | NS | NS | NS | NS |
| | Sub-plot | NS | * | NS | * |
| | Whole-plot * Sub-plot | * | NS | NS | NS |

NS = Not significant; * = significant difference at $P \leq 0.05$.

[y]Means followed by the same letter in a column are not significantly different ($P \leq 0.0$).

Table 4. N, P, K (% of Dry Weight) in tall fescue plant tissue as influenced by CaSi and flutolanil at Manhattan, KS in 2002.

| Treatment | | 2 August | | | 10 October | | |
|---|---|---|---|---|---|---|---|
| | | N | P | K | N | P | K |
| Whole-plot | Bonsai 2000 | 3.28 b[Y] | 0.33 | 2.17 | 3.26 | 0.39 | 2.4 |
| | Tar heel | 3.43 a | 0.34 | 2.23 | 3.45 | 0.40 | 2.6 |
| Sub-plot | Control | 3.37 | 0.34 | 2.22 | 3.35 | 0.41 | 2.5 |
| | CaSi (50 lbs) | 3.32 | 0.31 | 2.11 | 3.35 | 0.38 | 2.4 |
| | CaSi (100 lbs) | 3.35 | 0.32 | 2.12 | 3.33 | 0.39 | 2.4 |
| | CaSi (50 lbs) + flutolanil (1.1 oz) | 3.39 | 0.34 | 2.29 | 3.36 | 0.39 | 2.4 |
| | Flutolanil (2.2 oz) | 3.35 | 0.34 | 2.28 | 3.40 | 0.41 | 2.5 |
| Analysis | Whole-plot | * | NS | NS | NS | NS | NS |
| | Sub-plot | NS | NS | NS | NS | NS | NS |
| | Whole-plot * Sub-plot | NS | NS | NS | NS | NS | NS |

NS = Not significant; * = significant difference at $P \leq 0.05$.

[y]Means followed by the same letter in a column are not significantly different ($P \leq 0.05$).

**TITLE:** Effect of Soil Temperature and Lance Nematode Phytoparasitism Among Four Creeping Bentgrass Cultivars

**OBJECTIVE:** To determine if the lance nematode demonstrates host preference among creeping bentgrass cultivars and evaluate the effect soil temperature may have on the host-parasite relationship.

**PERSONNEL:** Derek Settle, Tim Todd, Jack Fry, and Ned Tisserat

**SPONSORS:** Plant Pathology Departmental Graduate Research Assistantship

## INTRODUCTION:

In the past, many golf course putting greens in Kansas were seeded with the popular cultivar Penncross. Today, Penncross is being supplanted on Kansas greens by improved creeping bentgrass cultivars. This greenhouse experiment was explored the hypothesis that differences in lance nematode (*Hoplolaimus galeatus*) host preference may exist among cultivars of creeping bentgrass. We continue to explore the interaction of warm soil temperature and dense lance nematode populations on visual quality of creeping bentgrass in the field during Kansas summers.

## MATERIALS AND METHODS:

A greenhouse study was conducted from October 2002 through March 2003. The experiment was a completely randomized block design with four creeping bentgrass cultivars (A-4, Crenshaw, L-93 and Penncross) with two soil temperature treatments (70 F or 85 F) and six replications, for a total of 48 pots. Pots were clipped flush with the upper edge twice weekly with hand operated grass shears which resulted in a 1/8 inch height. Pots were watered to pot-capacity at first sign of wilt, generally every fourth day, and fertilized using a Peters 10-20-10 liquid formulation to provide 0.25 lb N/1000 $ft^2$ bi-monthly. Creeping bentgrass sod pieces were obtained from established research greens, seeded between 1996 to 1999 at the Rocky Ford Research Center, Manhattan, KS. Prior to planting, the circular sod pieces (4-inch diameter) were washed to remove all soil and were verified to be nematode-free. Pots measuring 4 inches in diameter and 6 inches deep were established with 750 $cm^3$ of USGA-specification root zone mix from a naturally lance nematode-infested research green. Soil was homogenized using a cement mixer for 5 minutes prior planting to ensure uniform lance nematode populations in all pots, which numbered 155 nematodes per 100 $cm^3$ soil or 1200 per pot[1].

<u>Soil Temperature</u>

One of two soil temperatures was maintained in each individual pot by embedding a U-shaped segment of epoxy-coated copper tubing (0.3 cm i.d.) in the soil with both ends protruding through bottom drain holes. Beneath the greenhouse bench, each pot's copper tubing was connected to a rubber hose that circulated either warmed (85 F) or chilled (70 F) water. Each temperature system was unique and consisted of an in-line water pump, a thermostat, and a 50-gallon reservoir fitted with either an L-shaped heating element or an in-line water chiller. Following the 30 day grow-in period, soil temperature treatments began in November 2002 and continued for 4 months.

Measurements

Monthly, each individual pot was rated for visual quality (0-9, 9 = best) and percent turfgrass cover. Live nematode populations were quantified by a light sucrose soil extraction method using 100 g fresh soil weight of two, 2-cm diameter soil cores that were removed following the monthly visual ratings. A compound microscope at 40X magnification was used to enumerate lance nematodes and their life stage was noted as either juveniles (J2 and J3+J4) or adults (male and female). A sub-sample of approximately 50 g of fresh soil from each pot was taken and dried to calculate soil moisture, which also allowed nematode populations to be standardized per 100 g dry soil. At experiment's end, roots and shoots were harvested and dry plant weights calculated for each pot.

## RESULTS:

Soil temperature

Across all dates sampled, 85 F soil increased total lance nematodes by 30% when compared to 70 F soil. Primarily, the 85 F warm soil temperature increased juvenile numbers; J3+J4 numbers were fives times greater, and J2 numbers were six times greater than those from the 70 F soil. As expected, compared to cool soil, warm soil temperature reduced bentgrass visual quality (5.9 to 4.0 ), and percent cover (82% to 61%) across all cultivars. However, among cultivars, Crenshaw's visual rating was not adversely affected by the 85 F soil temperature, whereas A-4, L-93 and Penncross showed decreased visual ratings.

Lance Nematode Effect

Across the entire study period (n=192 ratings), visual quality ($r=-0.30$, $P=0.0001$) and percent turfgrass pot cover ($r= -0.29$, $P=0.0001$) declined as lance nematode populations increased. Similarly, at month four, final dry root weight was reduced as lance nematode density increased (Figure 1).

Cultivar Differences

Although no host preference was found, bentgrass cultivars were found to be affected differently by dense lance nematode populations. As density increased, A-4 and Crenshaw were visually unaffected, whereas L-93 and Penncross were greatly affected (Fig. 2).

## SUMMARY:

Our results demonstrate that lance nematode parasitism can increase during periods of warm soil temperature, and that dense populations of lance nematodes can directly damage roots resulting in reduced root biomass, turfgrass cover and visual quality. The study also suggests that some cultivars may be less affected by a combination of warm soil temperature and dense lance nematode populations. Interestingly, the visual rating of Crenshaw, a bentgrass cultivar selected for heat/drought tolerance, was not negatively affected by either warm soil temperature or increasing lance nematode densities in this greenhouse study.

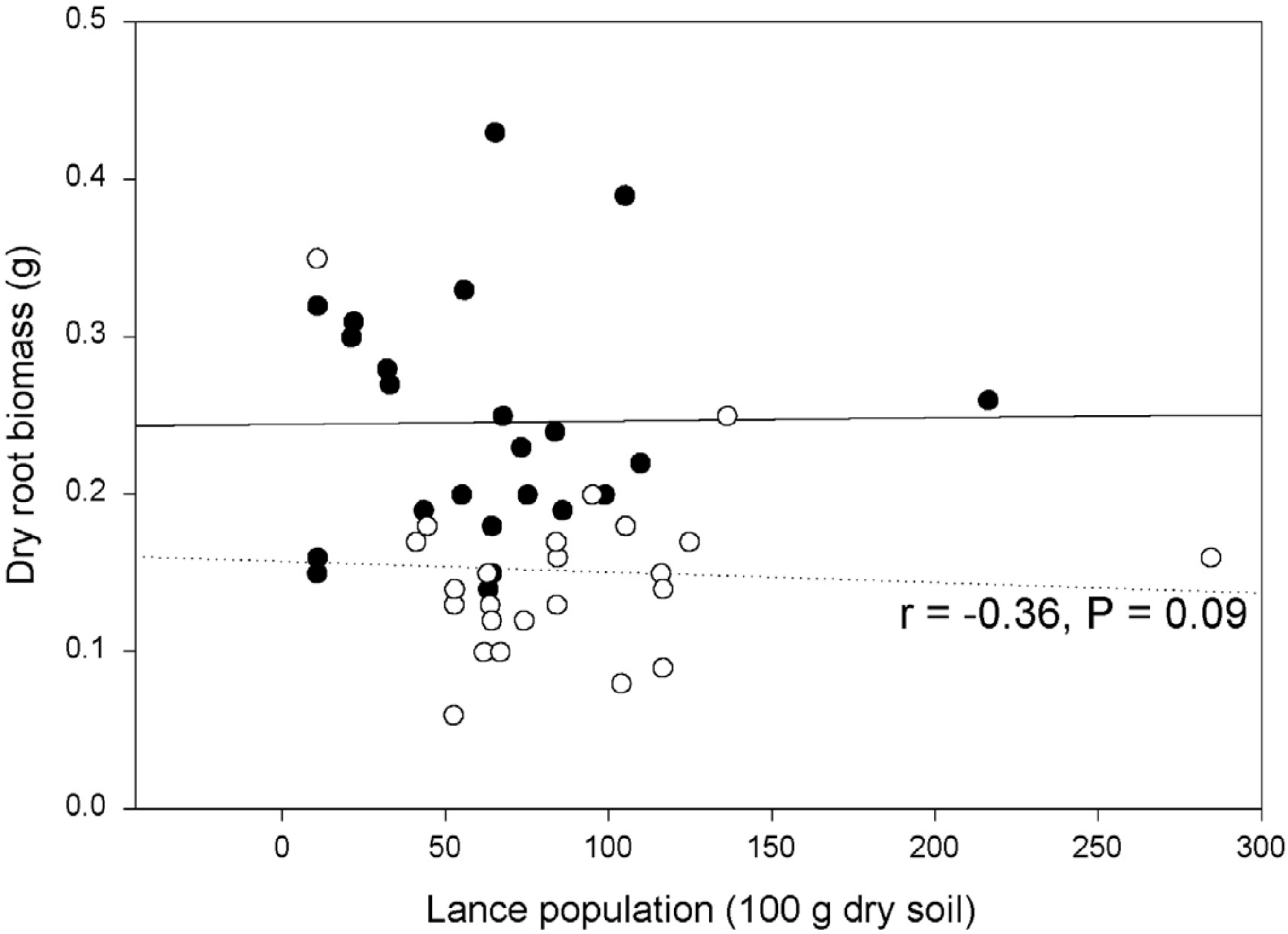


Figure 1. Effect of increasing lance nematode populations on root biomass in the warm soil treatment (85 F) across four creeping bentgrass cultivars in a greenhouse experiment at Manhattan, KS, 2003.

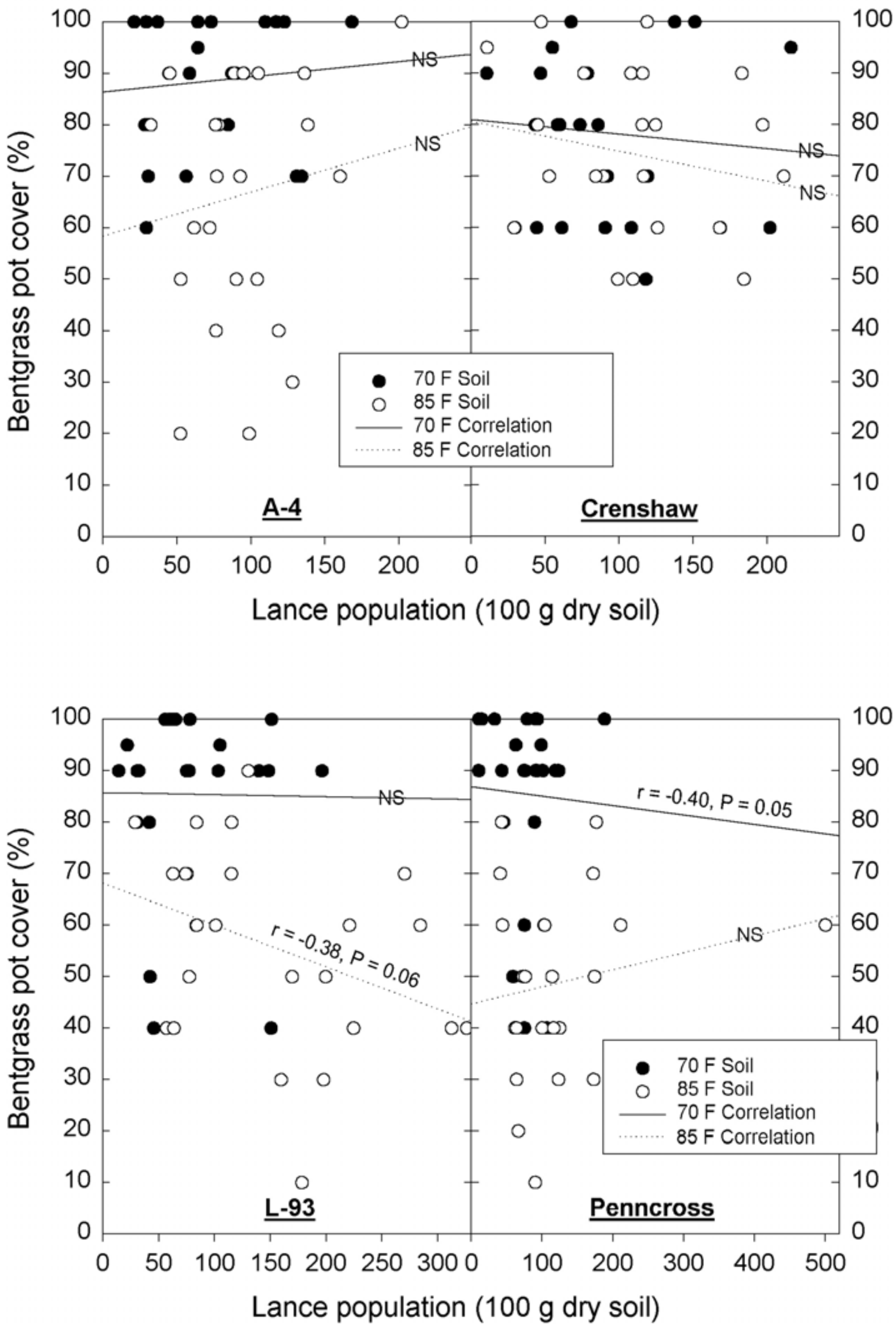


Figure 2. Differential effects of increasing lance nematode populations and two soil temperatures on creeping bentgrass percent cover in a greenhouse experiment at Manhattan, KS in 2003. No relationship existed for A-4 and Crenshaw, whereas L-93 and Penncross were negatively affected.

**TITLE:** Determining the Lance Nematode (*Hoplolaimus galeatus*) Damage Threshold Level to Creeping Bentgrass using Field Microplots

**OBJECTIVE:** Refine current damage threshold level of lance nematodes parasitizing creeping bentgrass putting greens in Kansas.

**PERSONNEL:** Derek Settle, Tim Todd, Jack Fry, and Ned Tisserat

**SPONSORS:** Plant Pathology Departmental Graduate Research Assistantship

## INTRODUCTION:

The lance nematode is a common inhabitant of Kansas putting greens. It is a relatively large nematode that possesses a robust stylet. Lance nematode densities greater than 150 per 100 $cm^3$ have been estimated as the damage threshold level for creeping bentgrass putting greens (Todd and Tisserat, 1993). An incorrect lance nematode damage threshold can lead to unnecessary nematicide use and associated risks for golf course superintendents.

## MATERIALS AND METHODS:

<u>Microplot construction</u>

This field experiment was conducted from 2000-2001 on a push-up constructed sand-silt research putting green at the Rocky Ford Research Center in Manhattan, KS (Figure 1). The experiment was a randomized complete block design with five replications with four levels of initial lance nematode populations per 100 cc of root zone mix: i) control = 0; ii) 0.5X = 125; iii) 1X = 250, and iv) 2X = 500. The microplots (nematode cages) were constructed using 12-inch diameter PVC pipe cut and installed 15 inches deep, encompassing the entire root zone to the clay base. The microplots centers were spaced 1 m apart and the entire PVC sleeve was buried with the upper edge visible and flush with the existing bentgrass putting surface, allowing normal maintenance. The sand-silt root zone mix was removed from each microplot, mixed to ensure homogeneity, steamed at 80 C for 90 minutes and then returned.

<u>Lance Nematode Inoculation</u>

Lance nematode inoculum was prepared from infested soil from a Penncross area of the bentgrass research green. Approximately 100 gallons of soil was processed using a sucrose extraction technique, and the resulting 87,500 lance nematodes were placed into 1.75 liters of water. On 6 June 2000, plots received 50 ml each of nematode-free filtrate and mixed inoculum of 50 *H. galeatus* per ml was delivered in 0 (control), 50, 100, and 200 ml amounts (0, 2209, 4418, and 8835 nematodes) to provide 0.5, 1 and 2X population levels. Treatment levels (100/$cm^3$ soil) were calculated for a soil volume inoculated to an initial 2.5 cm depth. Twelve-inch diameter A-4 creeping bentgrass, originally established from seed the fall of 1998 at the site, was washed and applied to each microplot surface following nematode inoculation. Each microplot was top-dressed with sand as needed to establish and maintain a flush installation with the surrounding putting green and ensured the same clipping height.

Data Collection

Population levels of *H. galeatus* were collected every-other month by removing two, 1.5-cm diameter by 16-cm deep cores for nematode extraction. A sub-sample of approximately 50 g fresh soil from each pot was taken to calculate soil moisture, allowing nematode populations to be standardized per 100 g dry soil.

Creeping bentgrass quality was monitored monthly using mean weekly visual quality ratings (0 = worst, and 9 = best) and multi-spectral radiometry (MSR) (Cropscan, Rochester, MN) at turfgrass canopy light reflectance wavelengths of 661, 813 and 935 nm. MSR reflectance data were used for calculating leaf area index (LAI = $R_{935} / R_{661}$), green leaf biomass expressed as normalized vegetation difference index (NDVI = $(R_{935} - R_{661}) / (R_{935} + R_{661})$), and canopy color index (CI = $1/ R_{661}$). Photosynthesis was measured monthly with an Li-6400 portable gas analyzer (Licor Inc., Lincoln, NE). Electrolyte leakage of roots was discontinued as we were unable to harvest roots of the microplots without excessive leakage following the summer of 2001. Instead 2.5 by 16 cm cores were harvested from each plot in August and September to evaluate root length and biomass in relation to lance nematode levels.

Each year, bentgrass received a total of 5 lbs N/1000 $ft^2$. Preventive applications of Heritage and Bayleton (0.2 and 2 oz/1000 $ft^2$) fungicides were done every 28 days from June through September to target brown patch and dollar spot. Supplemental applications of Chipco GT (4 oz 1000/$ft^2$) to the entire area were needed in June and September due to A-4‘s high susceptibility to dollar spot. No insecticides were applied to the area. Environmental data were monitored by the Rocky Ford Research Center weather station.

**RESULTS:**

Lance Nematode Numbers

During this final year of the study, we were able to study lance nematode densities comparable to natural creeping bentgrass putting green populations as populations appeared to peak in the microplots. Additionally, the weather was very dry through most of the summer and the microplots suffered their greatest drought stress thus far; supplemental hand watering was necessary most days from July thru September. The three levels of lance nematodes converged to a similar high level of infestation, averaging from 430 to 550 lance nematodes during the summer from June-September, while our control microplots remained lance nematode-free.

Lance Nematode Effects

Through the summer period beginning in June, the relationship between bentgrass parameters and increasing lance nematode density strengthened as the drought period lasted into September. A negative correlation occurred between increasing lance density and visual quality ($P = 0.001$), canopy photosynthesis and canopy color index reflectance ($P = 0.01$), and canopy temperature ($P = 0.03$) (Figure 2). Unexpectedly, canopy temperature was positively correlated with increasing lance nematode density ($P = 0.05$) (Figure 2). During August, increasing lance nematode densities reduced creeping bentgrass root length ($P = 0.03$) (Figure 2) and biomass. By September, no relationship between bentgrass roots and lance nematode numbers existed, with reduced root length and biomass measured. All of the above measures except color index and root biomass were also observed during the same period across a research green infested with a naturally occurring gradient of lance nematodes of similar levels. It should be noted that we were unable to harvest roots in the research green due to the site's compaction and higher organic matter content, whereas the microplots were valuable in preserving bentgrass root integrity.

**SUMMARY:**

This is the first report of direct root damage by the lance nematode to creeping bentgrass that we are aware of. It is interesting that we see increasing populations of lance nematodes from June to August, a time when root mortality due to high soil temperatures is reported to occur. In the future, more accurate turfgrass damage thresholds may be based on phytoparasitic nematodes per gram dry root weight. Additionally, nematode density related to root mass may explain why lance nematode damage only occurs during mid-summer in Kansas; a time of maximum feeding pressure on remaining creeping bentgrass roots.

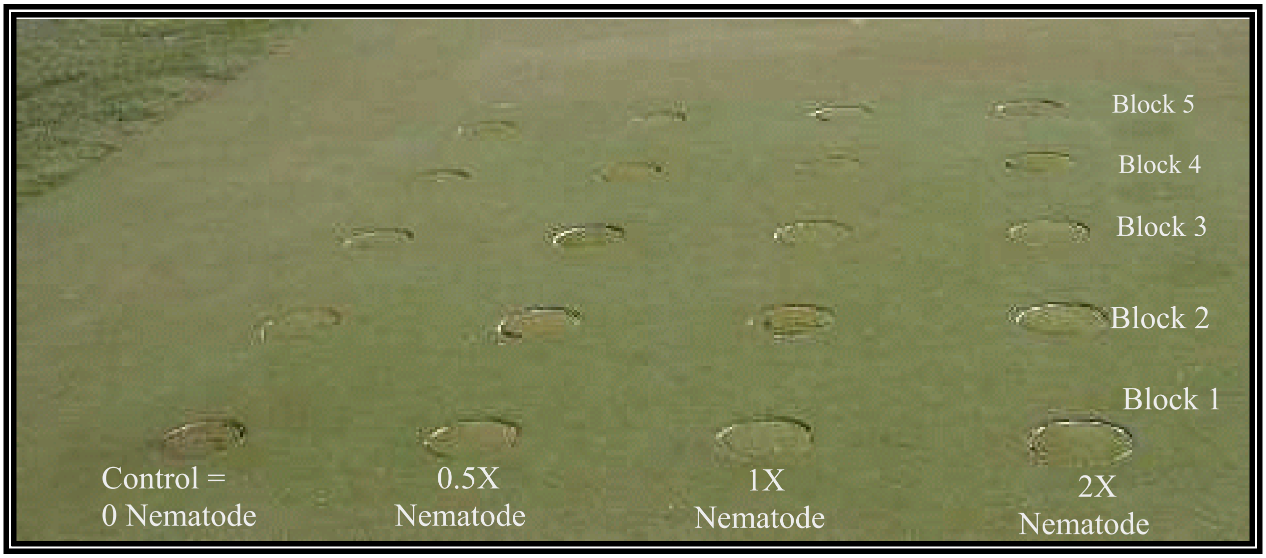


Figure 1. Finished creeping bentgrass microplots (12-inch diameter) were sodded with washed A-4 creeping bentgrass and given four levels of lance nematode densities (0-300 lance /100 cc soil) with five replications at the Rocky Ford Research Center, Manhattan, KS, 2000.

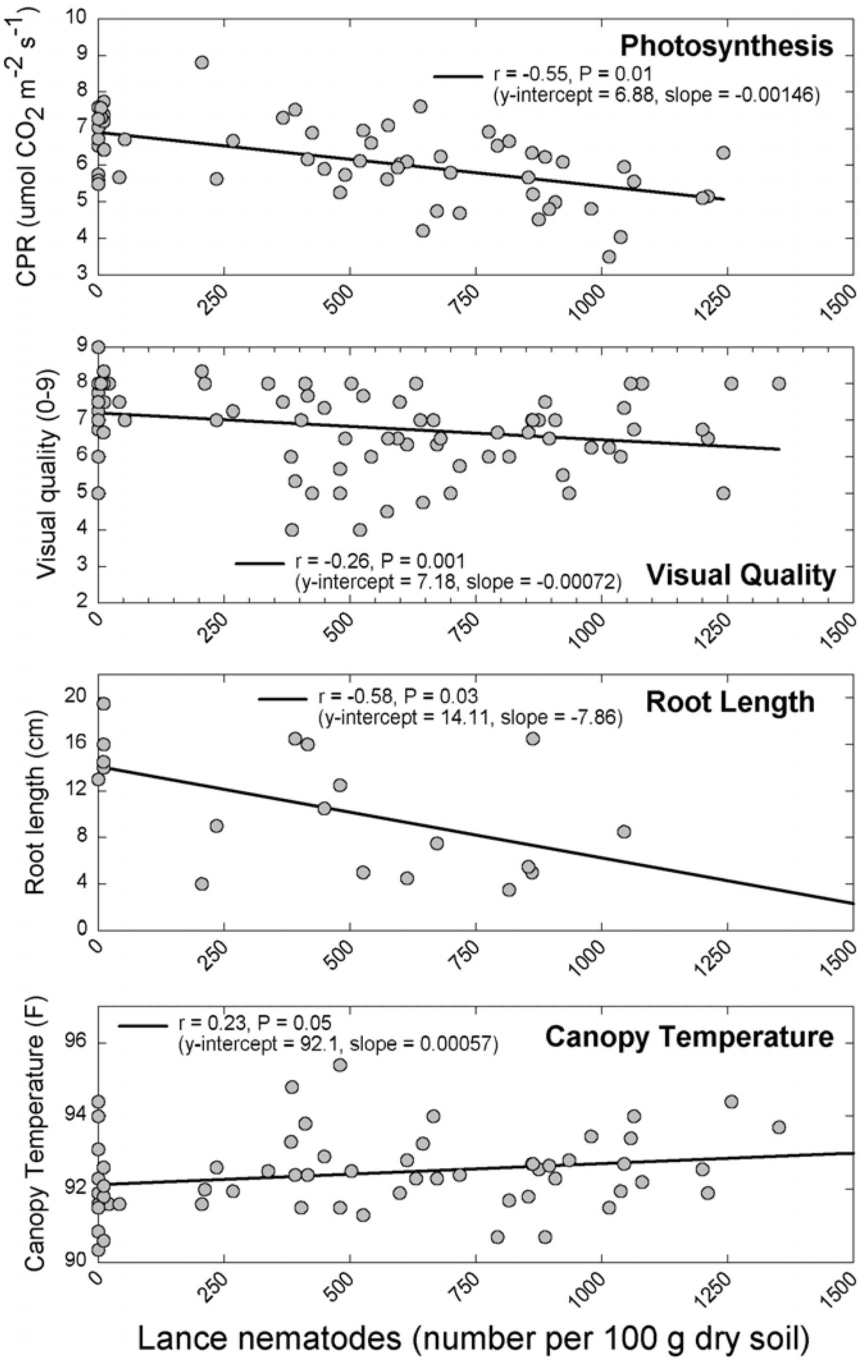


Figure 2. Correlation relationships of increasing population densities of the lance nematode in A-4 creeping bentgrass microplots versus canopy photosynthesis, visual quality, root length and canopy temperature measurements; June thru September in a field study at Manhattan, KS, 2003.

**TITLE:** Lance Nematode (*Hoplolaimus galeatus*) Population Effects In Creeping Bentgrass Given Cultivar, Mowing and Irrigation Cultural Practices

**OBJECTIVE:** Evaluate contribution of phytoparasitic nematodes to midsummer creeping bentgrass decline and their potential interaction with common cultural practices.

**PERSONNEL:** Derek Settle, Tim Todd, Jack Fry, and Ned Tisserat

**SPONSORS:** Plant Pathology Departmental Graduate Research Assistantship

**INTRODUCTION:**

The purpose of this research was to determine if high lance nematode populations exacerbate summer creeping bentgrass decline across a range of cultural management strategies. Previous research by Todd and Tisserat (1990) indicated that summer nematode populations in creeping bentgrass golf greens peak during July and that dense lance populations can cause visual chlorosis at midsummer in Kansas. This is the second and final year of the study. Unlike the humid 2001 summer, conditions during 2002 were very dry from July thru September, giving us ideal conditions to study the potential negative effects of these relatively large, root-feeding nematodes.

**MATERIALS AND METHODS:**

An existing field area with natural phytoparasitic nematode populations ranging from 0 to 1000 or more per 100 $cm^3$ was identified in June 2000. Lance nematode populations predominated with periodic occurrence of four other genera, *Criconemella* (ring), *Paratrichodorus* (stubby-root), *Hemicycliophora* (sheath), *Helicotylenchus* (spiral). The location measured 7 x 24 m, and was an established push-up sand constructed creeping bentgrass research green seeded the fall of 1996 at the Rocky Ford Turfgrass Research Center, Manhattan, KS. Treatments and measurements began in June 2001 and ended in September 2002. Cultural treatments of bentgrass cultivar, irrigation and clipping height were applied in a randomized strip-strip plot design with three replications. Four bentgrass cultivars were located in strips(2 x 7 m), and consisted of: i) Crenshaw, ii) L-93, iii) Penncross, and iv) Providence. Each cultivar was split by two daily mowing heights: i) 1/8 inch, and ii) 5/32 inch. Irrigation treatments (3.5 x 8 m) split whole blocks and consisted of either automatic every-other-day irrigation (1.2 inches $wk^{-1}$ ) or every-other-day irrigation plus mid-day hand watering every 24 h (2.4 inches $wk^{-1}$).

Each individual plot consisted of a cultivar x clipping height x irrigation treatment; lance nematodes were monitored by averaging two sub-samples taken approximately 1 m apart within each of 48, 2-$m^2$ plots. The total sample grid represented 96 potential *H. galeatus* population sites and was sampled monthly by obtaining three, 2-cm cores to a depth of 15 cm. Soil cores from each sampling site were combined and a 75 g fresh sample was removed for nematode extraction by a light sucrose flotation technique. A remaining ~100 g aliquot of soil was weighed, dried, and re-weighed to determine each sample's soil moisture content to allow standardization of lance population per 100 g dry soil.

Creeping bentgrass quality was monitored from nematode-sampled plots monthly using weekly visual quality average (0 = worst and 9 = best), percent necrosis when occurring, and multi spectral radiometry (MSR) (Cropscan, Rochester, MN) at turfgrass canopy light reflectance wavelengths of 661, 813 and 935nm. Reflectance MSR data was used for calculations of leaf area index ($LAI = R_{935} / R_{661}$), green leaf biomass expressed as normalized vegetation difference index ($NDVI = (R_{935} - R_{661})/(R_{935} + R_{661})$), and canopy color index ($CI = 1 / R_{661}$). Photosynthesis was measured with a Li-6400 portable gas analyzer (Licor, Lincoln, NE). Bimonthly, each plot was monitored for soil moisture using TDR (Time Domain Reflectometry) and soil temperature was measured using a digital thermometer placed on the canopy and 7cm deep at mid-day. Ambient environmental data was monitored by the Rocky Ford Research Center weather station.

Bentgrass received a total of 5 lbs N 1000/$ft^2$. Preventive applications of Heritage and Bayleton (0.2 and 2 oz per1000 $ft^2$) fungicides occurred every 28 days from June through September to target brown patch and dollar spot. No insecticides were applied.

**RESULTS:**

**Cultural Practices and Lance Nematodes**

Through the growing season in both 2001 and 2002 natural lance nematode populations followed similar temporal population dynamics in the field (Figure 1). Lance nematode densities rose during June and July, peaking in early August (predominantly due to increased numbers of juveniles), fell sharply (50%) by early September during a period of summer root decline, and then increased again in November prior to bentgrass dormancy.

<u>Cultivar</u>

No difference in host preference among Crenshaw, L-93, Penncross and Providence was evident; all cultivars supported similar levels of lance nematodes.

<u>Irrigation</u>

Bentgrass supplemental daily irrigation had increased lance nematode juvenile numbers in 2001, but had no effect on any life stage in 2002. Both alternate-day irrigation and alternate-day plus daily supplemental irrigation had similar levels of lance nematodes, although peak densities of lance nematodes in August were noted to occur in plots given alternate-day irrigation alone.

<u>Clipping Height</u>

Compared to clipping creeping bentgrass at 5/32 inches, a lower 1/8 inch mowing height reduced lance nematode numbers in Crenshaw and Providence and had no effect in Penncross. In contrast, L-93 clipped at 1/8 inch increased lance nematode numbers.

**Cultural Practices and Bentgrass Quality**

<u>Cultural Practices</u>

In the dry 2002 growing season, supplemental daily irrigation between 1200 and 1400 hr improved visual quality over every-other-day irrigation alone among cultivars Crenshaw, L-93 and Providence, but had no effect on Penncross quality. In contrast, during the humid summer of 2001 supplemental daily irrigation did not improve quality; instead it was associated with chlorosis and poor visual quality among all cultivars at midsummer, which was exacerbated by a low 1/8 inch clipping height.

Reducing clipping height from 5/32 to 1/8 inch reduced canopy photosynthesis by 14%.

Best visual quality across the summer period occurred where bentgrass received the combination of 5/32 inch clipping height and supplemental daily irrigation (6.9), whereas worst visual quality was observed where bentgrass received the combination of 1/8 inch clipping height and alternate-day irrigation alone (5.9).

**Lance Nematode Effects:**

Across the summer period (June-September), bentgrass measurements that were negatively correlated with increasing nematode densities included visual quality and canopy photosynthesis (Figure 2), as well as reflectance at 813 nm (a plant stress indicator) and soil moisture content. Conversely, bentgrass measurements positively correlated with increasing lance nematode density included foliar necrosis (June and July) and mid-day canopy temperature (Figure 2).

**SUMMARY:**

Overall, we found current damage thresholds will likely need to be adjusted upward to correctly reflect the very dense levels of lance nematodes required for visible damage on creeping bentgrass. Also, we found that cultural practices can influence lance nematode densities and may change the relationship or rate of damage that can occur. Finally, our study indicates that lance nematode parasitism of creeping bentgrass can not be entirely ruled out as a causal agent of mid-summer creeping bentgrass decline in Kansas, although all damage we recorded was slight to moderate.

High lance nematode populations can have negative visual effects on creeping bentgrass that can be similar in magnitude to other stressful cultural practices during summer periods, such as clipping at a low 1/8 inch height. Importantly, lance nematode damage occurs during periods of lowest bentgrass quality, mid-summer, and their phytoparasitic contribution to bentgrass root mortality has yet to be determined.

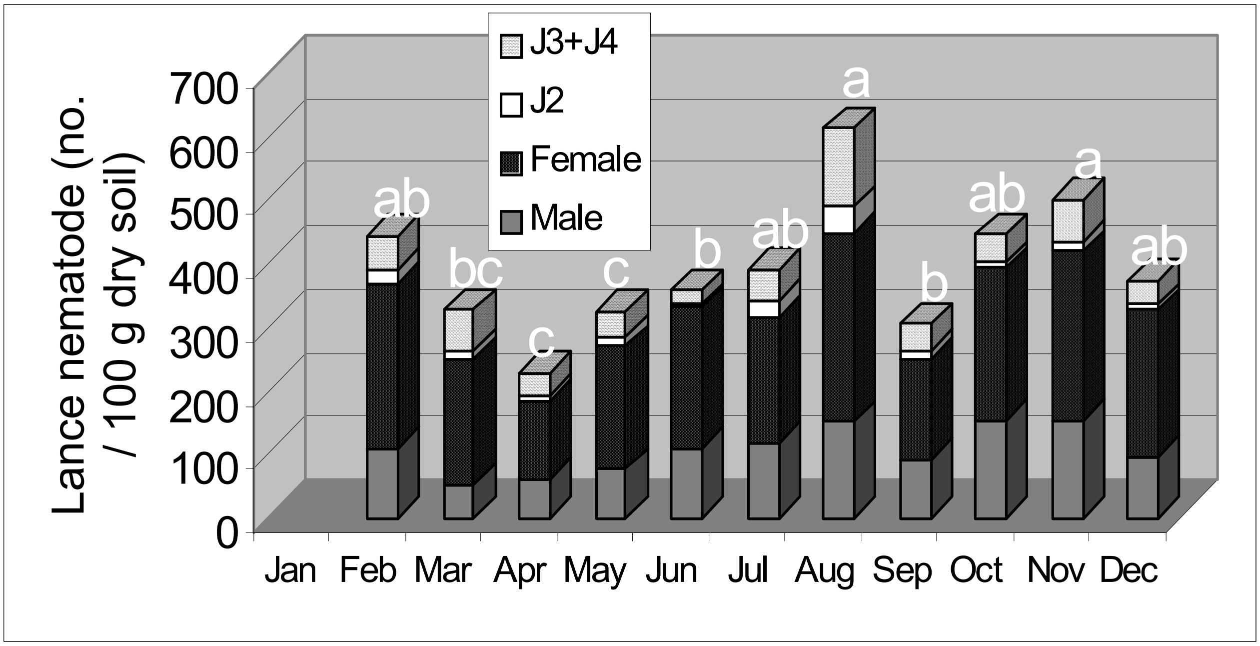


Figure 1. Annual fluctuations in lance nematode population densities were consistent during both 2001 and 2002 among a mean of 96 plots sampled monthly, except January, at Manhattan, KS. Means not given the same letter are significantly different (P=0.05) by Fisher's protected LSD.

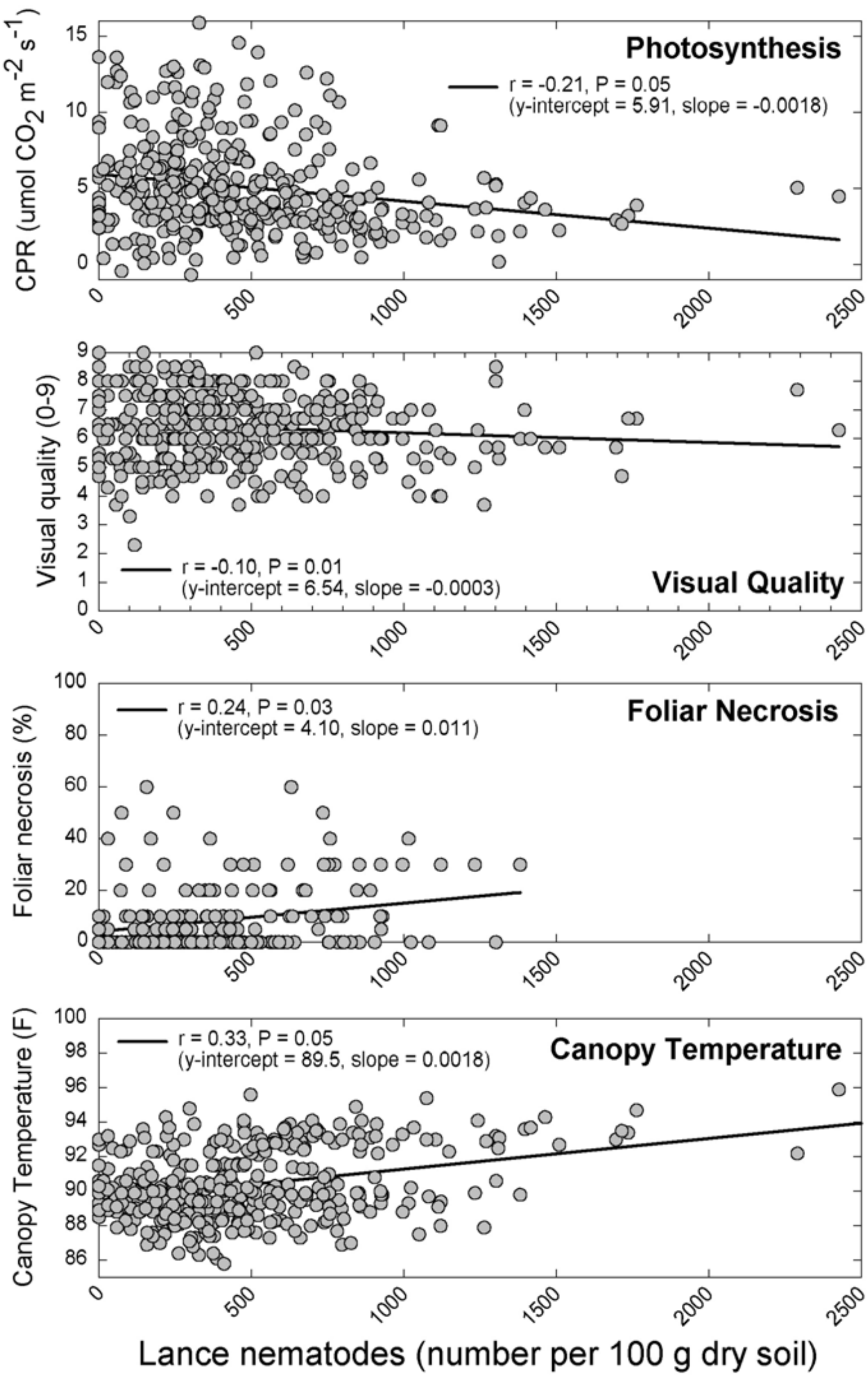


Figure 2. Correlations of increasing population density of the lance nematode across four cultivars of creeping bentgrass (Crenshaw, L-93, Penncross and Providence) versus canopy photosynthesis, visual quality, foliar necrosis and canopy temperature measurements during June thru September in a field study at Manhattan, KS, 2003.

**TITLE:** Postemergence Control of Yellow Nutsedge

**LOCATION**: Rocky Ford Research Center, Manhattan

**OBJECTIVE:** To evaluate various herbicide options for control of yellow nutsedge.

**PERSONNEL:** Matt Fagerness

**INTRODUCTION:**

Kansas supports a variety of summer weeds, including perennials like yellow nutsedge. Nutsedge is grass-like, but actually is a different type of plant and control options differ. Traditionally, nutsedge thrives in areas with high moisture but is capable of developing in a variety of habitats. Nutsedge is a widespread weed problem, therefore new control options are always worth exploring to optimize strategies for turfgrass managers.

**MATERIALS AND METHODS:**

Twelve different herbicide treatments were applied to an area infested with yellow nutsedge. Treatments included the following herbicides: MSMA at 9 pt/acre applied once or twice, Manage (halosulfuron) at either 0.031 or 0.062 lb a.i./acre applied once or twice, MSMA at 4.5 pt/acre + Manage at 0.031 lb a.i./acre, Basagran (bentazon) at 2 pt/acre applied once or twice, and Speed Zone (carfentrazone+2,4-D+MCPP) at 5 pt/acre applied once or twice. Manage and Basagran were applied with label recommended surfactants to optimize their performance. Treatments were first applied in late May with sequentials applied 6 weeks later. Treated plots were subsequently rated for percent weed control.

**RESULTS:**

Control of yellow nutsedge can be achieved with numerous herbicides (Table 1). Which to choose can depend upon cost and the level of infestation. It is clear that the best control was achieved with Manage, especially when more than one application was made. Sequential applications of all herbicides investigated improved control, although it seems likely that the less effective materials may warrant more than two annual applications to adequately control this weed species. Inclusion of potentially injurious crop oil concentrate (COC) may have accounted more for the early control of yellow nutsedge than the Basagran it was mixed with.

Table 1. Control of yellow nutsedge with various postemergence herbicides.

| Treatment | 4-June | 17-July | 23-July | 6-Aug |
|---|---|---|---|---|
| | **-----------------------Percent control-----------------------** | | | |
| Nontreated | 0 | 31 | 36 | 4 |
| MSMA (1 app.) | 44 | 63 | 66 | 30 |
| MSMA (2 apps.) | 36 | 80 | 90 | 75 |
| Manage (low rate, 1 app.) | 29 | 90 | 97 | 78 |
| Manage (low rate, 2 apps.) | 28 | 81 | 91 | 86 |
| Manage (high rate, 1 app.) | 30 | 89 | 95 | 73 |
| Manage (high rate, 2 apps.) | 31 | 88 | 96 | 89 |
| MSMA + Manage | 28 | 78 | 82 | 71 |
| Basagran + COC (1 app.) | 81 | 49 | 38 | 13 |
| Basagran + COC (2 apps.) | 83 | 68 | 79 | 53 |
| Speed Zone (1 app.) | 45 | 64 | 66 | 31 |
| Speed Zone (2 apps.) | 43 | 70 | 70 | 44 |
| LSD 0.05[1] | 8 | 18 | 20 | 19 |

[1]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

**TITLE:** Postemergence Control of Puncturevine and Spurge

**LOCATION:** Rocky Ford Research Center, Manhattan

**OBJECTIVE:** To evaluate various herbicide options for control of summer annual broadleaf weeds.

**PERSONNEL:** Matt Fagerness

**INTRODUCTION:**

Kansas supports a plethora of weed species, including many summer annual broadleaf species that must be controlled early in their life cycle for effective riddance. Sometimes, early control is not fully effective so turfgrass managers may need to target these weeds in summer. Research is needed to help optimize strategies for control of nuisance species like puncturevine or spurge, especially when they have become more developed.

**MATERIALS AND METHODS:**

Ten different herbicide treatments were applied to an area infested with both puncturevine and spurge. Treatments included three rates of each of the following herbicides: Confront (triclopyr+clopyralid) at 1, 2, or 4 pt/acre, Speed Zone (carefentrazone+2,4-D+MCPP) at 1, 2, or 4 oz/1000 $ft^2$, and Trimec Classic (2,4-D+MCPP+dicamba) at 1, 2, or 4 oz/1000 $ft^2$. Treatments were applied in early July and subsequently rated for percent weed control.

**RESULTS:**

Control of summer annual broadleaf weeds is more challenging once they have developed into the summer (Table 1). This is not surprising, considering the robustness these weeds can achieve as they mature. Single applications of herbicides were able to produce high levels of weed control, but only when applied at rates 2-3 times what would normally be recommended. Although more costly from a herbicide use standpoint, these weeds can and should be controlled with higher herbicide rates. Problem areas can be isolated to reduce total herbicide use and still obtain necessary levels of control.

Table 1. Control of puncturevine and spurge with various postemergence herbicides.

| Treatment | Rate | 17-July | 23-July | 6-Aug. |
|---|---|---|---|---|
| | | **--------------Percent control** | | **--------------** |
| Nontreated | | 0 | 0 | 0 |
| Speed Zone | 1 oz./1000 sq. ft | 41 | 49 | 60 |
| Speed Zone | 2 oz./1000 sq. ft | 58 | 69 | 79 |
| Speed Zone | 4 oz./1000 sq. ft | 65 | 76 | 86 |
| Confront | 1 pt./acre | 35 | 30 | 20 |
| Confront | 2 pt./acre | 28 | 24 | 26 |
| Confront | 4 pt./acre | 51 | 66 | 49 |
| Trimec Classic | 1 oz./1000 sq. ft | 36 | 50 | 34 |
| Trimec Classic | 2 oz./1000 sq. ft | 38 | 54 | 63 |
| Trimec Classic | 4 oz./1000 sq. ft | 58 | 79 | 86 |
| LSD 0.05[1] | | 15 | 19 | 27 |

[1]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

**TITLE:** Preemergence and Postemergence Control of Knotweed and Spurge

**LOCATION:** Rocky Ford Research Center, Manhattan

**OBJECTIVE:** To evaluate various herbicide options for control of summer annual broadleaf weeds.

**PERSONNEL:** Matt Fagerness

**INTRODUCTION:**

Kansas supports a plethora of weed species, including many summer annual broadleaf species that must be controlled early in their life cycle for effective riddance. Less is known about the effects of preemergence herbicides on broadleaf weeds than on grasses such as crabgrass that have a similar life cycle. Research is needed to help optimize strategies for control of nuisance species like knotweed or spurge, especially since cultural means of control are usually ineffective.

**MATERIALS AND METHODS:**

Nine different herbicide treatments were applied to areas infested with knotweed (Manhattan) and spurge (Wichita). Treatments included single or sequential applications of three common broadleaf herbicides: Confront (triclopyr+clopyralid) at 1 pt/acre, Speed Zone (carefentrazone+2,4-D+MCPP) at 1.5 oz/1000 $ft^2$, and Trimec Classic (2,4-D+MCPP+dicamba) at 1.5 oz/1000 $ft^2$. Additionally, Speed Zone at the rate above was applied with either Barricade (prodiamine) at 0.75 lb a.i./acre or Dimension (dithiopyr) at 0.5 lb a.i./acre to evaluate impact of preemergence herbicides on these weeds. Early treatments were applied in mid-April with sequentials applied one month later. Plots were rated for percent weed control.

**RESULTS:**

Our results show that control of summer annual broadleaf weeds may be enhanced with a preemergence herbicide application (Table 1). This effect may delay the need for sequential applications of broadleaf herbicides but is not an effective substitute for sequentials. The best long-term control of knotweed was observed in plots treated with two applications of either Speed Zone or Trimec Classic. Confront was not as effective against knotweed but performed better against spurge. Multiple applications appear to be essential for effectively controlling these troublesome summer annual broadleaf weeds.

Table 1. Control of knotweed and spurge with various herbicides.

| | Knotweed | | | Spurge | |
|---|---|---|---|---|---|
| Treatment | 23-April | 22-May | 6-Aug. | 8-May | 21-May |
| | -------------------Percent control------------------ | | | | |
| Nontreated | 18 | 6 | 8 | 8 | 6 |
| Speed Zone + Dimension | 96 | 96 | 73 | 66 | 93 |
| Speed Zone + Barricade | 95 | 95 | 49 | 79 | 73 |
| Speed Zone (2 apps.) | 93 | 80 | 99 | 65 | 59 |
| Confront (2 apps.) | 14 | 10 | 6 | 70 | 63 |
| Trimec Classic (2 apps.) | 59 | 59 | 98 | 49 | 71 |
| Speed Zone (1 app.) | 95 | 88 | 40 | 74 | 70 |
| Confront (1 app.) | 24 | 16 | 10 | 61 | 66 |
| Trimec Classic (1 app.) | 68 | 61 | 14 | 56 | 34 |
| LSD 0.05[1] | 15 | 8 | 30 | 24 | 35 |

[1]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

**TITLE:** Drought Resistance of Two Texas Bluegrass Hybrids Compared with Kentucky Bluegrass and Tall Fescue

**OBJECTIVES:** Evaluate the visual qualities of two Texas bluegrass hybrids (HB129 and HB329), Kentucky bluegrass (Apollo), and tall fescue (Dynasty) under varying irrigation regimes and water deficits.

**AUTHORS:** Dale Bremer, Kemin Su, Steve Keeley, and Jack Fry

**SPONSORS:** The Scotts Co., Inc, Golf Course Superintendents Association of America, and the Kansas Turfgrass Foundation.

## INTRODUCTION:

Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) are cool-season grasses commonly used for lawns in the United States and in some areas these are subjected to frequent drought. Kentucky bluegrass commonly goes dormant and loses color during periods of high temperature and drought in the Midwest. Tall fescue has good drought resistance, but some homeowners prefer the finer texture that Kentucky bluegrass offers. New Texas bluegrass (*Poa arachnifera* Torr.) hybrids, which are genetic crosses between Kentucky bluegrass and native Texas bluegrasses, have the appearance of Kentucky bluegrass but may be able to withstand higher temperatures and extended drought without going dormant. In warm-season climates such as in the South, Texas bluegrasses stay green all year long. Furthermore, Texas bluegrass hybrids may use significantly less water than other cool-season species while maintaining their green color. The latter is important given the increasing competition for water and the rising costs of irrigation.

## MATERIALS AND METHODS:

Two cultivars of Texas bluegrass (HB129 and HB329 - seed provided by The Scotts Co.) were compared with Kentucky bluegrass (Apollo) and tall fescue (Dynasty) in a water-deficit trial at the Rocky Ford Turf Research Center near Manhattan, Kansas. Two irrigation treatments and a control were applied to plots. Irrigation treatments include the replacement of 60%, and 100% of the water lost from plants and soil via evapotranspiration (ET). Control plots received minimal irrigation (i.e., the only water they received was from precipitation or approximately 40% ET replacement from irrigation during extremely hot and dry periods). The split-plot design includes 12 main plots (8 x 3 m each) of one irrigation treatment each that are arranged in a Latin square design. Each main plot is subdivided into 12 subplots (2 x 1 m each) that are arranged in 3 rows (i.e., 4 subplots per row). The subplots in each row contain 1 each of Apollo, Dynasty, HB129, and HB329. Thus, each species or cultivar was replicated three times within each main irrigation plot, and species/cultivar was blocked by row. Plots were planted on 8 October 2001. All plots were mowed at a height of 2.5 inches once or twice weekly, depending upon growth rate. Turf received 3 to 4 lbs N/1000 $ft^2$/yr. No pesticides were applied. This study was originally intended to be conducted from October 2001 through the end of 2004.

ET was calculated using empirical equations (FAO-56 Penman-Monteith) and weather data obtained from the weather station located at the research center. In addition, dual-probe heat-capacity sensors were used to monitor soil moisture and soil temperature; these sensors were fabricated in our turfgrass laboratory at Kansas State University. Dual-probe measurements verify the overall accuracy of ET calculations and prevent over- or underwatering of the plots. Precipitation was monitored with a tipping-bucket rain gauge.

All plots were evaluated on a biweekly basis for visual quality. This included a relative ranking of the overall density, uniformity, texture, and color of the turfgrass in each plot. Visual evaluations were also conducted for drought resistance and included observations of leaf firing and appearance of wilt. Clippings were collected biweekly during the study.

**RESULTS:**

In the first summer of the study (2002), evaluations for quality, density, and color began in mid-May. Collection of clippings began immediately prior to the beginning of water-deficit treatments. Water deficit treatments did not begin until late June to allow turf sufficient time to establish before subjecting it to drought stress. Once water-deficit treatments began, irrigations were applied two times per week. Immediately after water deficit treatments were imposed, the weather turned extremely hot and dry, with temperatures well into the 90's ($^{o}$F) every afternoon. Within one week of the beginning of the water-deficit treatments, the bluegrasses (including Kentucky and both Texas hybrids) were showing significant firing of leaves. Two weeks after the initiation of water deficit treatments, we began irrigating the 0% plots with 40% replacement of ET because of concern over their survival. Only one measurable rain occurred during July (1.9 inches on the 28$^{th}$). In early August, the water deficit treatments were halted because many of the bluegrass plots still exhibited substantial leaf firing and stress; some plots were nearly 100% fired. During August, irrigation was applied daily in order for plots to recover from the severe drought and heat, which continued throughout August. However, a number of the bluegrass plots, including some of Apollo, HB329, and HB129, never recovered. Other complicating factors besides heat and drought may have been involved. For example, billbugs may have infested some bluegrass plots near the west border and constant westerly winds during establishment may have caused uneven irrigation patterns that resulted in drier plots and subsequent weaker root systems along the same (west) border; most of the hardest hit plots were on the west side. Dynasty was not affected by any of these factors and consistently performed well during the study as is illustrated below. By early September it was decided that the plots should be reseeded and the experiment re-initiated. To be fair to all varieties, Roundup was applied to all plots including Dynasty 7 September. On 24 September 2002 all plots were reseeded.

Dynasty consistently performed well during the entire summer. For example, quality ratings on 26 June, prior to water deficit treatments, showed that Dynasty rated the highest at 7.4 (scale of 1 to 9), followed by Apollo and HB129 (~5.2 - 5.6; Fig. 1). HB329 exhibited the lowest quality ratings at 3.7, primarily because of poor density. Color ratings on the same day revealed that Dynasty ranked the highest at 7.6 (1 to 9 scale; Fig. 2). HB 329 ranked second in color ratings, although as mentioned above, poor density caused its lower quality ratings. HB 129 had the lowest color ratings primarily because it was distinctly lighter compared to the other turfgrasses. This remained true throughout the summer. On 25 June Dynasty yielded the most of clippings at 73 g/m$^2$, while HB 129 ranked a distant second at 43 g/m$^2$ (Fig. 3). HB 329 and Apollo yielded the least amount of clippings and were not statistically different (~31 g/m$^2$).

Leaf firing ratings on 24 July, approximately 27 days after the beginning of the water-deficit treatments, showed significant firing in HB129, HB329, and Apollo (Fig. 4). The firing was typically higher as the irrigation amounts decreased, but differences were not always significant between irrigation treatments. Dynasty showed extremely small amounts of firing, with no firing evident in 100% irrigation plots. Due to the severity of the firing in a significant number of plots, and to the reinstatement of irrigation in August, clipping data were not collected after July. The plots were rated for quality and density on 7 September, immediately prior to treatment with Roundup. Quality and density ratings showed that Dynasty remained high in both categories (generally >7), while HB129, HB329, and Apollo ranked low (generally between 2 and 4.5; Figs. 5 and 6).

Soil moisture sensors in the Dynasty plots revealed lower soil water contents at 15 cm (6 inches) than at either 5 cm (2 inches) or 30 cm (12 inches) during repeated drying trends (Fig. 7). For example, volumetric soil water content on 12 July (day of year 193) was 26% at 6 inches compared with 29% at 2 inches and 31% at 12 inches. This suggests that rooting density and root-water uptake may be higher in Dynasty at 6 inches compared to shallower and deeper depths. The maximum soil temperature at a 2-inch depth was nearly 31$^{o}$C (89$^{o}$F) on 9 July (day of year 190), compared with about 27$^{o}$C (81$^{o}$F) at 6 inches and 25$^{o}$C (77$^{o}$F) at 12 inches (Fig. 8). In HB329, which had poorer density stands and thus more soil exposed to solar radiation, the soil temperature at 2 inches reached nearly 35$^{o}$C (95$^{o}$F; data not shown). Higher soil temperatures in HB329 compared with Dynasty illustrates the moderating effect on soil temperatures of shading by the turfgrass canopy and the cooling effect of evapotranspiration.

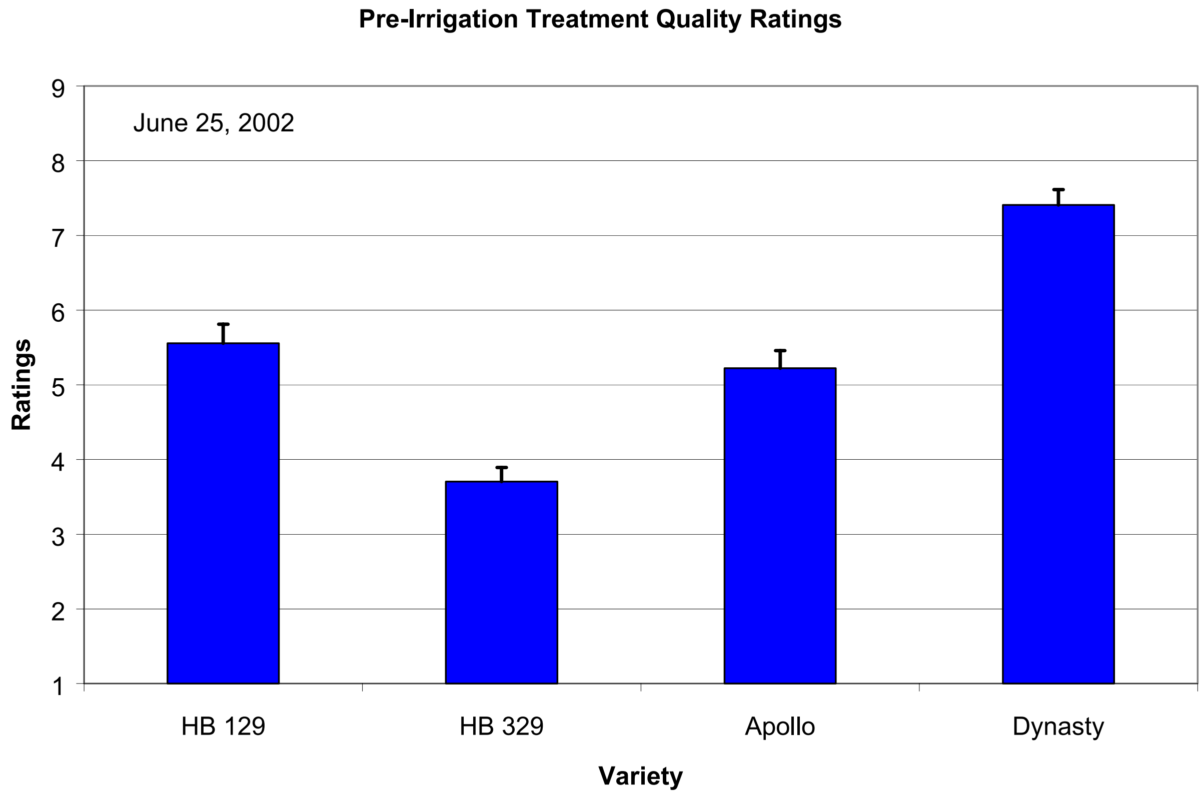


Figure 1. Visual quality ratings of four varieties of turfgrass: two hybrids of Texas bluegrass (HB129 & HB329); Kentucky bluegrass (Apollo); and Tall Fescue (Dynasty). Ratings are on a scale of 1 to 9, with 9 representing the best possible quality. Error bars represent one standard error (9 replicates).

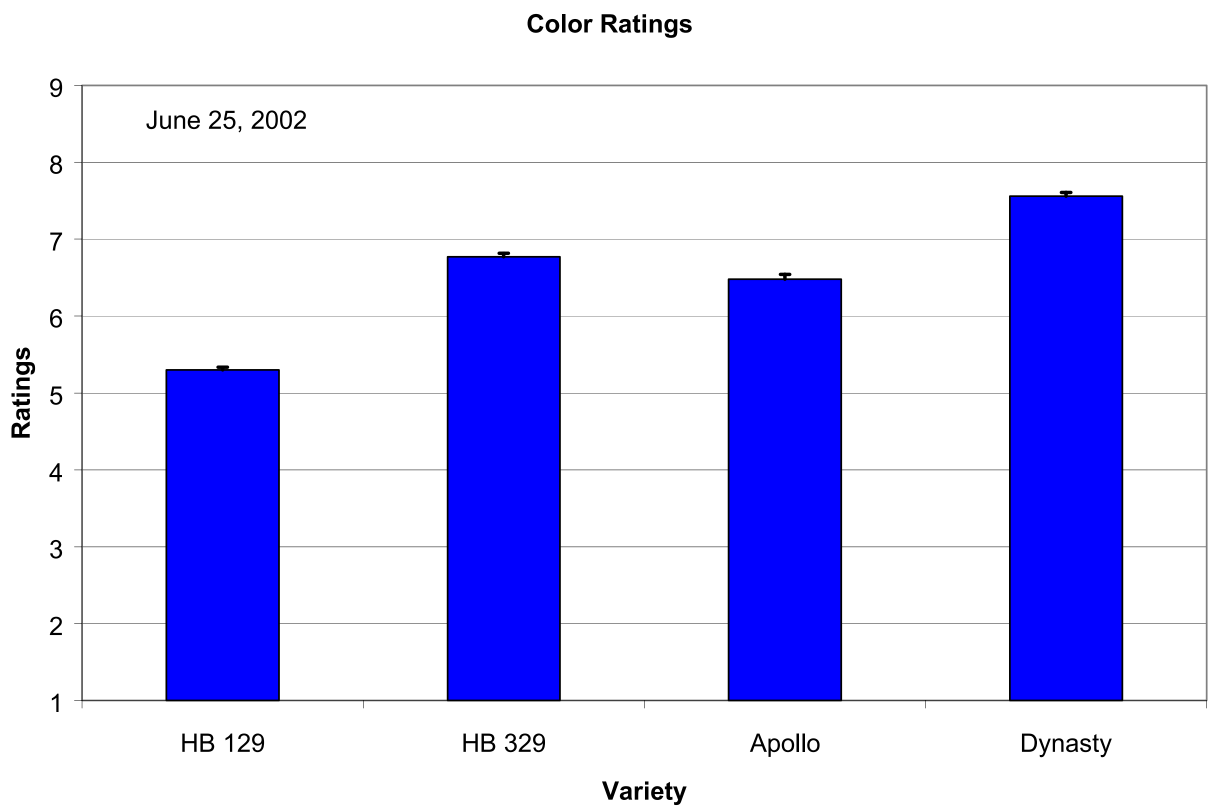


Figure 2. Visual color ratings of the same 4 varieties on a scale of 1 to 9, with 9 representing the most desirable color. Error bars represent one standard error (9 replicates).

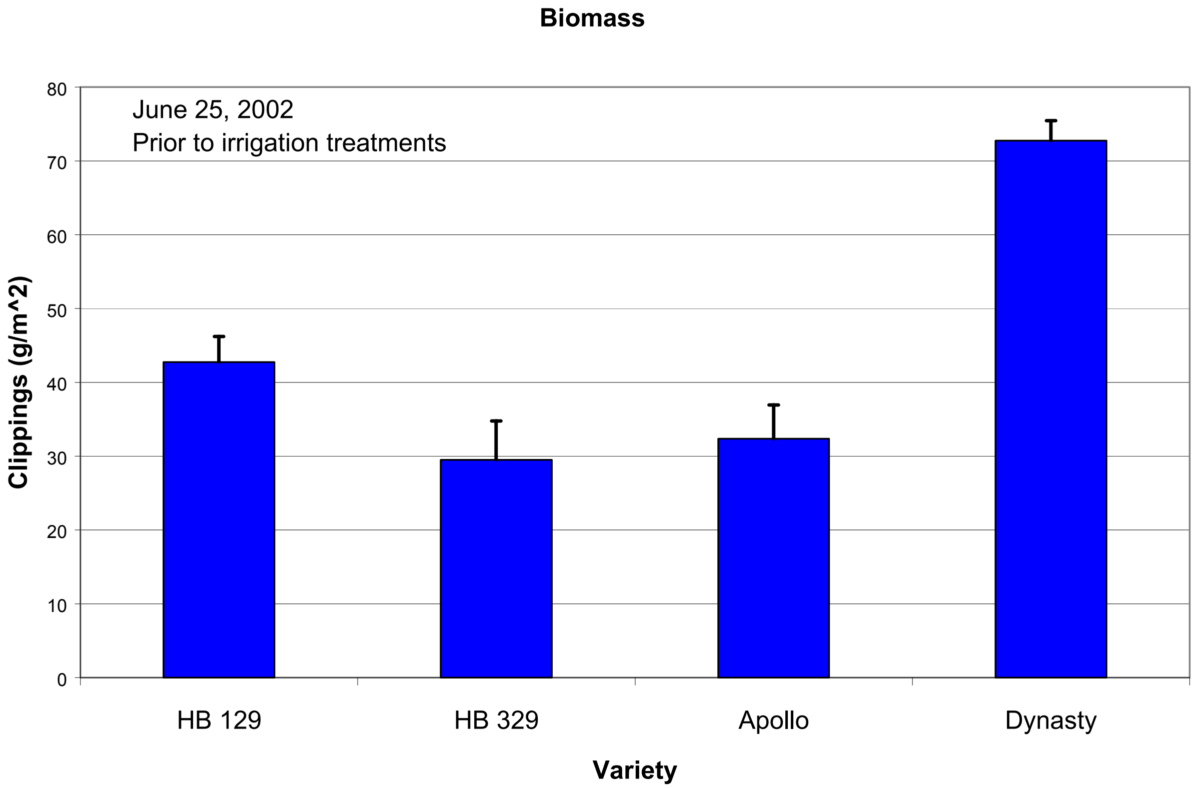


Figure 3. Gravimetric measurements of clippings collected from each of the 4 varieties. Error bars represent one standard error (3 replicates).

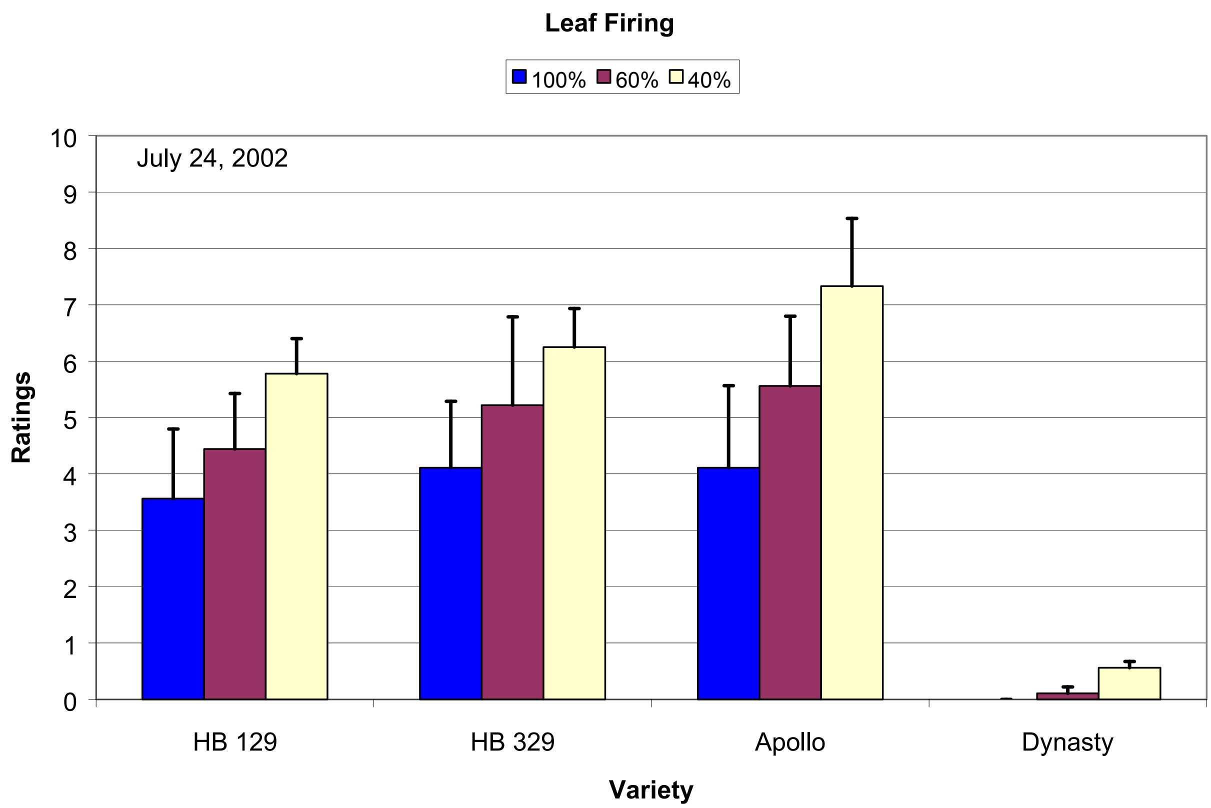


Figure 4. Visual estimates of leaf firing in all varieties after 27 days of water-deficit treatments on a scale from 0 to 10, with 10 representing 100% firing. Irrigation treatments were 100, 60, and 40% ET replacement. Error bars represent one standard error (9 replications).

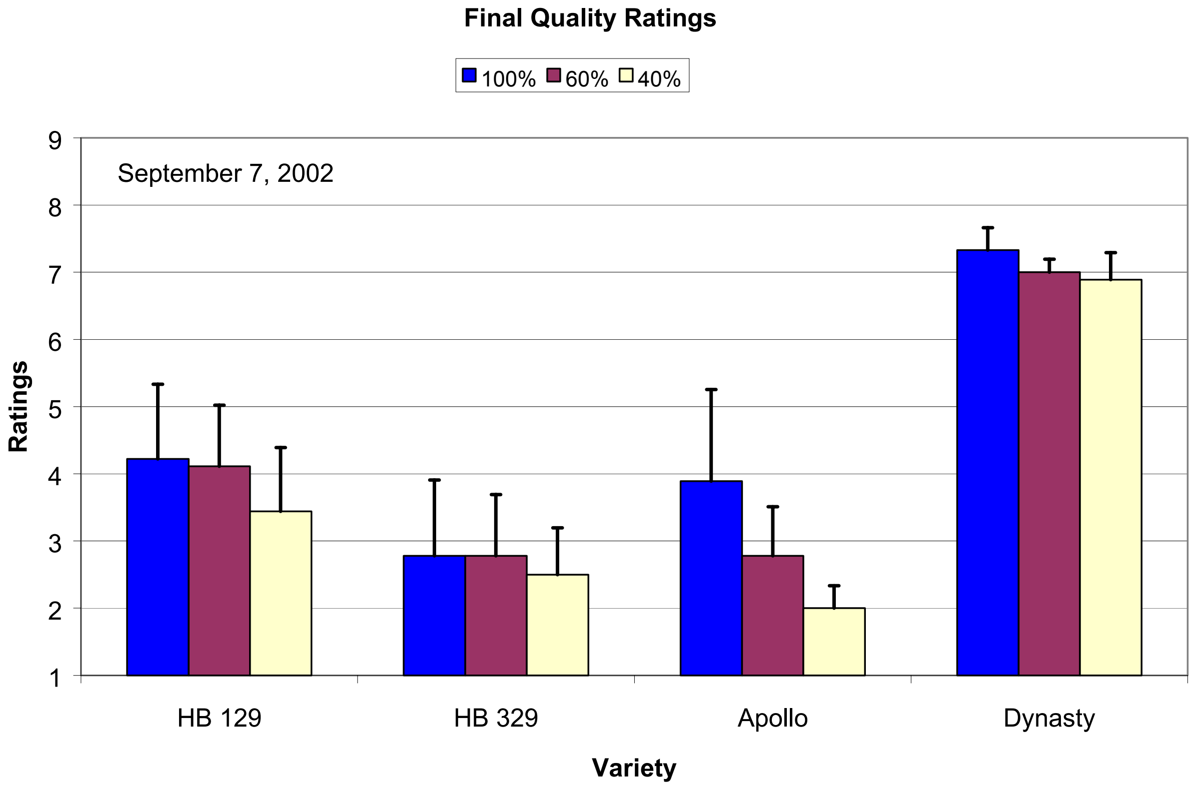


Figure 5. Final visual quality ratings prior to reseeding on a scale from 1 to 9 with 9 representing the best possible quality. Irrigation treatments were 100, 60, and 40% ET replacement. Error bars represent one standard error (9 replicates).

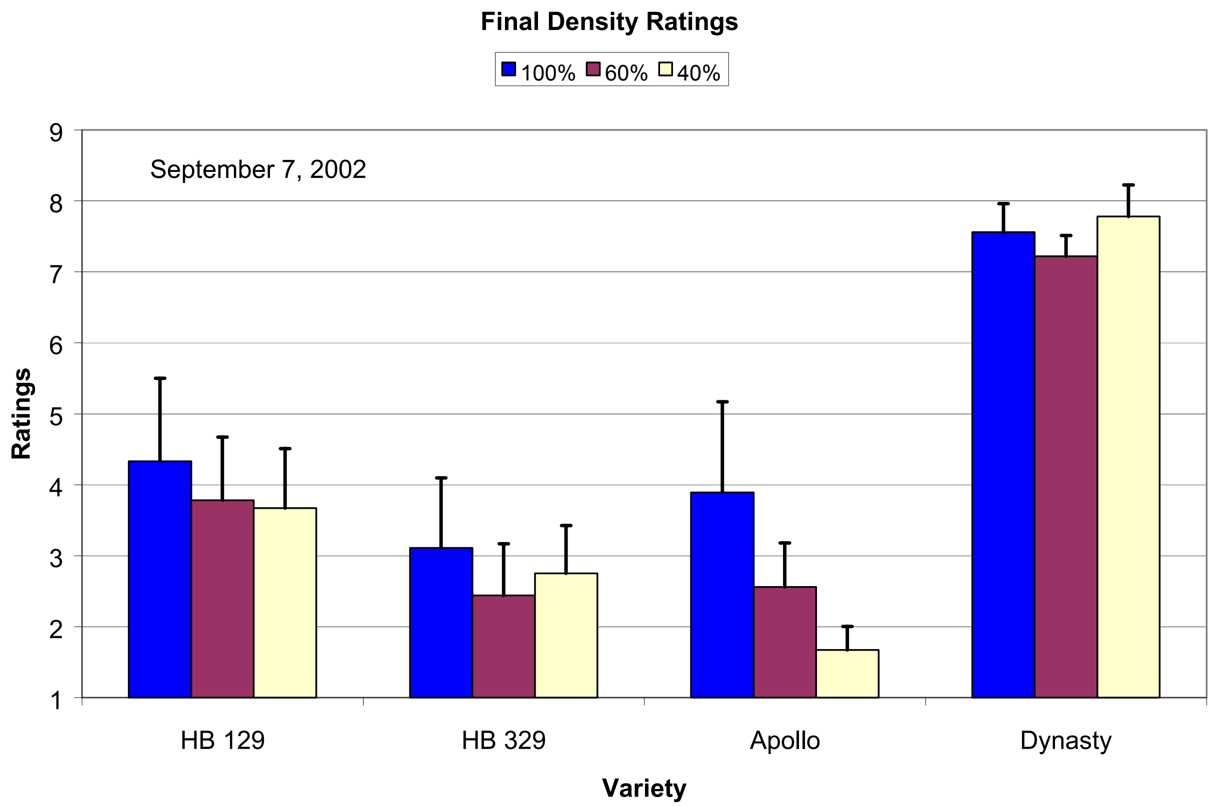


Figure 6. Final visual density ratings prior to reseeding on a scale from 1 to 9, with 9 representing the most desirable density. Irrigation treatments were 100, 60, and 40% ET replacement. Error bars represent one standard error (9 replicates).

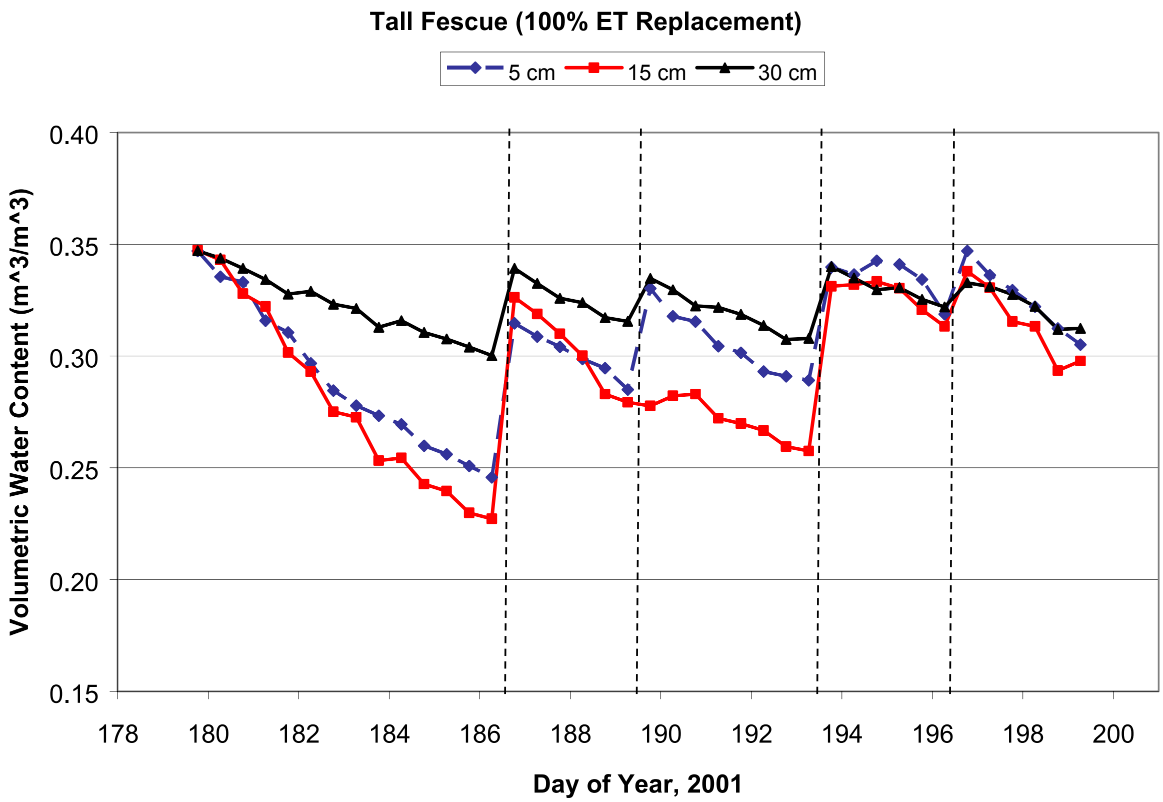


Figure 7. Volumetric soil water content in fully irrigated Dynasty plots from June 28 (day of year 179) to July 18 (day of year 199), 2002, at 5 cm (2 inch), 15 cm (6 inch), and 30 cm (12 inch) depths.

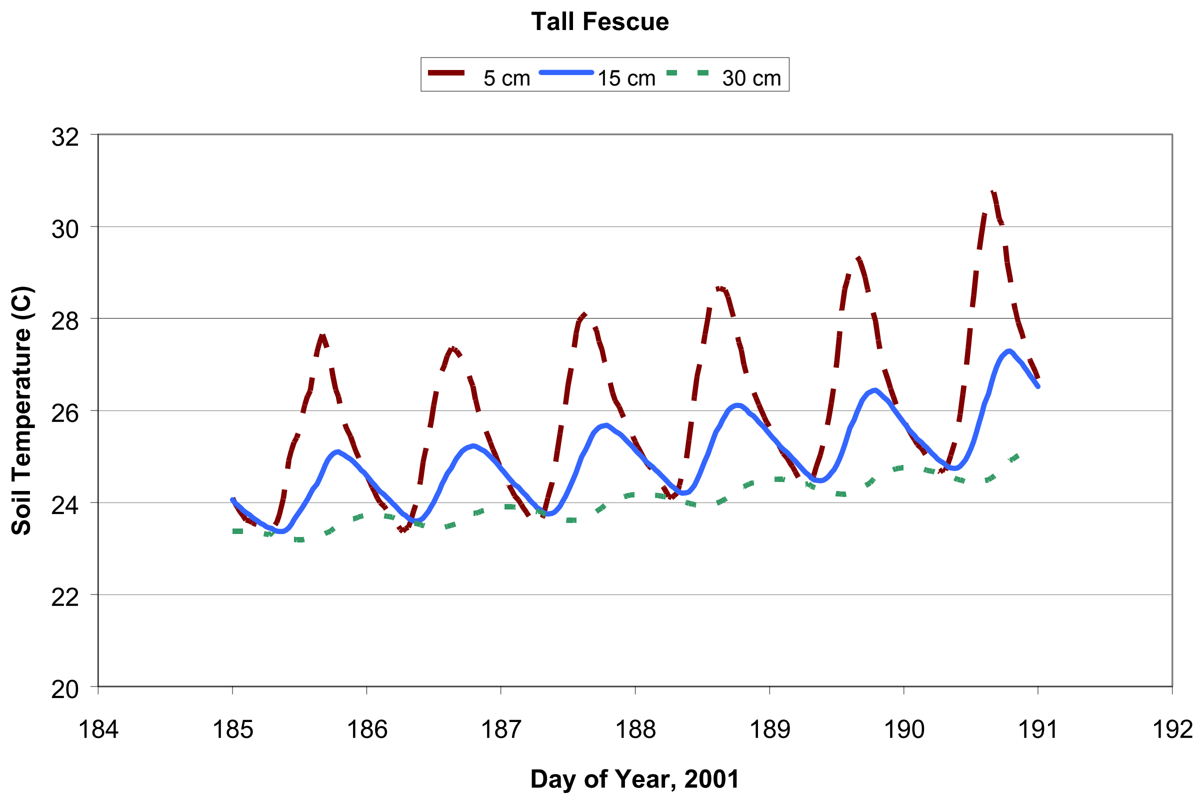


Figure 8. Soil temperatures in Dynasty plots from July 4 (day of year 185) to July 9 (day of year 190). 2002, at 5 cm (2 inch), 15 cm (6 inch), and 30 cm (12 inch) depths.

**TITLE:** Evaluating Microlysimeters used in Turfgrass Evapotranspiration Studies Using the Dual-Probe Heat-Pulse Technique

**OBJECTIVES:** Evaluate the effect of microlysimeter design on: 1) Soil water content and temporal changes in soil water content among three types of microlysimeters using soil moisture sensors (dual probes) inside the microlysimeters and in the adjacent (ambient) soil profile; and 2) gravimetric estimates of ET among 5 microlysimeter types, 3 of which were equipped with dual-probe sensors as mentioned in objective 1.

**PERSONNEL:** Dale Bremer

**SPONSOR**: Kansas Turfgrass Foundation

**INTRODUCTION:**

In turfgrass, estimating water-use rates and evaluating the effects of cultural practices on evapotranspiration (ET) are important because of increasing competition for water. ET studies in turfgrass are sometimes designed to identify cultivars or species that maintain high quality while using less water. Microlysimeters are often used in turfgrass studies to gravimetrically estimate ET rates and to compare ET rates among cultivars or species. Using this method, microlysimeters are irrigated, allowed time for the free drainage of water to cease, and then weighed wet; microlysimeters are then weighed one or more days later and the water loss is attributed to ET. However, no standard design for microlysimeters exists and consequently, a wide variety of styles are used in turfgrass ET studies. For example, microlysimeters may be fabricated at different sizes (e.g., diameters and depths), from different wall materials (e.g., plastic or steel), with different types of bases (e.g., mesh screen or solid), filled with different materials (e.g., native soil or fritted clay), prepared differently (e.g., planting sod into microlysimeters weeks ahead of deployment to allow sod establishment vs. using intact cores from field at beginning of study), or deployed differently in the field (e.g., holes may or may not be lined with sleeves, and bases may or may not be lined with gravel). The effects of microlysimeter design on soil moisture or on temporal changes in soil moisture remain uncertain.

Recently, the dual-probe heat-pulse (DPHP) technique has been developed and tested for measuring volumetric soil water content ($\theta_v$) and changes in $\theta_v$ over time in the laboratory and in the field, including under turfgrass. The DPHP sensor is approximately 5.5 cm long x 1.6 cm diameter, with the probe spacing around 6 mm, which allows for small-scale spatial measurements of $\theta_v$ that can be made in small containers such as microlysimeters.

**MATERIALS AND METHODS:**

<u>Microlysimeter design, construction, and deployment</u>

Differences in microlysimeter design included three sizes (10 cm diam. x 20 cm, 15 cm diam. x 30 cm, and 25 cm diam. x 20 cm), two fill materials (native soil and fritted clay), two base covers (screen and plexiglass), two preparation techniques (pre-sodding in greenhouse 86 d prior to deployment and use of intact soil cores from field), and two types of holes (pre-dug with sleeves installed to prevent sides from collapsing and bases lined with gravel, and holes with no sleeves and no gravel bases). Five designs of microlysimeters, replicated three times each, were fabricated from poly-vinyl chloride (PVC) tubes for this study. Four of the five microlysimeter types were installed into pre-dug holes where the perimeters were lined with larger PVC tubes (~5 cm larger than their respective microlysimeter diameters) to prevent the sides from collapsing, and the bases were lined with approximately 5 cm of gravel. Sleeves were not required in a smaller microlysimeter type, nor were the bases lined with gravel (#3 – next paragraph). Turf type was K-31 tall fescue.

The five designs included: 1) 15 cm diam. x 30 cm, base covered with fine-mesh aluminum screen (~1 $mm^2$ openings in screen) and reinforced with larger wire mesh (~6.5 mm), and packed with native soil from the field site (MSL; mesh [base], soil [fill], lined [sleeve]); 2) 15 cm diam. x 30 cm, base covered with solid plexiglass with one hole in center for drainage (13 mm diam.), and packed with native soil from the field site (PSL; plexiglass, soil, lined); 3) 10 cm diam. x 20 cm, base covered with screen described for MSL, filled with intact cores of native soil (MSNL; mesh, soil, not lined); 4) 15 cm diam. x 30 cm, base covered with screen described for MSL, filled with fritted clay (MFCL; mesh, fritted clay, lined); and 5) 25 cm diam. x 20 cm, bottom covered with plexiglass with one hole in center (13 mm diam.) for drainage, and packed with native soil from the site (WPSL; wide, plexiglass, soil, lined).

Evaluation of soil water content inside microlysimeters with dual-probe heat-pulse technique

DPHP sensors were installed at three depths (5, 15, and 25 cm) in MSL and PSL microlysimeters and in AP, and at two depths in the smaller MSNL microlysimeter (5 and 15 cm); all sensors were installed prior to deployment to the field. DPHC sensors were not installed in all microlysimeters because of practical limitations in sensor availability and data acquisition capacity and because DPHC sensors may not be appropriate for use in fritted clay, which was used in MFCL.

Gravimetric measurements, green leaf area index, and aboveground biomass

At the beginning and periodically throughout the study, microlysimeters were saturated with water and the surrounding area irrigated with ~5 cm of water. After allowing 12 to 30 h for drainage, ML were removed from the field, weighed, and immediately returned (microlysimeters were not sealed during ET measurements). Microlysimeters were then weighed every 24 to 96 hours during periods without precipitation to obtain gravimetric estimates of ET during the study. Microlysimeters were consistently weighed between 1230 and 1400 h. During one 2-week period (DOY 234 to 248), irrigation was withheld to observe the effects of drydown on soil moisture (with DPHP sensors) and gravimetric estimates of ET among microlysimeter types. Laboratory tests later revealed that drainage may have occurred up to 24 hours after irrigation. Therefore, only gravimetric estimates of ET from the 2-week drydown were reported, when drainage was not a factor (27 h were allowed for drainage prior to the first ET measurement and no precipitation occurred during the 2-week drydown period).

Green leaf area index and aboveground biomass were measured in microlysimeters and in surrounding turfgrass to evaluate their impact on estimates of ET.

**RESULTS:**

DPHP data revealed that microlysimeter design had significant effects on $\theta_v$ in MSL and PSL compared to AP (Fig. 1). Following irrigation, $\theta_v$ was comparable among microlysimeters and AP, but after 3 to 6 days became significantly lower in MSL and PSL; soils in MSL consistently dried the fastest. The $\theta_v$ in MSNL was comparable to AP throughout the study; MSNL may have been in hydraulic contact with the ambient soil. Significant effects were also observed at different depths in MSL and PSL compared to AP (Fig. 2). At 5 cm, $\theta_v$ declined faster in PSL than in the other microlysimeters or AP. At lower depths (15 and 25 cm), $\theta_v$ declined more rapidly in MSL and PSL than AP although the decline was most rapid in MSL. The largest differences in $\theta_v$ occurred at 25 cm, with MSL substantially lower than PSL and AP, and PSL lower than AP. The same patterns were consistently observed during three drydown periods, including a final drydown that lasted 2 weeks (Figs. 3 and 4).

Linear regression analysis revealed good agreement between measurements of $\theta_v$ from DPHC sensors and gravimetric measurements in each microlysimeters (Fig. 5). Agreement was less in MSNL (i.e., DPHP sensors tended to overestimate gravimetric $\theta_v$), probably because of greater uncertainty in bulk density measurements compared to MSL and PSL; measurements of $\theta_v$ with DPHP sensors are sensitive to errors in bulk density measurements.

Gravimetric estimates of ET varied significantly among microlysimeter designs (Table 1). For example, cumulative ET during the 14-d drydown period was about 2 times greater from MSL and PSL than from MSNL; ET estimates were highest from MSL and PSL and lowest from MSNL. Early in the period when soil moisture was non-limiting, ET from MSL and PSL was about 24% higher than reference ET (theoretical maximum ET from well-watered grass calculated from weather data using the FAO-56 Penman-Monteith equation), and ET from MSNL was 47% lower than reference ET. Estimates of ET from MFCL and WPSL were similar and both were similar to reference ET when water was non-limiting. Interestingly, estimates of ET from MSL and PSL were similar throughout the drydown despite the differences in $\theta_v$ observed at different depths with DPHP sensors (Figs. 1-4). ET rates were strongly correlated to green LAI and aboveground biomass, which varied considerably among microlysimeter types (Fig. 6). LAI and biomass were highest in MSL and PSL, which corresponded to the highest ET rates observed in this study, while lowest LAI, biomass, and ET rates were observed from MSNL.

In summary, the high variability in $\theta_v$ and in ET estimates among microlysimeter types suggests that ET estimates from microlysimeters may not be representative of ET rates from surrounding turfgrass. In particular, factors that cause differences in green LAI and aboveground biomass may impact ET estimates from microlysimeters. Because drainage may occur for at least 24 h in microlysimeters filled with silt loam soils, it may be necessary to seal microlysimeters during periods of ET measurements; fritted clay may be more desirable in microlysimeter studies because of its favorable drainage and aeration properties (van Bavel et al. 1978). Furthermore, where gravel is not placed in the holes, sealing microlysimeters would prevent hydraulic contact with ambient soils during ET measurements. In studies where ET rates are compared among cultivars or species using microlysimeters, the same design, fill material, etc. should be used to ensure that differences in ET represent actual differences from plants and not from microlysimeter design.

Table 1. Gravimetric estimates of daily evapotranspiration (ET) from microlysimeters in K-31 tall fescue during a 14 d drydown period from day of year (DOY) 234-248. Five different microlysimeter designs included: 15 cm diam. x 30 cm, mesh base, soil fill, lined hole (MSL); 15 cm diam. x 30 cm, plexiglass base, soil fill, lined hole (PSL); 10 cm diam. x 20 cm, mesh base, soil fill holes not lined (MSNL); 15 cm diam. x 30 cm, mesh base, fritted clay fill, lined hole (MFCL); and 25 cm diam. cm x 20 cm, plexiglass base, soil fill, lined hole (WPSL).

| DOY[1] | MSL | PSL | MSXNL | MFCL | WPSL | $ET_r$[2] | $ET_p$[3] |
|---|---|---|---|---|---|---|---|
| | ---------------------------------------mm--------------------------------------- | | | | | | |
| 235-238 | 6.47 a | 6.62 a | 2.81 c | 4.93 b | 4.81 b | 5.29 | 6.64 |
| 239-240 | 5.85 a | 5.34 a | 2.47 c | 2.31 c | 4.09 b | 5.08 | 6.24 |
| 241-242 | 6.97 a | 6.10 b | 3.24 D | 2.48 E | 4.74 C | 5.17 | 7.07 |
| 243-246 | 4.52 AB | 4.40 AB | 2.42 C | 2.24 C | 3.13 BC | 5.36 | 8.05 |
| 247-248 | 1.43 a | 1.80 a | 1.48 a | 1.47 a | 1.09 a | 5.21 | 7.56 |
| Cumulative | 72.46 | 70.56 | 35.30 | 41.20 | 51.60 | 73.52 | 100.50 |

[1]Day of the year; the first DOY is January 1
[2]Reference ET calculated from weather data and the Penman-Monteith Equation (FAQ-56).
[3]Potential ET calculated from weather data and the Penman equation (Penman 1948)

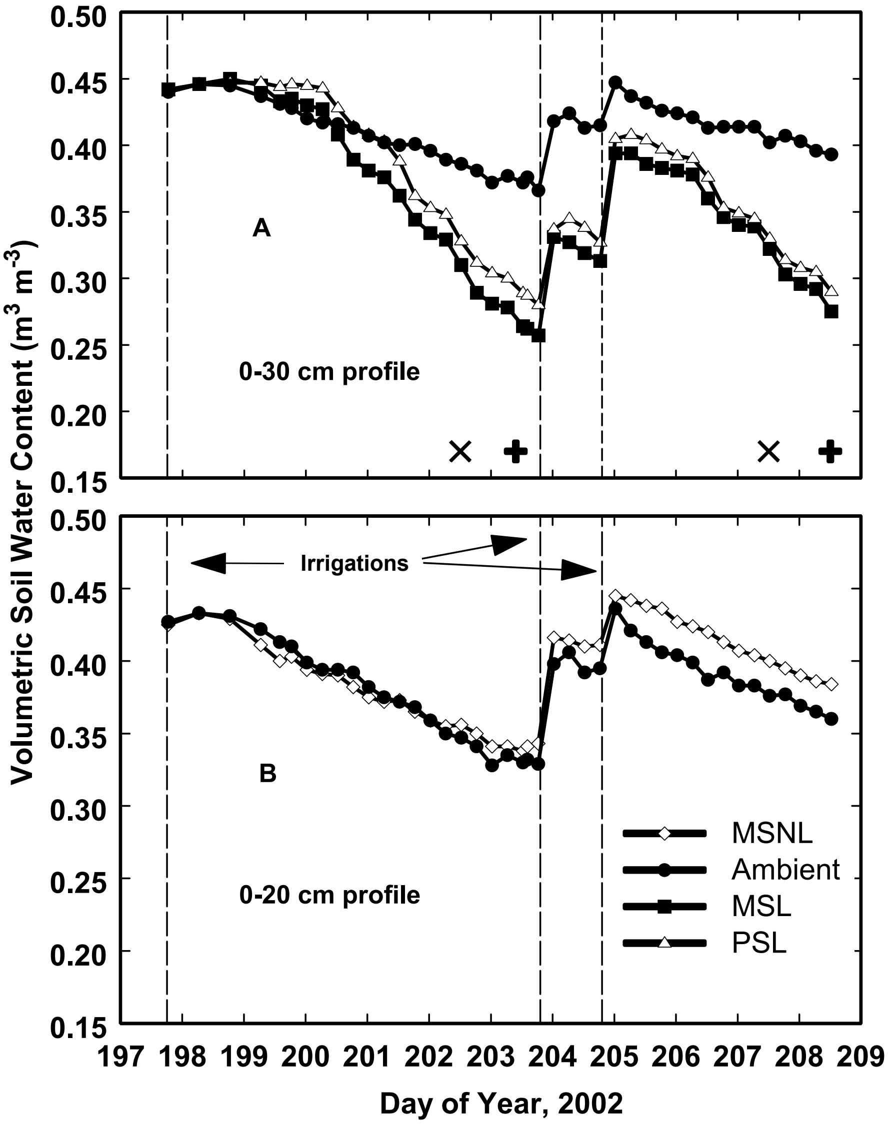


Figure 1. Comparisons of volumetric soil water content from DPHP sensors: A) among MSL and PSL containers and the Ambient soil (average 5, 15, and 25 cm [0-30 cm profile]); and B) between MSNL and the Ambient soil (average 5 and 15 cm [0-20 cm profile]). Vertical dashed lines highlight irrigation dates. Symbols (x) along the abscissa of each graph indicate significant differences between MSL and ambient soil ($P<0.05$), and plus (+) indicates significant differences between both MSL and PSL and the ambient soil on a given day.

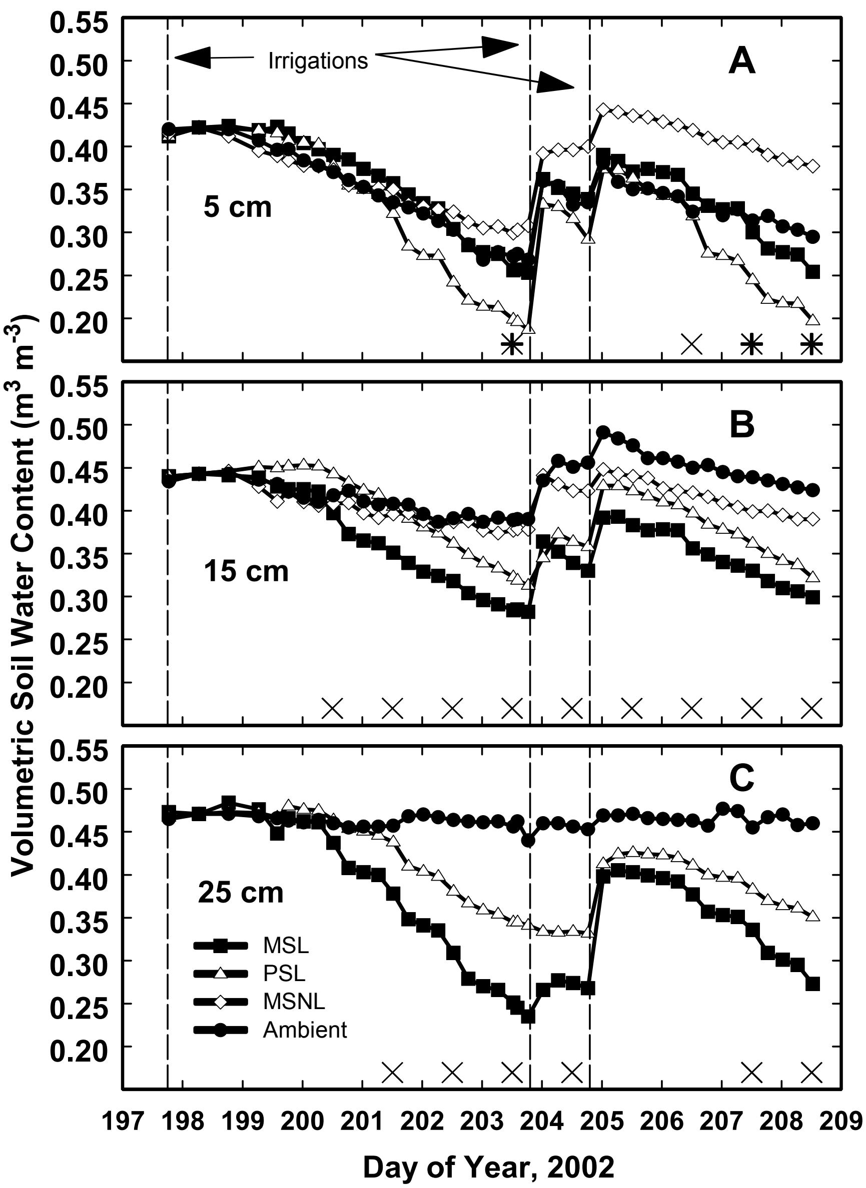


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Figure 2. Comparisons of volumetric water content from DPHP sensors at 5 (A) and 15 cm (B) among MSL, PSL, MSNL, and Ambient soil, and at 25 cm (C) among MSL, PSL, and Ambient soil. Vertical dashed lines highlight irrigation dates. Symbols (plus-x) along abscissa of each graph indicate significant differences among 3 treatments ($P<0.05$), and x indicates significant differences between 2 treatments.

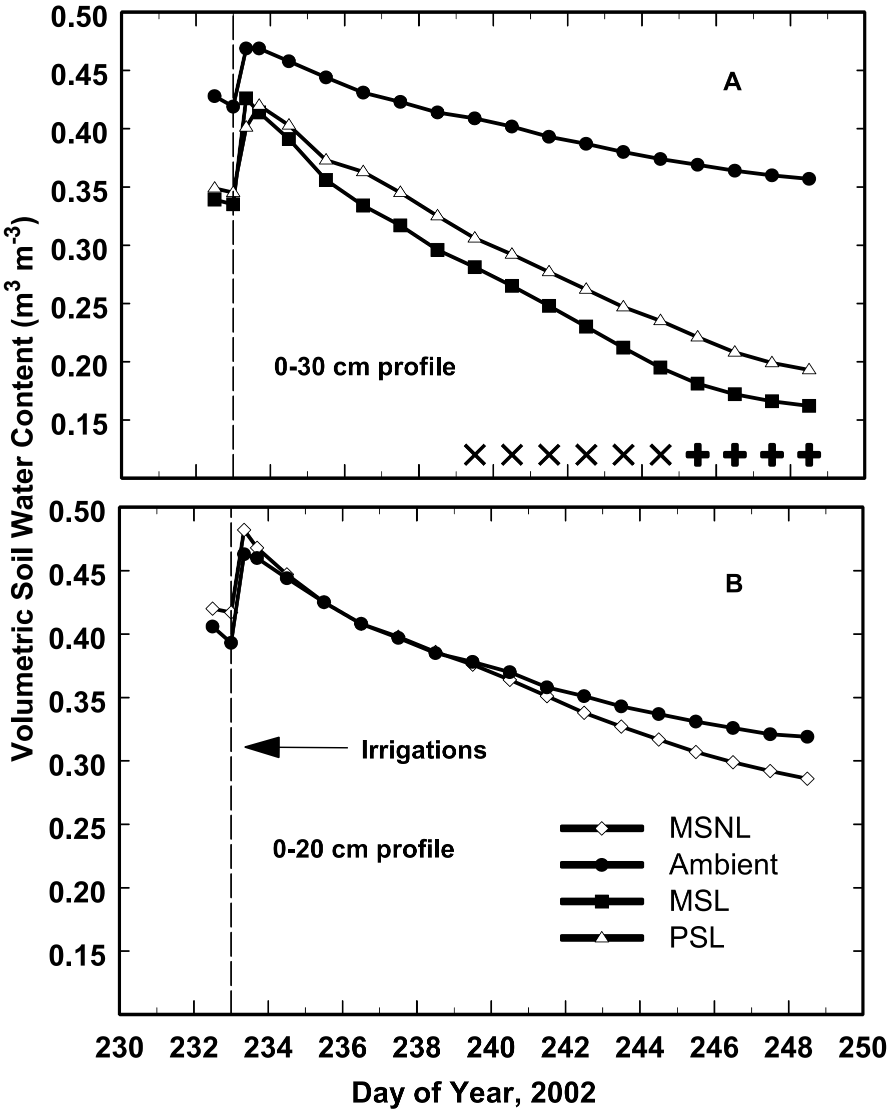


Figure 3. Comparisons of volumetric water content from DPHP sensors: A) among MSL and PSL containers and the Ambient soil (average 5, 15, and 25 cm [0-30 cm profile]); and B) between MSNL and the Ambient soil (average 5 and 15 cm [0-20 cm profile]). Vertical dashed lines highlight irrigation date. Symbols (x) along the abscissa of each graph indicate significant differences between MSL and ambient soil ($P<0.05$), and plus (+) indicates significant differences between both MSL and PSL and the ambient soil on a given day.

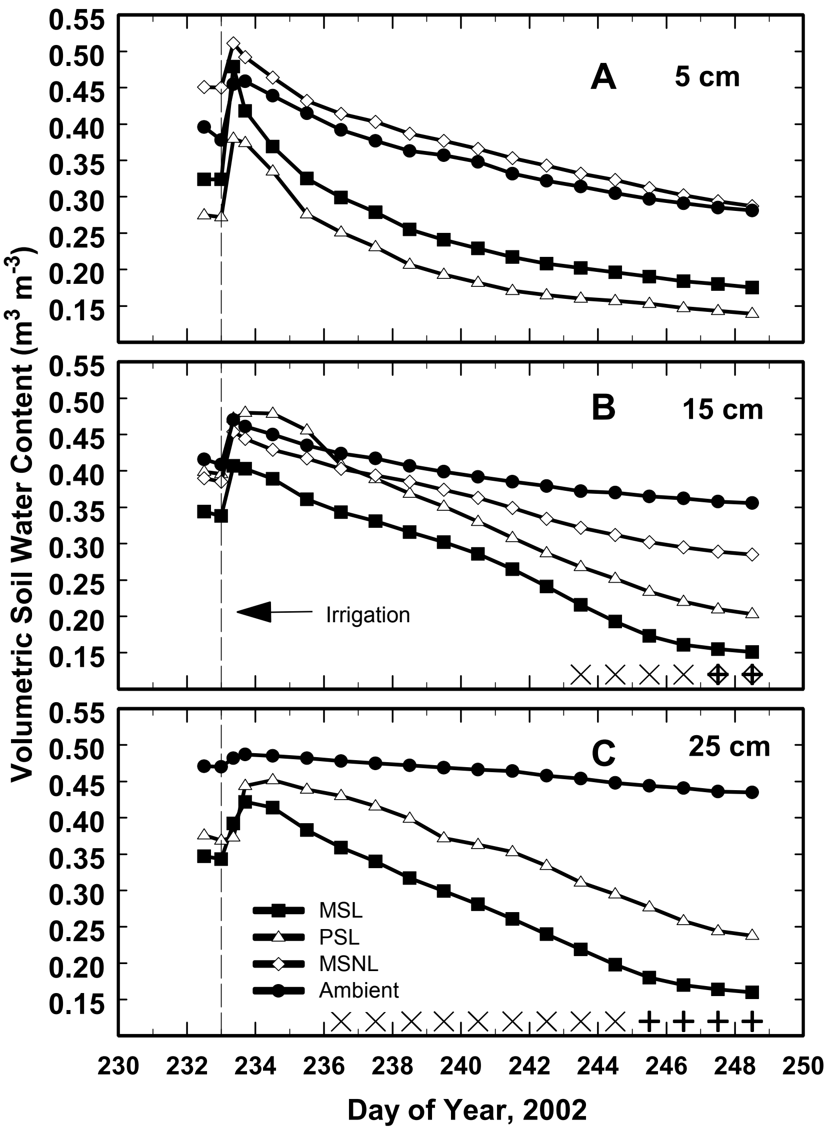


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Figure 4. Comparisons of volumetric water content from DPHP sensors at 5 (A) and 15 cm (B) among MSL, PSL, MSNL, and Ambient soil, and at 25 cm (C) among MSL, PSL, and Ambient soil. Vertical dashed lines highlight irrigation date. Symbols (x) along abscissa of each graph indicate significant differences between MSL and Ambient soil (P<0.05), diamond-x indicates significant differences between MSL and both Ambient soil and MSNL, and plus (+) indicates significant differences between both MSL and PSL and that Ambient soil.

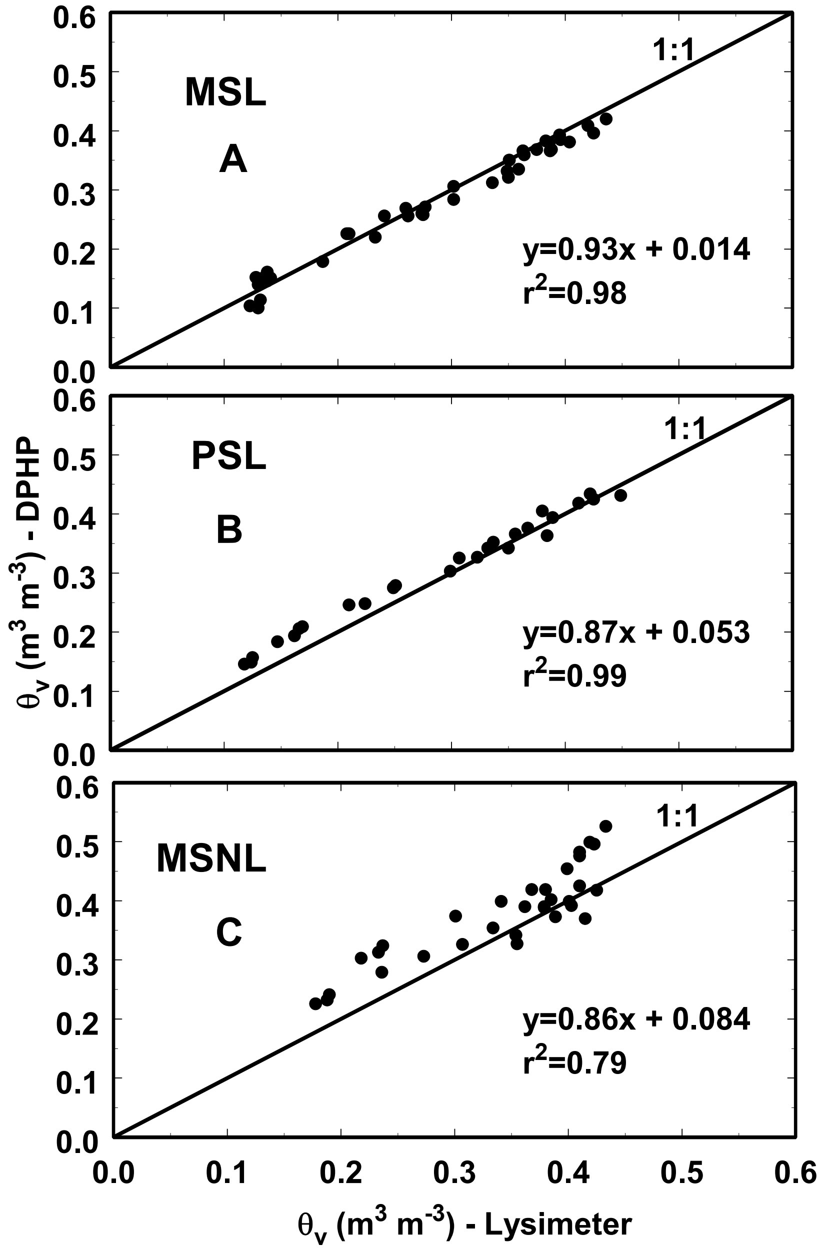


Figure 5. Comparison of volumetric water content ($\theta_v$) as determined by DPHP sensors and gravimetric (Lysimeter) methods for MSL (A), PSL (B), and MSNL (C) microlysimeters.

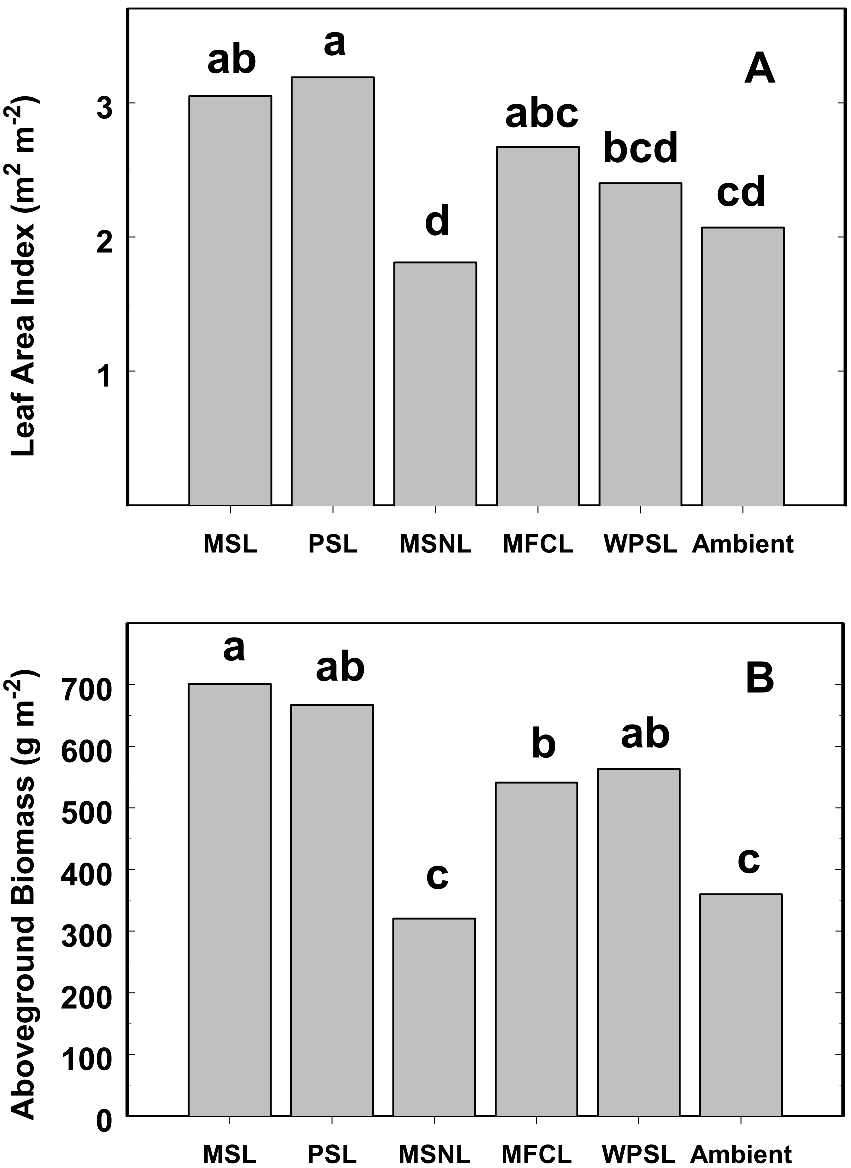


Figure 6. Green leaf area index (A) and aboveground biomass (B) in MSL, PSL, MSNL, MFCL, and WPSL microlysimeters and in the surrounding turfgrass.

**TITLE:** Effects of Deficit Irrigation on Photosynthesis, Respiration, and Water Use Efficiency of Zoysiagrass and Tall Fescue

**OBJECTIVES:** To evaluate the effects of deficit irrigation on photosynthesis, respiration, and water use efficiency of tall fescue and zoysia.

**PERSONNEL:** Jinmin Fu, Jack Fry, and Bingru Huang

**SPONSOR:** Turf Producers International

## INTRODUCTION:

Water availability for use in irrigating green spaces becomes limited when concerns over water shortages arise. Deficit irrigation, or application of water at levels less than potential evapotranspiration (ETo), can be used as one strategy to minimize water demand for turfgrasses. The influence of deficit irrigation on photosynthesis, respiration, and water use efficiency has not been reported. Photosynthesis and respiration may be affected differently by drought. Such responses could influence reserve carbohydrate levels. A negative whole-plant carbon balance could occur as a result of reduced photosynthetic capacity during drought, unless simultaneous and proportionate reductions in growth and carbon consumption take place.

Water use efficiency is an indicator of the amount of water lost through evapotranspiration relative to the amount of carbon fixed. Tall fescue and zoysia are widely used in the transition zone; however, little is known about the influence of deficit irrigation on their water use efficiency.

## MATERIALS AND METHODS:

The experiment was conducted using an automated, mobile rainout shelter (180 $m^2$) at the Rocky Ford Turfgrass Research Center at Manhattan, beginning 3 June. The study was set up as a split-plot design, with turfgrass species as the whole plots and irrigation levels as the sub-plots. ‘Meyer’ zoysia and ‘Falcon II’ tall fescue were sodded in spring 2000 in whole plots. Sub-plot irrigation levels were 20, 40, 60, 80, and 100% (well-watered) of ETo applied twice weekly. Total water applied to well-watered tall fescue for the entire season was 598 mm; 449 mm was applied to well-watered zoysia.

Turf was mowed twice weekly at 5-6 cm using a rotary mower. Nitrogen was applied at 1 lb N/1000$ft^2$ for tall fescue in May, September and November, and zoysia received an equivalent level of N in May and August.

Amounts of water to deliver respective deficit irrigation levels were determined by taking the fraction of turf ETo measured in well-watered lysimeters using the water balance method. Data were collected on photosynthesis, respiration, water use efficiency, and soil water content using standard methods.

**RESULTS:**

Canopy net photosynthesis (CNP).

Zoysia had higher CNP than tall fescue on nearly all evaluation dates at irrigation levels of 40% ETo or above. CNP of tall fescue irrigated at 20% or 40% ETo was lower than that of well-watered turf beginning 73 DAT. Zoysia irrigated at 20, 40 or 60% ETo had lower CNP than well-watered turf during most of the 2001 study period (Fig. 1). In 2002, zoysia irrigated at 20, 40 or 60% ETp had a lower CNP than well-watered turf during most of the study period.

Whole-plant respiration (WPR).

Irrigation at 20% and 40% ETo reduced tall fescue WPR compared to well-watered turf beginning at 44 DAT (Fig. 2). Zoysia WPR was reduced to below levels of well-watered turf at 60% ETo beginning at 44 DAT in 2001, and at 20 and 40% ETo beginning at 44 DAT in 2002 (Fig. 2).

Water use efficiency (WUE).

Zoysia had higher WUE than tall fescue, especially at irrigation levels >40% ETo (Fig. 3). Deficit irrigation had no effect on WUE of tall fescue during most of study period. Irrigation at 20% and 40% ETo reduced WUE for zoysiagrass during most of study period (Fig. 3).

Soil water content(SWC).

Compared to zoysia, tall fescue had higher soil water content at a given irrigation level on all measurement dates in both years. Soil water content was lower under tall fescue receiving 20% and 40% ETo than under well-watered turf beginning at 7 DAT in 2002 (Fig. 4). All deficit irrigation levels reduced SWC under zoysia during most of the study period.

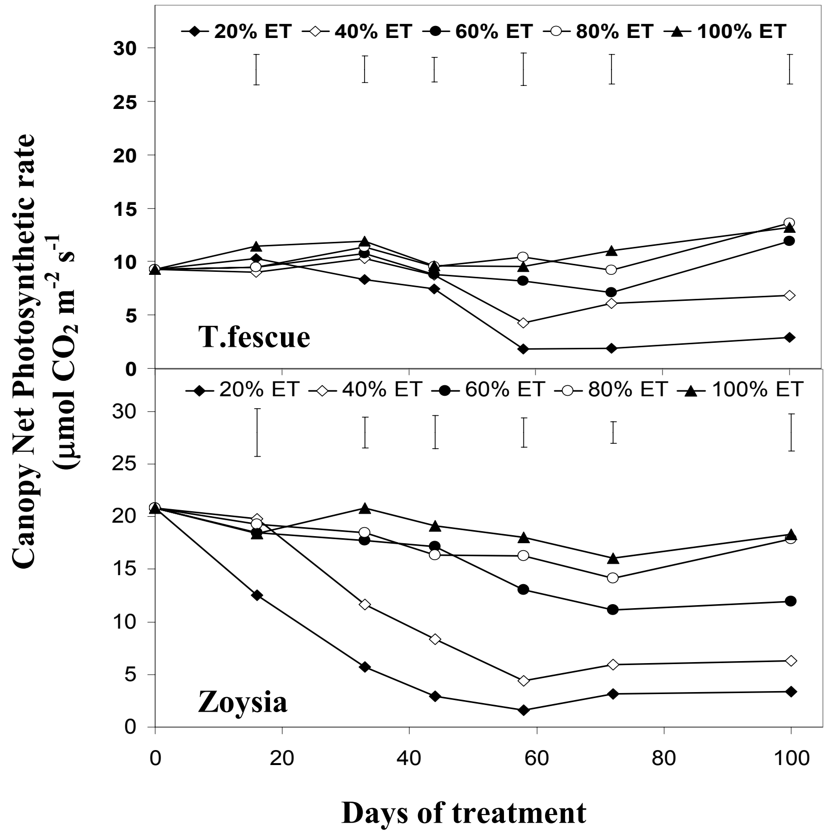


Figure 1. Canopy net photosynthesis of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P < 0.05$).

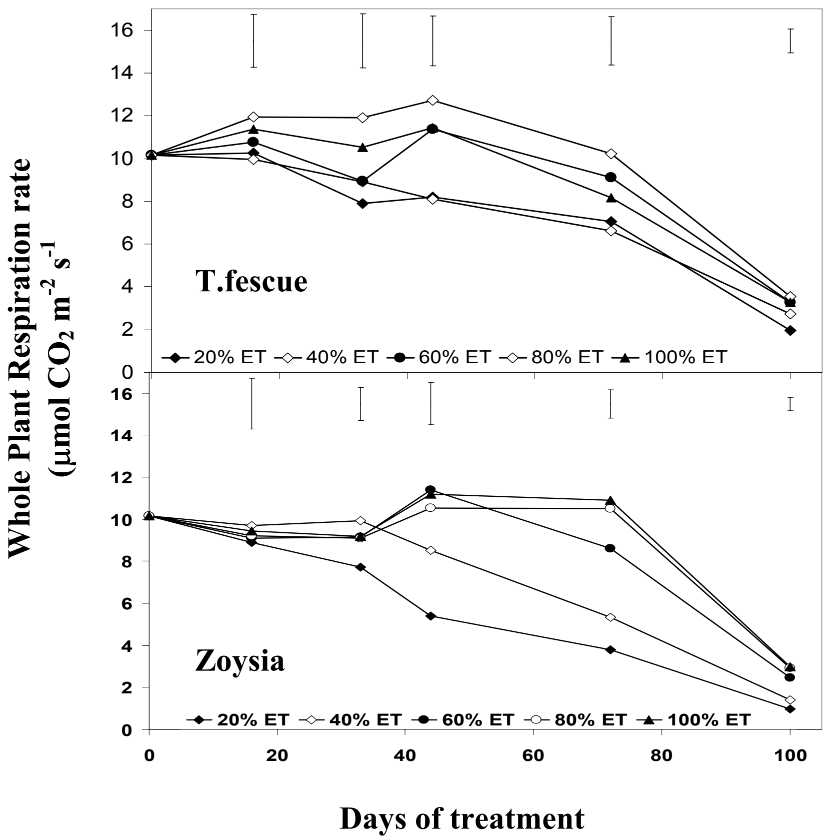


Figure 2. Whole plant respiration of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P < 0.05$).

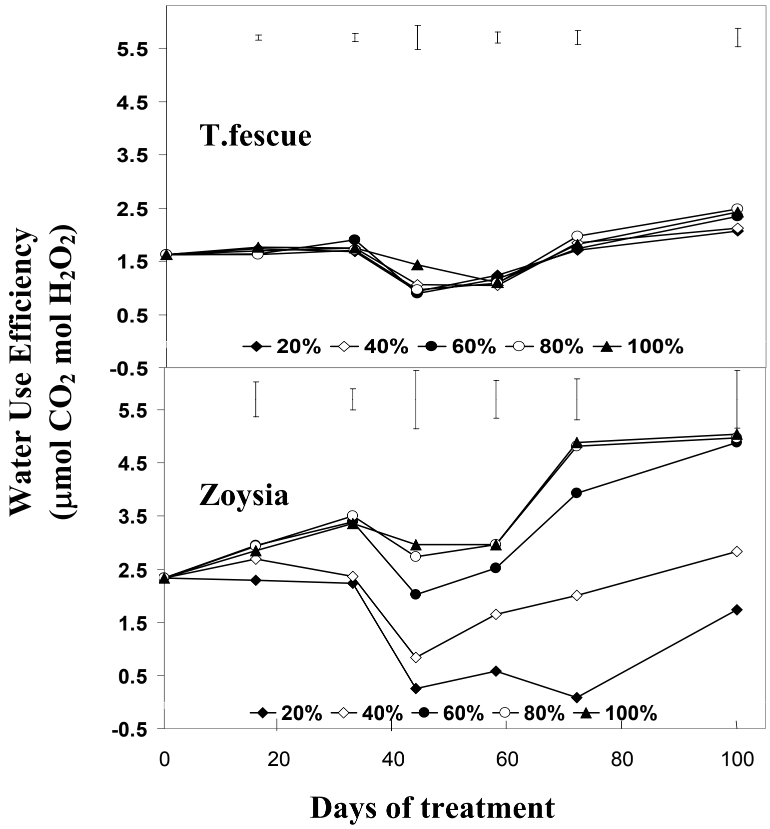


Figure 3. Water use efficiency of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P < 0.05$).

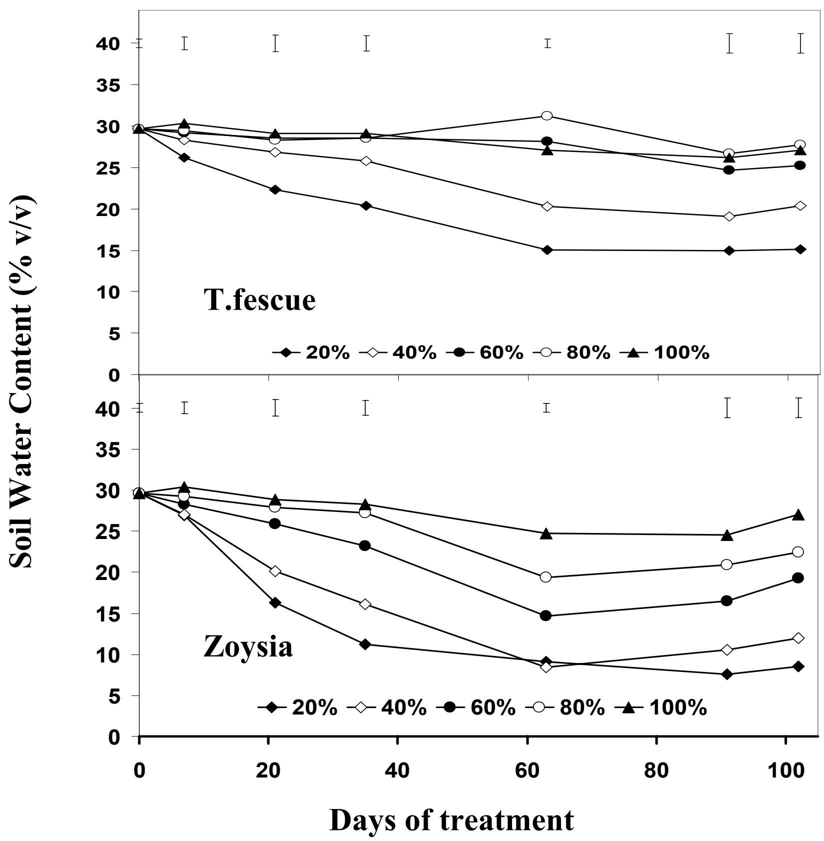


Figure 4. Soil water content of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values (P < 0.05).

**TITLE :** Osmotic Potential and Sucrose Metabolism in Response to Deficit Irrigation in Zoysiagrass and Tall Fescue

**OBJECTIVES:** To investigate the influence of irrigation management on sucrose accumulation, and the activity of sucrose phosphate synthase and sucrose synthase in zoysiagrass and tall fescue.

**PERSONNEL:** Jinmin Fu and Jack Fry

**SPONSOR:** Turf Producers International

## INTRODUCTION:

Zoysiagrass and tall fescue are considered as relatively drought resistant grasses. Drought tolerance mechanisms include internal physiological adjustments that allow the plant to survive. Osmotic adjustment is an important process facilitating water retention and turgor maintenance of leaves and roots. Sucrose is often associated with osmotic adjustment. Therefore, sucrose metabolism plays an important role in plant tolerance to drought stress. Sucrose is the main carbohydrate transported in plants. Sucrose phosphate synthase (SPS) and sucrose synthase (SS) play key roles in sucrose formation. Knowledge of the response of sucrose formation and enzyme mechanisms will help understand drought tolerance mechanisms of zoysiagrass and tall fescue.

## MATERIAL AND METHODS:

Sod pieces of 'Meyer' zoysiagrass and 'Falcon II' tall fescue were collected from 2-year-old plots at the Rocky Ford Turfgrass Research Center, Manhattan, KS. Grasses were transplanted into polyvinychloride tubes with a mixture of 10% profile and 90% sand and placed in growth chambers. The irrigation evaluation period ran for 29 days. Irrigation levels were 100% ETo (well-watered turf), 60% ETo (mild drought) and 20% ETo (serious drought); irrigation was applied every three days. Total water applied to turf receiving 100% ETo during the study period was 450 mm for tall fescue and 224 mm for zoysia. Osmotic potential, sucrose content, and activities of SPS and SS were measured during deficit irrigation using standard methods.

## RESULTS:

Zoysia had a higher osmotic potential than tall fescue on nearly all evaluation dates and at all irrigation levels. Beginning at 12 days of treatment (DAT), zoysia osmotic potential was lower than that of well-watered turf when irrigated at 20% ETo (Fig. 1). Irrigation at 60% ETo had no effects on osmotic potential of zoysia. Osmotic potential of tall fescue irrigated at 20% and 60% was similar as that of well-watered turf until 6 DAT.

Irrigation at 60% ETo increased sucrose content of zoysia at 8 and 14 DAT (Fig. 2). Irrigation at 20% ETo increased sucrose content at 14 DAT, but reduced it by the end of the experiment. Deficit irrigation had no effect on sucrose content in zoysia or tall fescue on other dates.

Zoysia irrigated at 20% and 60% ETo had higher SPS activity than well-watered turf, beginning at 14 and 23 DAT (Fig. 3), respectively. Tall fescue had higher SPS activity than well-watered turf beginning at 14 DAT.

Zoysia and tall fescue receiving 20% and 60% ETo had a significantly higher SS activity than that receiving 100% ETo (Fig. 4), beginning at 14 DAT.

In summary, the increase in activity of SPS and SS play an important role in sucrose metabolism. The enhancement in sucrose content may adjust osmotic potential and help zoysia and tall fescue tolerate deficit irrigation.

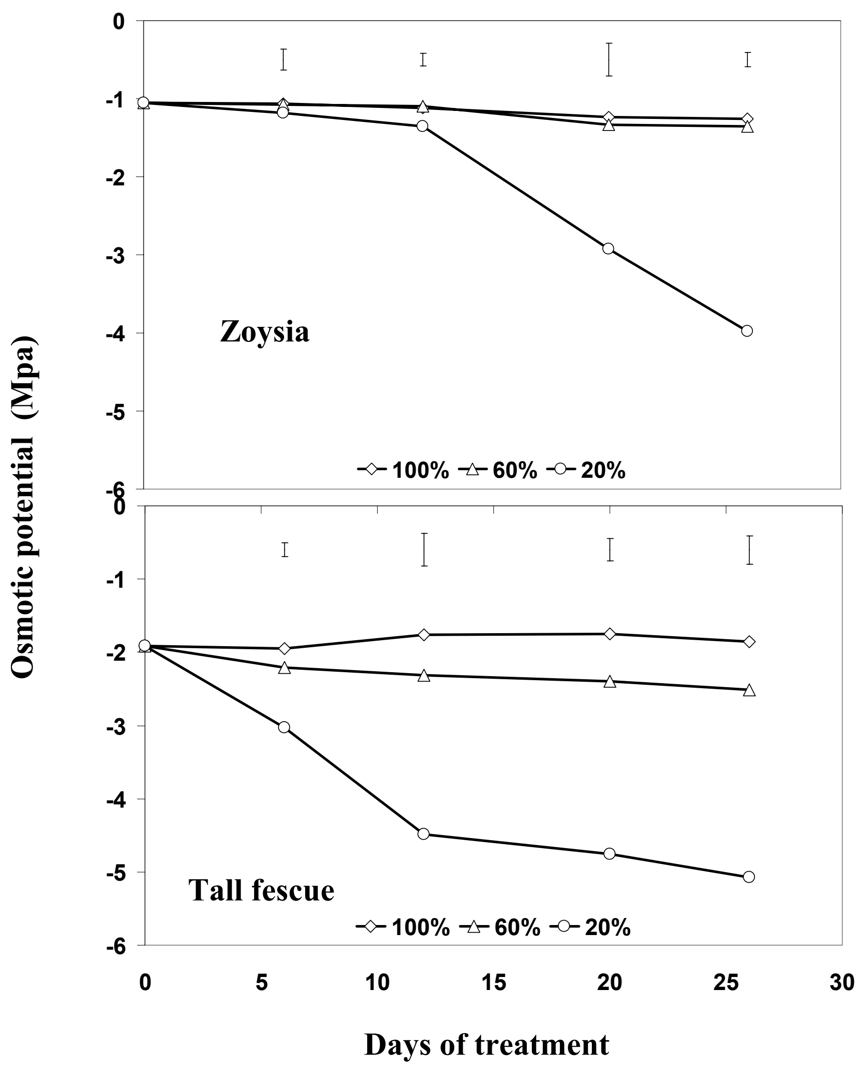


Figure 1. Osmotic potential of tall fescue in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day.

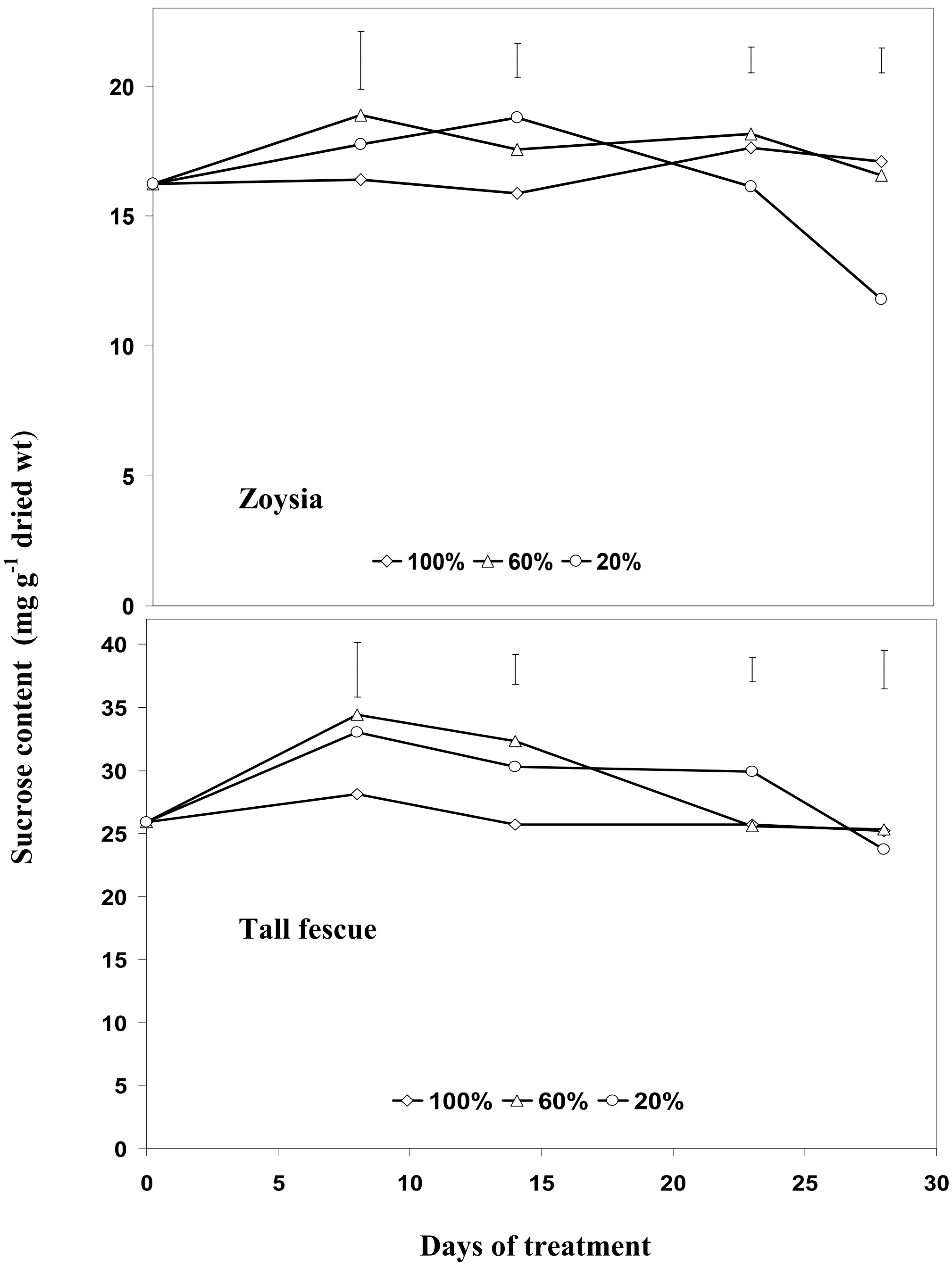


Figure 2. Sucrose content of tall fescue in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day.

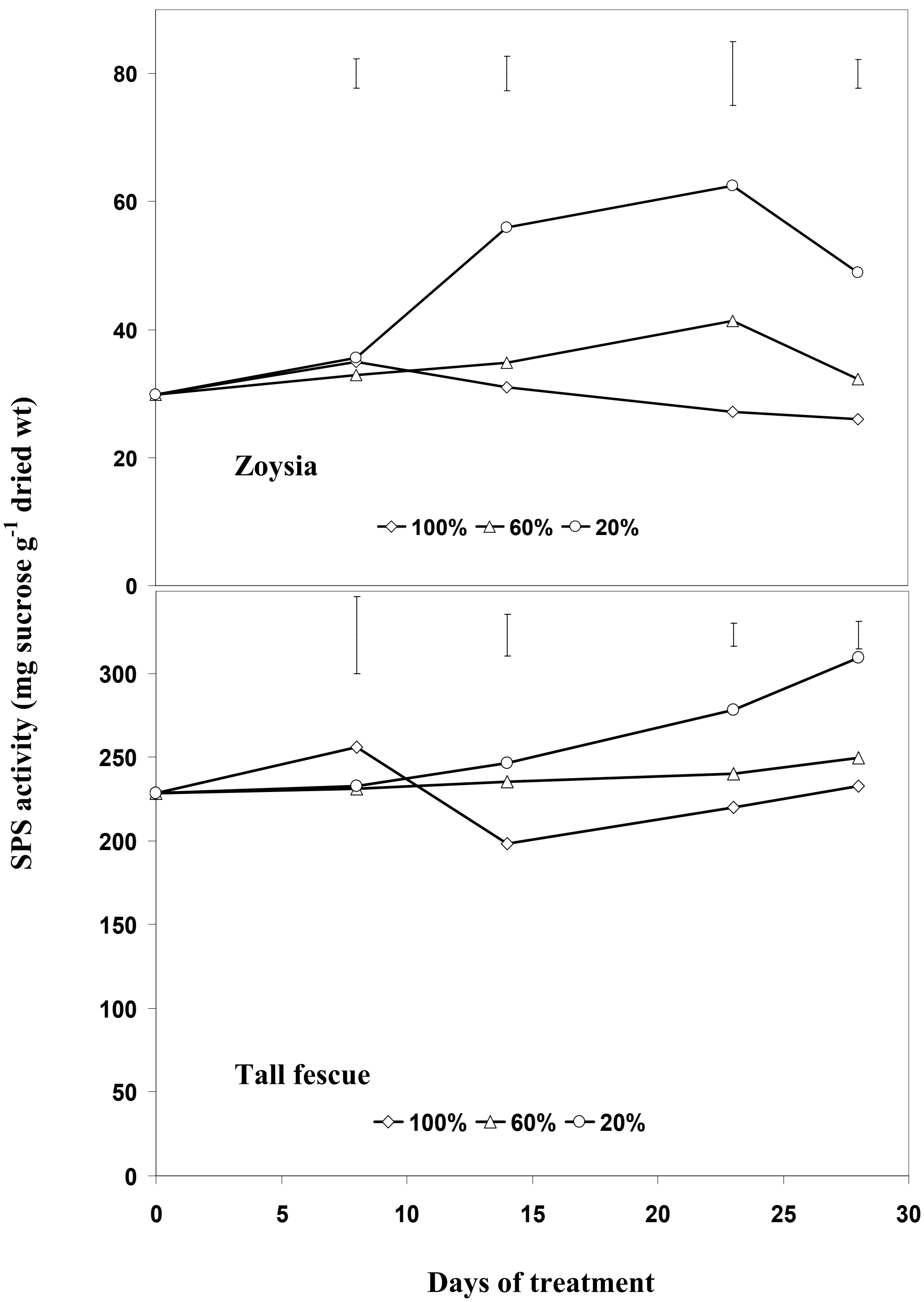


Figure 3. SPS activity of tall fescue in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day.

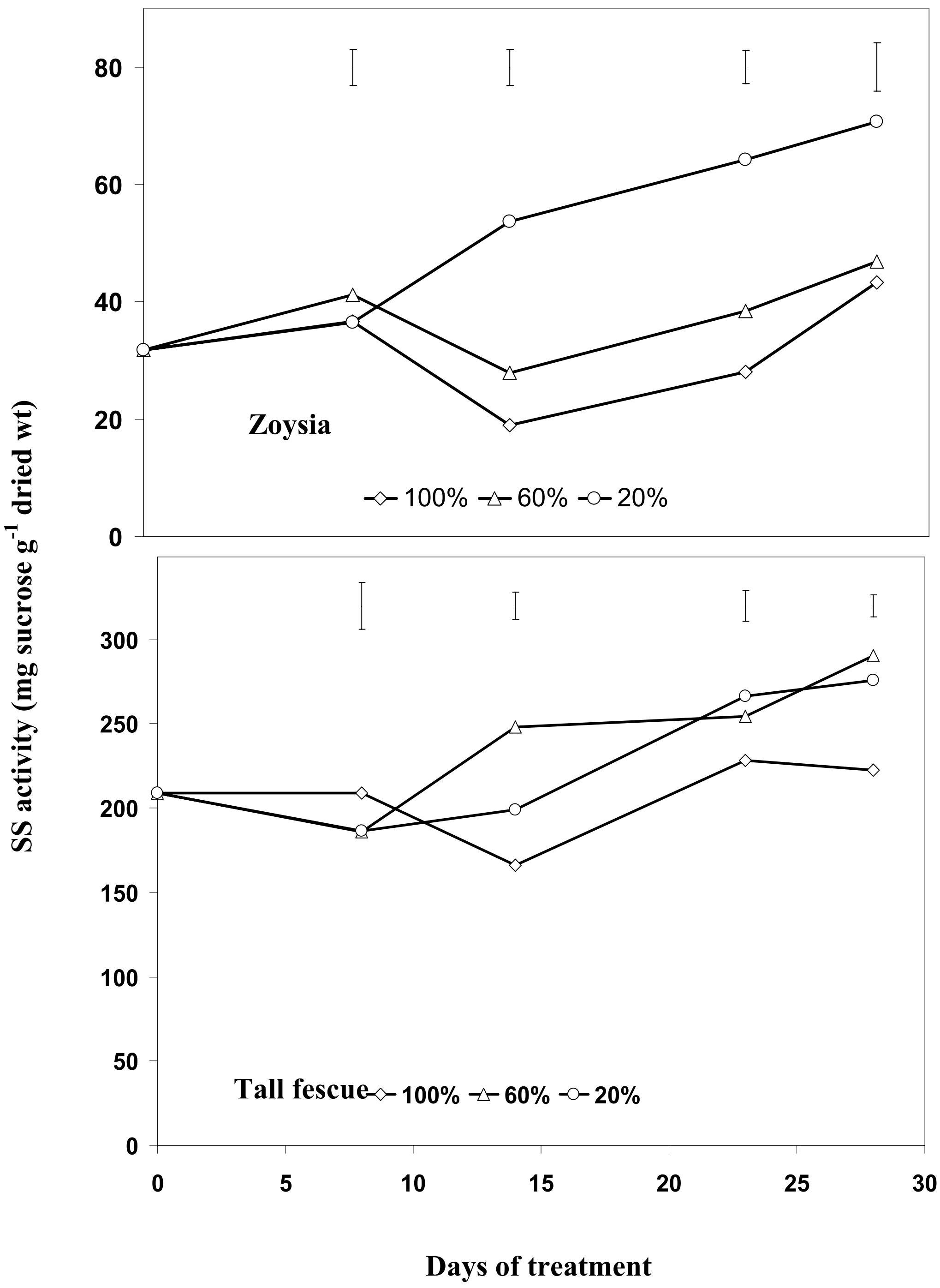


Fig. 4. SS activity of tall fescue in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day.

**TITLE:** Seasonal Changes in Root Growth of Tall Fescue under Deficit Irrigation

**OBJECTIVES:** To investigate seasonal changes in root growth, using the minirhizotron imaging technique, of tall fescue that was exposed to deficit irrigation during summer months

**PERSONNEL:** Jinmin Fu, Jack Fry and Bingru Huang

**SPONSOR:** Turf Producers International

**INTRODUCTION:**

Soil water deficits are common in the field in the transition zone and cool climatic areas. An extensive and deep root system can help to encourage plant survival during periods of drought stress. However, roots have been investigated much less than the aboveground parts of plants because soil limits accessibility for observation. The minirhizotron imaging technique allows nondestructive monitoring of root growth and production. Its greatest advantage is that it provides greater information on the dynamic changes and demographics of roots.

In recent years, there has been increasing interest in deficit irrigation, returning water in amounts less than potential evapotranspiration (ETo), as a water conservation technique. The influence of deficit irrigation on root growth has not been reported using the minirhizotron imaging technique. The objective of this study was to use the minirhizotron imaging technique to investigate seasonal changes in root growth of tall fescue that was exposed to deficit irrigation during summer months.

**MATERIALS AND METHODS:**

This experiment was conducted using an automated, mobile rainout shelter (180 $m^2$) at the Rocky Ford Turfgrass Research Center at Manhattan from 3 June to 13 September, 2002. 'Falcon II' tall fescue was established by sodding in spring 2000. Treatments consisted of irrigation levels of 20, 60, and 100% of ETo applied twice weekly through a metered, hand-held hose. Potential evapotranspiration was determined using well-watered lysimeters situated in each 100% ETo plot. Total water applied to 100% ETo turf was 598 mm. Turf was mowed twice weekly at 5-6 cm. Nitrogen was applied at 1 lb/1000 $ft^2$ on 3 May, 18 September and 15 November in 2002.

Two minirhizotron (clear butyrate) tubes (90 cm long and 5 cm in diameter) were installed at a $45^o$ angle from the soil surface in each plot for root observation. On the upper side of each tube etched frames (1.3 by 1.8 cm) extended along the length of the tube, allowing the camera to return to exact locations in all tubes. Video images of roots visible against the surface of the tube were recorded. The majority of roots for tall fescue were found in the upper 13 - 39 cm of soil; therefore, image frames at 26 to 27.3 cm of soil were captured as BMP files onto a PC and analyzed using an image analysis program. The length, surface area, diameter, and number of roots on each image were traced and measured manually.

**RESULTS:**

Tall fescue irrigated at 20% ETo had higher root numbers than those receiving 100% ETo, beginning at 29 DAT (Fig. 1), and also resulted in more roots than turf receiving 60% ETo during most of experimental period. Irrigation at 60% ETo had no effect on root number.

Compared to well-watered and 60% ETo irrigated plants, 20% ETo increased root length, beginning at 29 DAT. However, no differences in root length were observed between 20% ETo and 60% ETo (Fig. 2). Irrigation at 60% ETo had no effect on root length.

Tall fescue receiving 20% ETo had higher root surface area than well-watered turf at 29, 43, and 99 DAT (Fig. 3). However, no difference in root surface area was observed between 60% and 100% ETo. Root surface area at the three irrigation levels declined over the study period.

No differences in root diameter were observed among irrigation levels (Fig. 4). However, root diameter declined in all irrigation treatments over the study period.

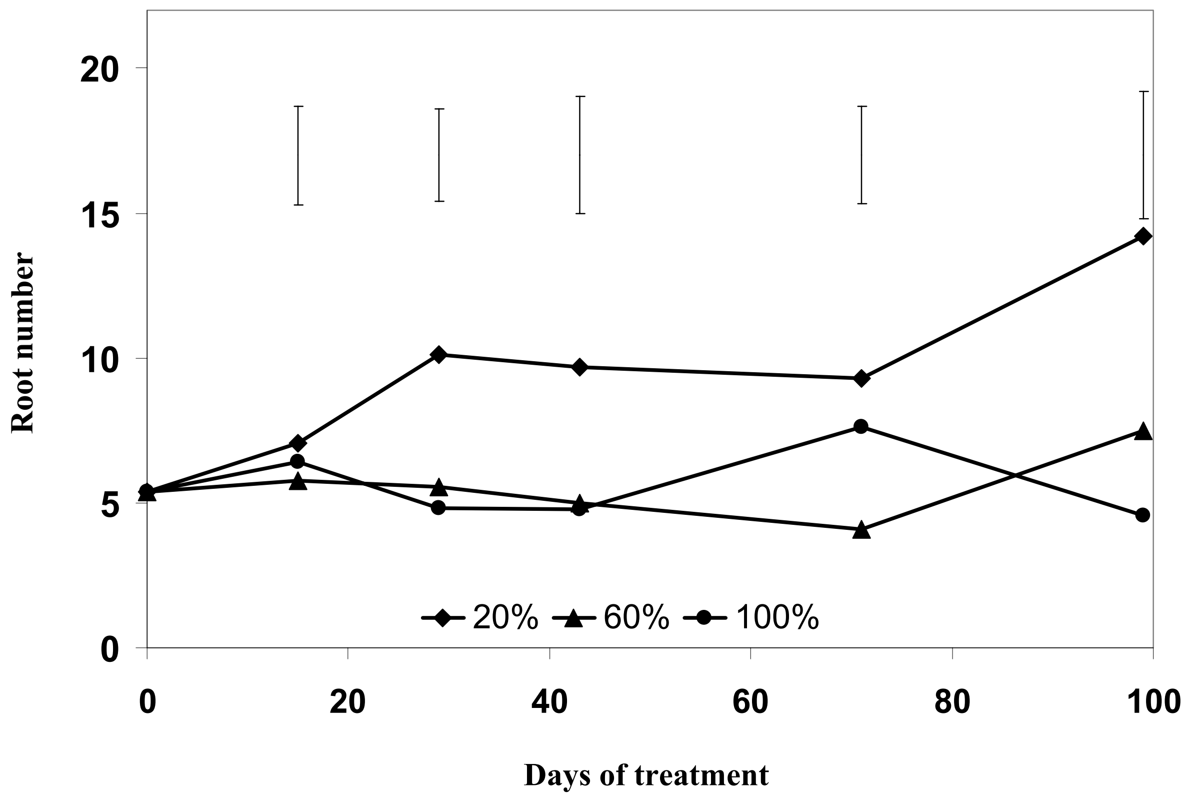


Figure 1. Root number of tall fescue at a 26-cm depth in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day. Day 0 is 3 June and day 100 is 11 Sept.

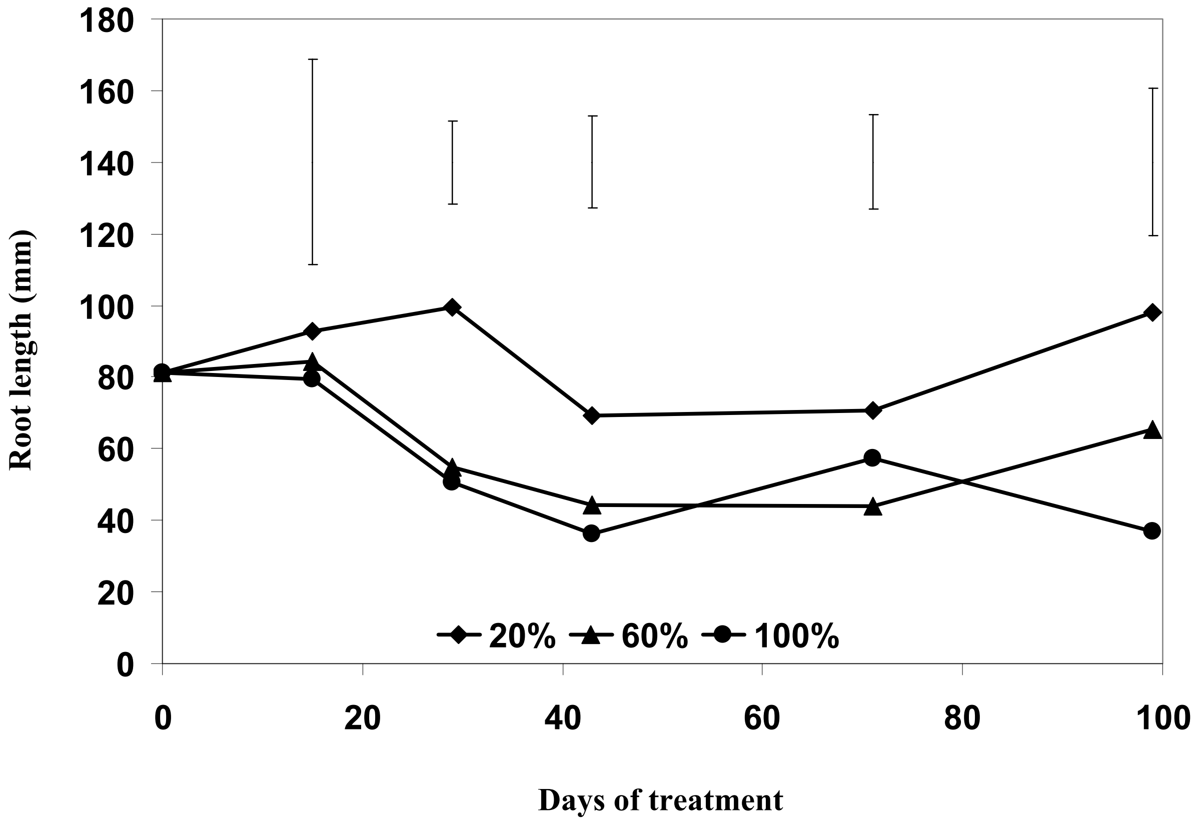


Figure 2. Root length of tall fescue at a 26-cm depth in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day. Day 0 is 3 June and Day 100 is 11 September.

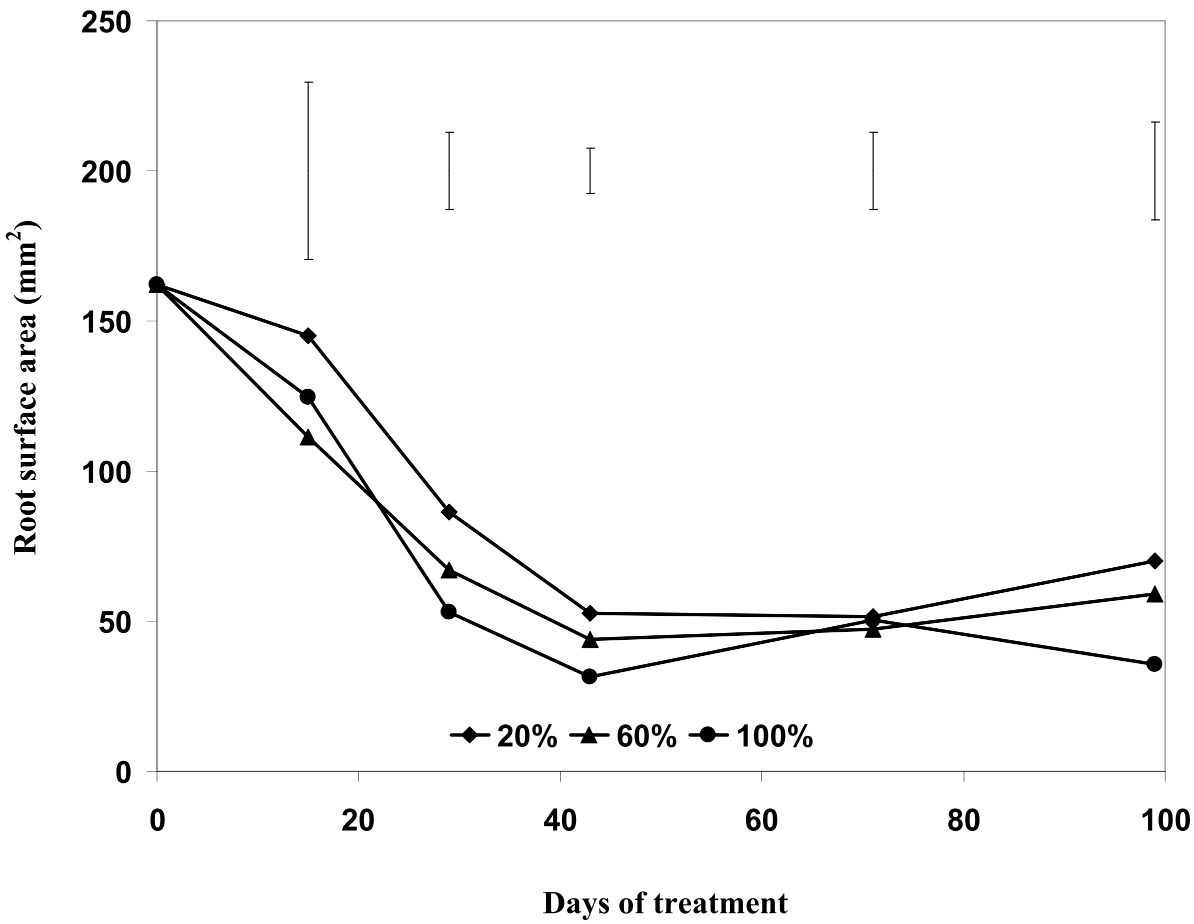


Figure 3. Root surface area of tall fescue at a 26-cm depth in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day. Day 0 is 3 June and Day 100 is 11 September.

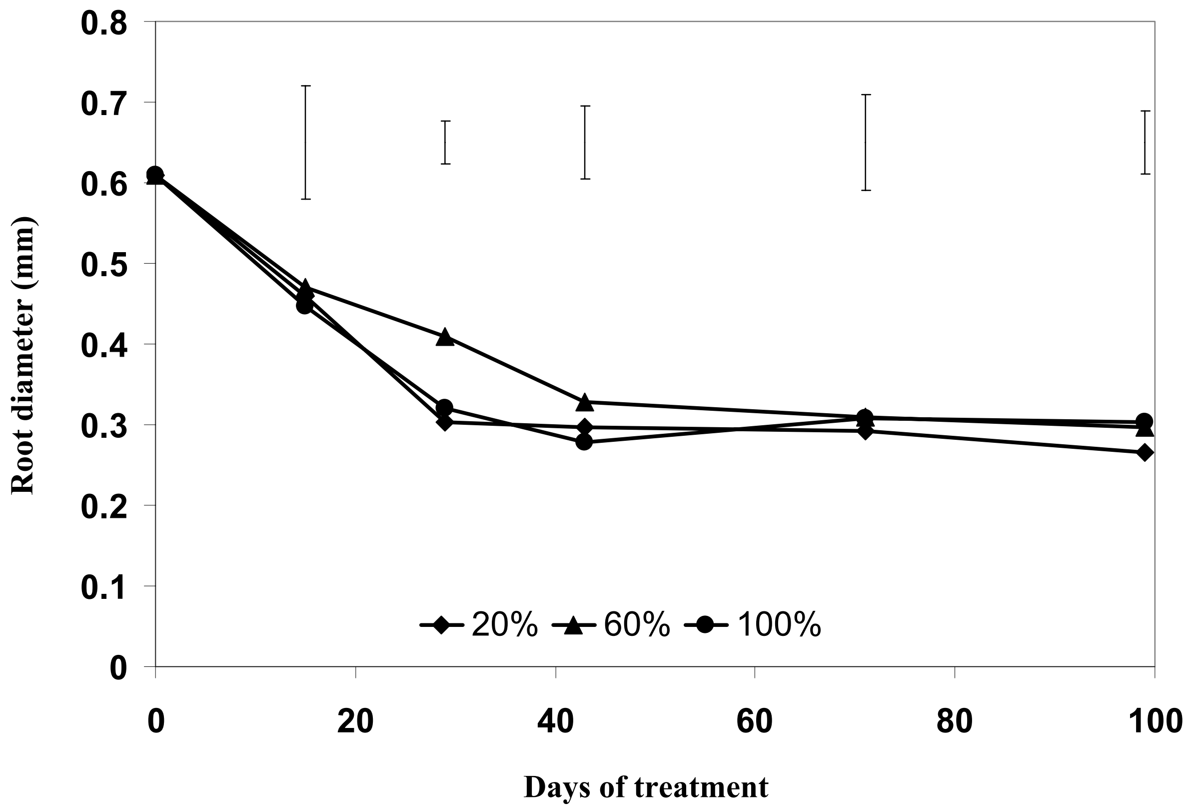


Figure 4. Root diameter of tall fescue at a 26-cm depth in response to deficit irrigation. Vertical bars on the top of the figure are LSD values (P=0.05) for treatment comparison at a given day. Day 0 is 3 June and Day 100 is 11 September.

**TITLE:** Effects of Deficit Irrigation on Performance and Canopy Characteristics of Zoysiagrass and Tall Fescue

**OBJECTIVE:** To evaluate effects of deficit irrigation on drought-related turfgrass stress canopy characteristics

**PERSONNEL:** Jinmin Fu, Jack Fry, and Bingru Huang

**SPONSOR:** Turf Producers International

**INTRODUCTION:**

Turfgrass water use rates often exceed natural precipitation and during extended periods without rainfall, restrictions may be imposed limiting water that can be applied to turf areas. In recent years, there has been increasing interest in deficit irrigation, returning water in amounts less than potential evapotranspiration (ETo), as a water conservation technique. However, the amount of water required to maintain acceptable quality of various turfgrass species throughout the growing season in the transition zone has not been well defined. More information is needed to determine deficit irrigation effects on plant stress indicators. For example, leaf relative water content, an indicator of leaf water status, decreases as drought stress progresses. Drought stress also increases leakage of ions and electrolytes; the degree of leakage can be measured. Leaf area index and the amount of green turf cover are also reduced during drought stress, and can be measured using a multispectral radiometer. No work has been done to determine how deficit irrigation influences plant stress as measured by one or more of the aforementioned techniques. The objective of this study was to evaluate effects of deficit irrigation on drought-related turfgrass stress canopy characteristics.

**MATERIALS AND METHODS:**

This experiment was conducted using an automated, mobile rainout shelter (180 $m^2$) at the Rocky Ford Turfgrass Research Center at Manhattan, KS from 3 June to 13 September, 2002. The experimental design was a split-plot, with turfgrass species as the whole plot and irrigation level as the sub-plots. Whole plots consisted of 'Meyer' zoysiagrass, 'Midlawn' bermudagrass 'Falcon II' tall fescue, and 'Brilliant' Kentucky bluegrass. Sub-plots consisted of irrigation levels of 20, 40, 60, 80, and 100% of ETo.

Water was applied twice weekly using a metered, hand-held hose with a fan spray nozzle attached. Deficit irrigation amounts were determined by taking the fraction of water use of lysimeter-grown turf receiving 100% ETo. Total water applied to turf receiving 100% ETo during the study period was 598 mm for tall fescue, 449 mm for zoysia, 364 mm for Kentucky bluegrass and 412 mm for bermuda.

Turf was mowed twice weekly at 2.4 inches. Nitrogen was applied at 1 lb N/1000 $ft^2$ to tall fescue and Kentucky bluegrass 3 May, 18 September and 15 November. Zoysia and bermudagrass received an equivalent level of N on 3 May and 5 August in 2002. Severe decline of Kentucky bluegrass in 2002 precluded collection of data.

**RESULTS:**

Kentucky bluegrass is included in the figures, but results are not reported here due to the severe decline in quality resulting in part from high temperature stress.

Visual quality.

All irrigation levels had turf of unacceptable quality throughout the study period (Fig. 2). Tall fescue experienced a reduction in quality compared to well-watered turf beginning at 38 DAT at 20% and 40% ETo and at 81 DAT at 60% ETo (Fig. 2). At 80% ETo, tall fescue quality was similar to well-watered turf throughout the summer. Bermudagrass receiving 20% or 40% ETo had lower quality than that of well-watered turf beginning 38 DAT (Fig. 2). Irrigation at 60% ETo led to a decline in zoysia quality relative to well-watered turf beginning at 23 DAT.

Leaf relative water content (LRWC).

Tall fescue irrigated at 20% and 40% ETo had lower LRWC compared to well-watered turf starting at 36 DAT (Fig. 2). Bermudagrass irrigated at 20 and 40% ETo exhibited a similar decline beginning at 36 DAT (Fig. 2). LRWC of zoysia receiving 20, 40, and 60% ETo was reduced relative to well-watered turf at 22, 36, and 36 DAT, respectively (Fig. 2).

Electrolyte leakage.

Irrigation at 20% and 40% ETo increased the EL of tall fescue, beginning at 37 DAT (Fig. 3). Tall fescue at 60% ETo had significantly higher EL than well-watered turf at 37 and 64 DAT. Irrigation at 20% ETo resulted in higher EL of Bermuda at 23 and 37 DAT . Irrigation at < 80% ETo resulted in higher EL levels than observed in well-watered zoysiagrass, beginning at 23 DAT for 60 % ETo or below and at 37 DAT for 80% ETo.

Canopy Characteristics.

Tall fescue irrigated at 20% and 40% ETo had lower LRWC compared to well-watered turf starting at 24 DAT (Fig. 4, and Fig. 5). Bermudagrass irrigated at 20% and 40% ETo exhibited a similar decline beginning at 24 DAT. The ND and IR/R ratio of zoysia receiving 20 and 40% ETo was reduced relative to well-watered turf at 24 DAT. 60% ETo reduced the ND and IR/R ratio of zoysia, beginning at 51 and 38 DAT, respectively.

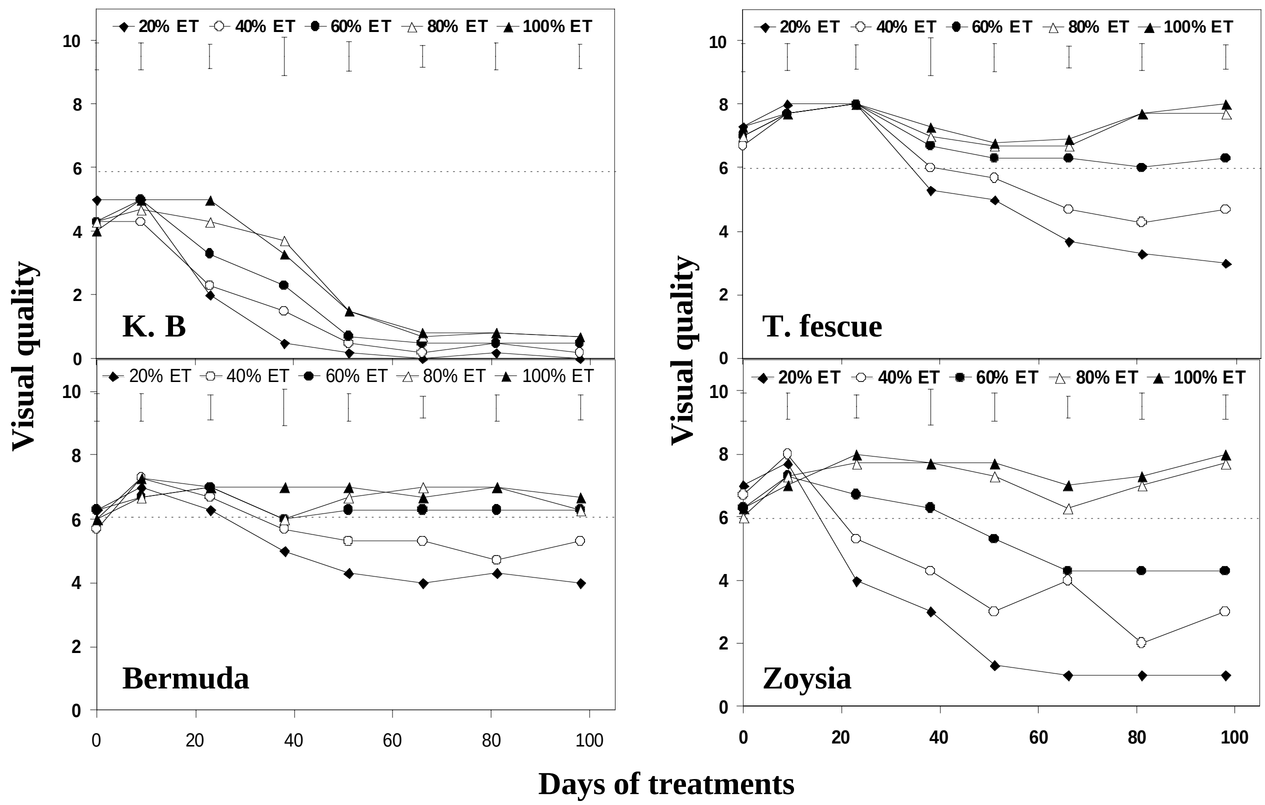


Figure 1. Visual quality of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 Sept. Vertical bars represent LSD values ($P < 0.05$).

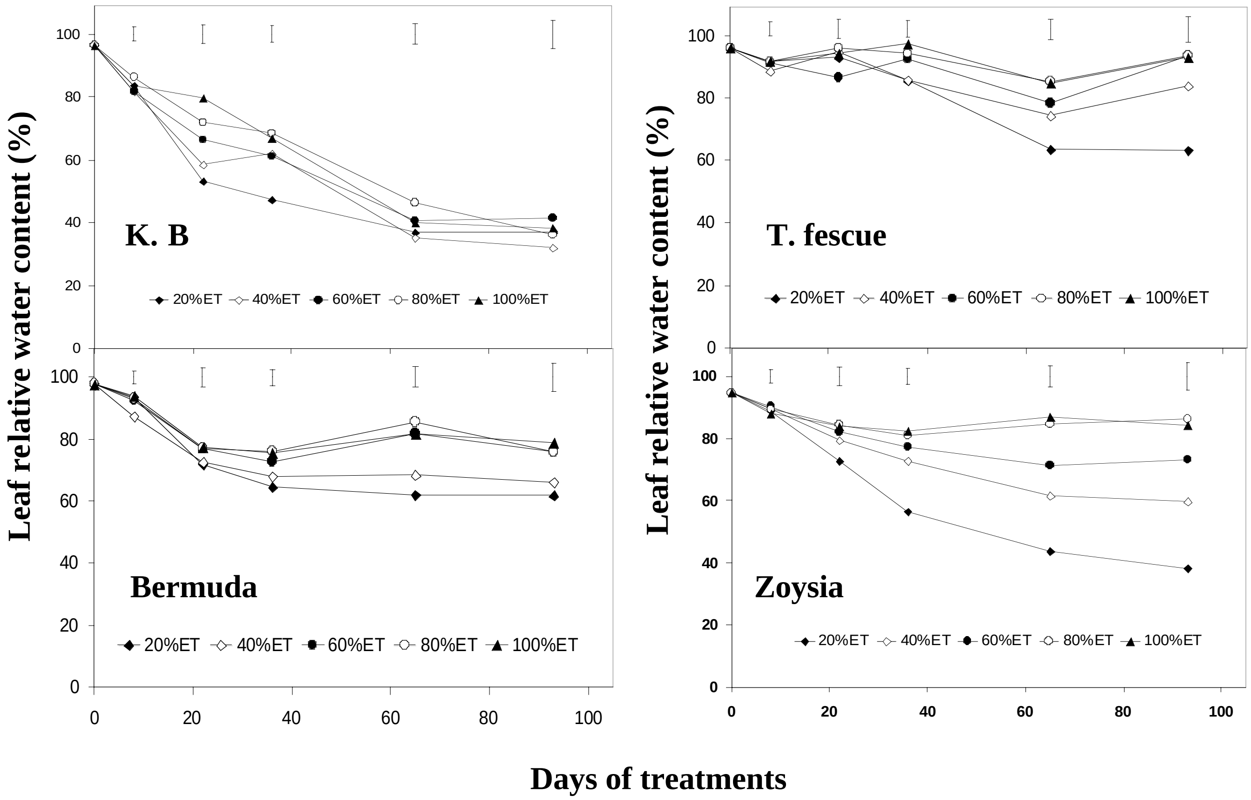


Figure 2. Leaf relative water content of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P < 0.05$).

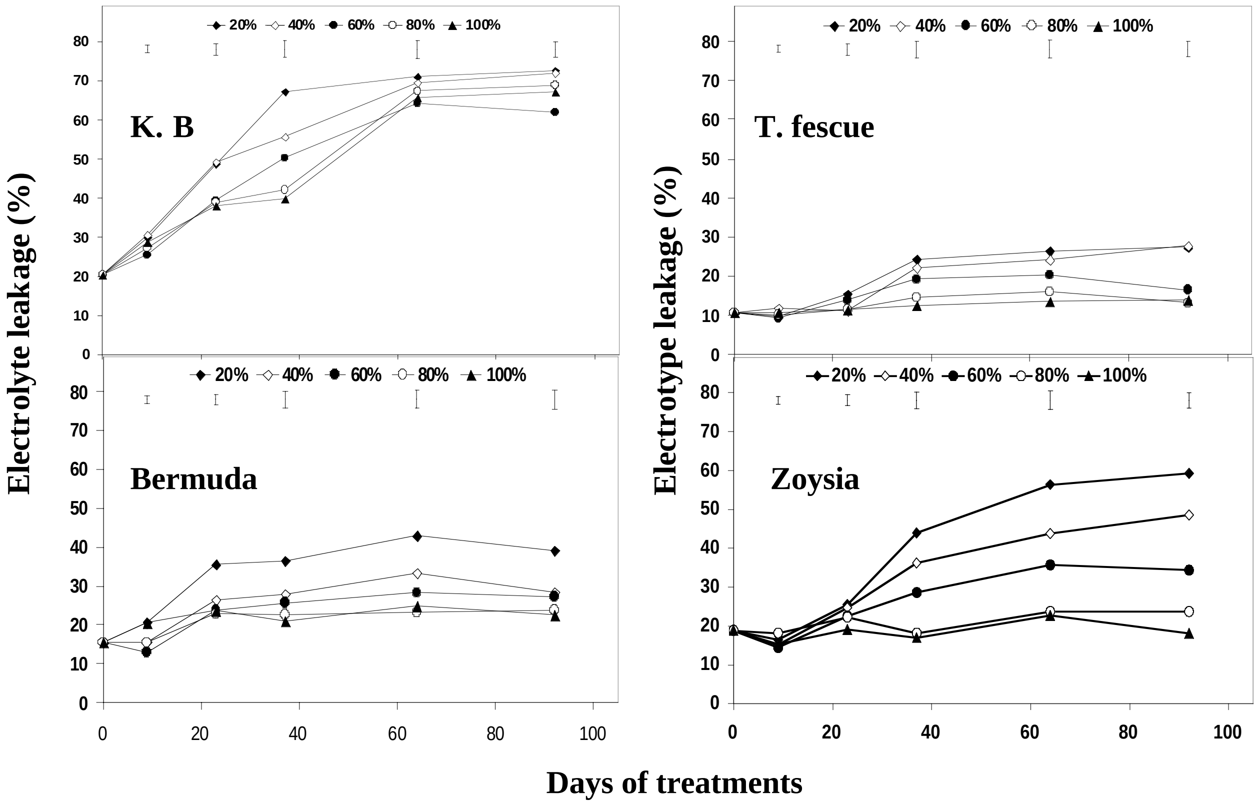


Figure 3. Electrolyte leakage of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P < 0.05$).

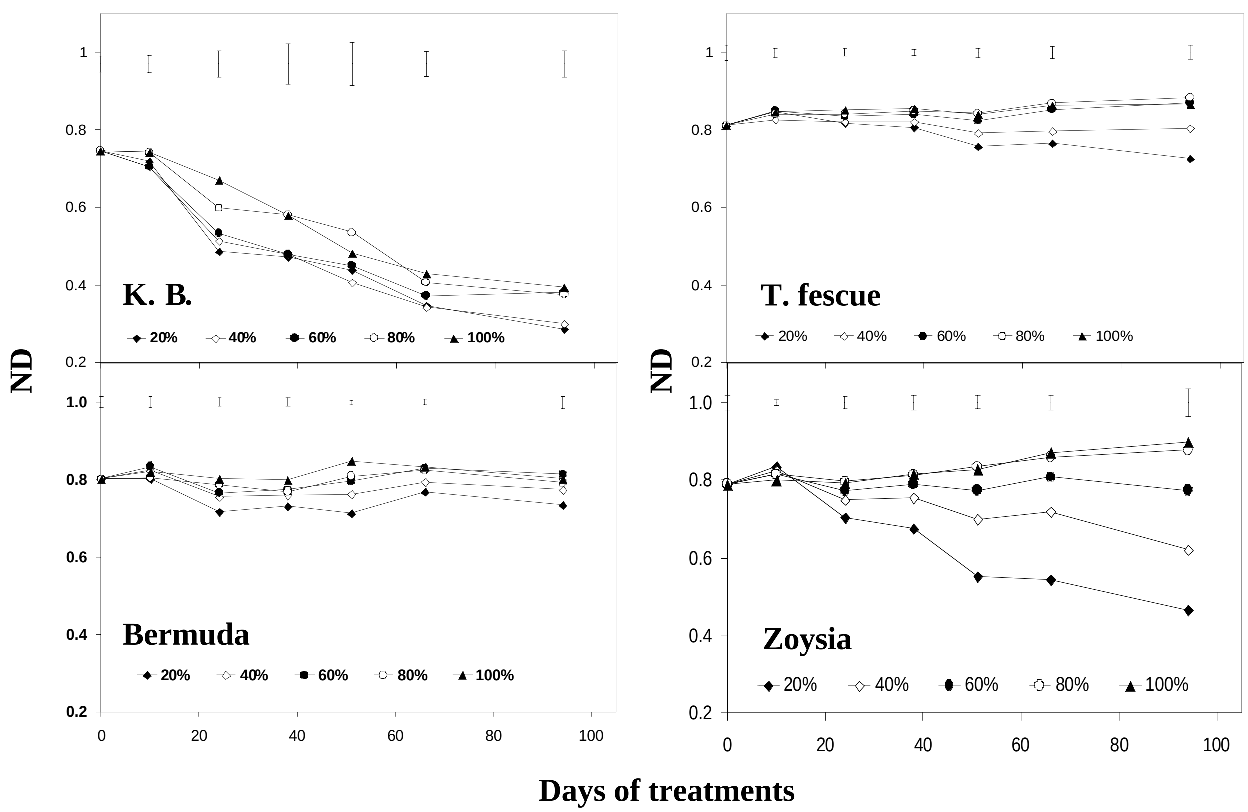


Figure 4. The normalized difference vegetation index of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P$ < 0.05).

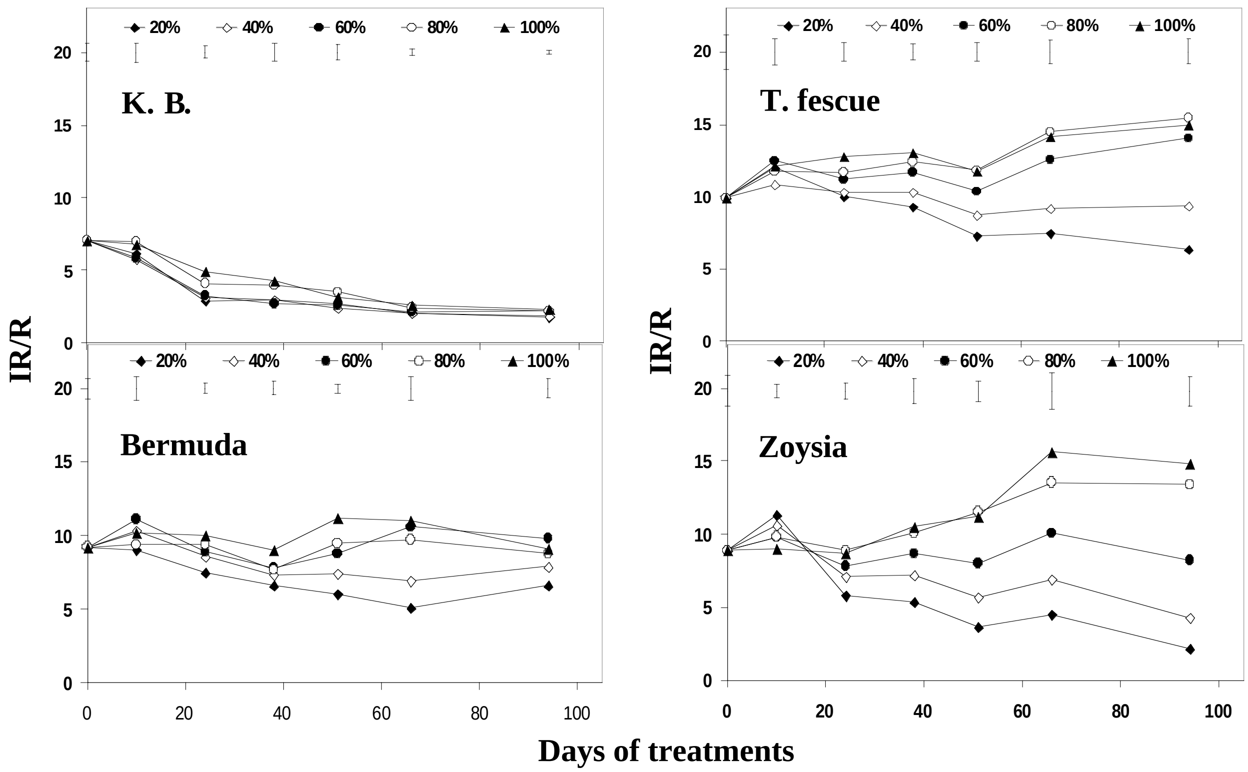


Figure 5. The IR/R ratio of tall fescue and zoysia in response to deficit irrigation. Day 0 is 3 June and day 100 is 11 September. Vertical bars represent LSD values ($P < 0.05$).

**TITLE:** Gradual Conversion of Perennial Ryegrass Fairways to Kentucky Bluegrass

**PURPOSE:** Evaluate strategies for their effectiveness in converting established perennial ryegrass fairway turf to Kentucky bluegrass.

**PERSONNEL:** Steve Keeley, Robb Kraft, and Kemin Su

**LOCATION:** Rocky Ford Turfgrass Research Center, Manhattan, Kansas

**MATERIALS AND METHODS:**

Perennial ryegrass is used for golf course fairways and tees throughout cool regions of the United States. However, the cost of maintaining perennial ryegrass in the transition zone, in particular, has become uneconomical for many golf courses. Multiple fungicide applications through the summer months are usually required to prevent outbreaks of brown patch and pythium blight. In recent years, fear of gray leaf spot epidemics has led superintendents to make preventive late-summer and early-fall fungicide applications. It is not unusual for courses to spend over $20,000 annually on fungicide applications to ryegrass fairways and tees.

Research at K-State over the past few years has shown that there are alternatives to ryegrass. Data collected from the Kentucky bluegrass cultivar trial, sponsored by the National Turfgrass Evaluation Program, has shown that there is great diversity among cultivars in performance at close mowing heights. As a result, we have clearly identified a few top performing varieties that seem to be well suited for fairway conditions in our climate, including 'America', 'Apollo', 'Brilliant', 'Showcase', and 'Unique'.

Conversion to Kentucky bluegrass would be most easily accomplished by closing the golf course for up to one year to allow grow-in on ryegrass fairways previously treated with glyphosate. However, the potential revenue losses and golfer dissatisfaction resulting from such an extended closure dictates that superintendents consider establishing Kentucky bluegrass into existing ryegrass stands. The logistics for accomplishing this conversion have not been determined and are the focus of this project.

This research was conducted from 1999-2002 in an established perennial ryegrass turf maintained under fairway conditions at Rocky Ford Turfgrass Research Center.

**Study I**

Primo application (1.5 qts./A), Roundup application (3 qts./A), scalping (once, at 0.25 in.) and core-aeration were evaluated, alone and in combination, for their effects on Kentucky bluegrass establishment in an existing perennial ryegrass stand. All treatments were applied prior to seeding. Treatments were as follows:

1) Primo
2) scalping
3) core-aeration
4) Primo + scalping
5) Primo + core-aeration
6) scalping + core-aeration
7) Primo + scalping + core-aeration
8) Roundup
9) untreated (control)

The study was established in mid-September 1999. Individual plots measured 4 by 8 feet and were arranged in a randomized complete block design with three replications. Prior to seeding, the entire area was verticut to encourage seed to soil contact. Kentucky bluegrass (cv. Unique) was seeded at 2 lbs PLS/1000 $ft^2$. The seedbed was kept moist until Kentucky bluegrass seedlings were well-established. Normal mowing was continued in order to simulate a fairway in play.

In 2000, the study area was mowed three times weekly at 9/16 inch. Irrigation was applied as needed to prevent dormancy. No fungicides were applied. Percent Kentucky bluegrass was evaluated in the spring and fall using a grid method that uses plant species counts at grid intersections to determine coverage.

**Study II**

Based on results from Study I, this study was established to investigate more aggressive approaches to conversion. The experiment was established in mid-September 2000, as a strip-split-plot design. Whole plots were pre-seeding plant growth regulator treatment (None or Embark at 2.5 qts/a). Sub-plots were Kentucky bluegrass (cv. Unique) seeding rate and timing (2 or 4 lbs PLS/1000 $ft^2$, and fall-only or fall+spring. Check plots were treated with Roundup (3 qts/a) to kill all existing vegetation and then seeded at either 2 or 4 lbs PLS/1000 $ft^2$. Prior to seeding, the entire study area was core-aerated and vertical mowed to enhance seed to soil contact.

After seeding, a scalping treatment was imposed in strips across the whole plots. The treatment consisted of scalping twice weekly at 0.25 inch until Kentucky bluegrass seedlings grew above 0.25 inch.

The seedbed was kept moist until Kentucky bluegrass seedlings were well-established. The study was maintained like a typical fairway. Percent Kentucky bluegrass was evaluated in March 2001 (before the spring seeding treatments were applied) and July 2002. We used a grid method that uses plant species counts at grid intersections for these measurements. Visual quality during the post-seeding scalping treatment, and through the growing season, was evaluated using a 1-9 scale.

**RESULTS:**

**Study I**

The pre-seeding Roundup treatment was the only treatment that resulted in significant establishment of Kentucky bluegrass one year after establishment. At that time, the Roundup-treated plots consisted of greater than 98% Kentucky bluegrass. No other treatment or treatment combination resulted in greater than 3.6% Kentucky bluegrass, and a statistical analysis showed that only the Roundup treatment was significantly different from the untreated check. The results of this study showed us that, where Roundup is not used, a more aggressive approach is needed.

**Study II**

Scalping ryegrass during the 4 weeks following seeding was the most important factor in enhancing Kentucky bluegrass establishment. Six months after seeding, scalped plots averaged 8.1% Kentucky bluegrass, compared to only 2.0% in unscalped plots. By 21 months after seeding, scalped plots averaged 31.9% Kentucky bluegrass, compared to 18.1% in unscalped plots (Table 1). By comparison, when perennial ryegrass was treated with Roundup prior to seeding in September, Kentucky bluegrass coverage averaged 84% after 6 months (March), with complete coverage obtained by mid-summer. However, using Roundup would dictate that the fairways be closed for an extended period of time.

Visual quality ratings during the scalping period showed a significant difference between the scalped and unscalped treatments, as expected. Average visual quality for the scalped plots during the 4-week scalping period was 4 (on a 1-9 scale), compared to 6 for the unscalped plots. Scalped fairways would remain playable. After scalping ceased, the scalped plots recovered rapidly and within 2 weeks following the scalping period there was no difference in visual quality between the scalped and unscalped plots; this remained the case for the rest of the season.

In addition to post-seeding scalping, high seeding rates also enhanced Kentucky bluegrass establishment. Six months after seeding, plots seeded with 2 lbs/1000 $ft^2$ averaged 2.8% Kentucky bluegrass, whereas plots seeded with 4 lbs/1000 $ft^2$ averaged 7.3% (averaged across the scalped and unscalped plots). By 21 months after seeding, plots seeded with 2 lbs/1000 $ft^2$ averaged 19.7% Kentucky bluegrass, whereas plots seeded with 4 lbs/1000 $ft^2$ averaged 26.3%. Although there was a trend toward higher percent Kentucky bluegrass when additional spring seedings were used, the increases were not statistically significant compared to fall seedings.

Plant growth regulators were of little value in encouraging Kentucky bluegrass establishment. Plots treated with Embark did not have significantly more Kentucky bluegrass regardless of scalping treatment or seeding rate/timing.

Interestingly, under all treatments, Kentucky bluegrass coverage increased between the March 2001 and July 2002 evaluation dates. Therefore, if time is not a concern, it appears that gradual conversion towards Kentucky bluegrass will occur even if lower seeding rates are used and post-seeding scalping is not implemented. This is probably a result of the rhizomatous growth habit of the Kentucky bluegrass. However, much faster conversion can be obtained, without closing the fairways, by using a 4 lbs/1000 $ft^2$ seeding rate combined with continuous post-seeding scalping for 4 weeks.

Table 1. Post-seeding scalping and seed rate/timing effects on % Kentucky bluegrass coverage 6 and 22 months after seeding[x].

| Treatment | | % Kentucky bluegrass | |
|---|---|---|---|
| Post-seeding scalping[y] | Seed rate (lbs/1000 $ft^2$) and timing | March 2001 | July 2002 |
| Yes | 4 (Fall only) | 11.8 | 34.1 |
| Yes | 2 (Fall only) | 4.3 | 26.5 |
| No | 4 (Fall only) | 2.7 | 18.5 |
| No | 2 (Fall only) | 1.3 | 12.9 |

[X]The study was initially seeded in mid-September of 2000. Plots receiving an additional spring seeding were seeded in mid-April of 2001. Plots were core-aerated and vertical mowed prior to seeding.
[y]The treatment consisted of scalping twice weekly at 0.25 inch until Kentucky bluegrass seedlings grew above 0.25 inch.

**TITLE:** Evaluation of Cultural Methods for Converting Perennial Ryegrass to Seeded Bermudagrass

**PERSONNEL:** Jack Fry, Randy Taylor, Bob Wolf, and Alan Zuk

**SPONSOR:** Kansas Turfgrass Foundation, United States Golf Association

## INTRODUCTION:

With the cost of maintaining perennial ryegrass fairways increasing due to water and fungicide requirements, there is interest in alternative warm-season grasses that may be established at relatively low cost. These grasses include 'Yukon' and 'Riviera' bermudagrass, seeded cultivars that have exhibited excellent cold hardiness.

## METHODS:

This study was established on a mature stand of perennial ryegrass maintained under golf course fairway conditions. Plots measured 6 by 6 feet and were arranged in a randomized complete block design with four replicates. Treatments were: untreated, glyphosate-treated, scalped, planting with the minimal disturbance (MinD) seeder, and planting with the MinD seeder with rows oversprayed with glyphosate. Coated 'Riviera' bermudagrass seed was obtained from Johnston Seed Co. in Enid, Oklahoma. The label indicated that purity was 51% and germination 85%; hence, the pure live seed (PLS) contained was 43%.

Prior to planting, all plots except those receiving the MinD seeder treatments were core aerified (12 holes per square foot, approximately 1 inch deep) and verticut (four passes). Bermudagrass seed was mixed with approximately 300 g Milorganite (6-2-0) and spread at 1.5 lbs PLS/1000 $ft^2$ in each plot using a shaker bottle on 2 July 2002.

Glyphosate was applied at the label recommended rate with a backpack sprayer 7 days prior to seeding. Turf in the scalping treatment was mowed three times weekly at 0.25 inches from 2 July (seeding date) until 31 July, when a regular fairway-height mowing schedule began.

The MinD seeder was set to disturb 4, 2-inch wide rows, 15 inches apart, the entire length of each plot. This resulted in disturbance of approximately 4 $ft^2$ in each plot (11% of the entire plot area). Seed was mixed with approximately 100 g Milorganite to apply bermudagrass PLS at 2.38 lbs/1000 $ft^2$ in rows. A shaker bottle was modified to include a 0.25 in. diam. tube in its lid to deliver the seed/Milorganite mixture in a narrow row. A glyphosate treatment was applied over the rows in one of the MinD seeder treatments immediately after seeding. Application was done with a backpack sprayer to eliminate ryegrass 1 inch in either direction of the row.

After seeding, irrigation was applied 2 to 3 times daily during the first 4 weeks to provide a total of about 0.1 inch of water in each session. After 4 weeks, irrigation was applied every 1 to 2 days to prevent bermudagrass stress. Nitrogen from urea was applied at 1 lb N/1000 $ft^2$ on 10 July, and 1 and 22 August.

Data were collected on bermudagrass coverage and turfgrass quality. A modification of the vertical point quadrant method was used to determine bermudagrass coverage within each treatment plot after growth had ceased in October. The vertical point quadrant was constructed of a PVC frame with an internal monofilament grid spaced on 4-inch centers. The grid was placed over each plot to estimate coverage in each treatment. The presence of any part of a bermudagrass plant under an intersection was recorded as a "hit." To determine percent coverage, the number of hits was divided by the number of intersections on the grid. Turf quality was rated weekly using a 0 to 9 scale where 0 = brown, dead turf; 7 = acceptable quality for a golf course fairway; and 9 = optimum color, density, and uniformity. Rating dates were 10, 17, 23, and 31 July; 6, 12, 20, and 27 August; 3, 10, 18, and 25 September; and 9 October. Quality data for each month were averaged for presentation. Data were analyzed using the Statistical Analysis System. The analysis of variance (ANOVA) procedure was used to test for treatment effects. Means were separated using Tukey's least significant difference test (LSD).

**RESULTS:**

Coverage.

Complete bermudagrass coverage the first season was attained by treating entire plots with glyphosate (Table 1). In fact, visual observations indicated that complete coverage had occurred within 4 to 5 weeks after seeding (data not shown). Scalping the ryegrass turf for the first 4 weeks after planting resulted in 87% coverage by October. Untreated ryegrass exhibited 12% bermudagrass coverage at the end of the first season.

The MinD seeder, although disturbing only 11% of the plot area at planting, resulted in 41% coverage by October. Applying the glyphosate spray over rows resulted in an additional loss of 11% of the plot area (22% total), and resulted in 15% greater coverage compared to the MinD seeder without glyphosate. If we assume a hypothetical 1-acre golf course fairway measures 90 feet by 484 feet (43,560 $ft^2$), a comparison in seed requirements can be made between planting using a traditional broadcast method vs. using the MinD seeder. Broadcasting seed over the acre at the rate used in this test (1.5 lbs PLS per 1000 $ft^2$) would require 65.3 lbs of PLS. If bermudagrass were planted with the MinD seeder as described herein, there would be 72, 2-inch wide rows running the length of the fairway (484 ft). These rows create a total seedbed area of 5,819.6 $ft^2$, and at the seeding rate evaluated in this test (2.38 lbs/1000 $ft^2$), 13.9 lbs of PLS would be required. As such, a seed savings of 79% would have been realized using the MinD seeder vs. the broadcast method. If the MinD seeded rows were to be seeded at the same rate as the acre that was broadcast (1.5 lbs PLS/1000 $ft^2$), only 8.7 lbs of PLS of bermudagrass would be required, and a seed savings of 87%, on a weight basis, would result. These figures are used to provide a cost comparison for bermudagrass established using a broadcast method vs. MinD seeder technique (Table 2). Over $35,000 could be saved by using the MinD seeder compared to broadcasting seed over an entire 25 acre area.

Turf quality.

Poorest quality the initial month was observed where glyphosate was used over entire plots or over rows created by the MinD seeder. In August, quality in treatments was similar except for turf treated with the MinD seeder + glyphosate. In September and October, highest ratings were given plots where glyphosate had been applied as complete bermudagrass coverage and good uniformity were observed. Other plots, including the untreated plots, were less uniform due to presence of random or linear arrangements of bermudagrass.

The most rapid, and also most destructive method for converting ryegrass to bermudagrass is to treat the entire area with glyphosate; however, course closure is usually required. As such, courses can expect a loss of revenue during this period. Less destructive options for conversion that would allow golf to continue while converting ryegrass to seeded bermuda include scalping during the initial weeks of establishment or use of the MinD seeder. The MinD seeder allows conversion to take place with seed requirements up to 87% lower (on a per acre weight basis using the MinD seeder spacing evaluated in this test) than broadcasting seed over the entire area. Although complete coverage will not be achieved in the first season using the MinD seeder, it is likely that bermudagrass will encroach into the remaining plot area in the second season, depending upon weather conditions.

**PLANS FOR 2003:**

Bermudagrass coverage will be monitored during 2003, and a new test area will be established to confirm results found in 2002. Depending upon funding, we hope to evaluate the MinD seeder on-site at golf courses that are interested in converting from perennial ryegrass to seeded bermudagrass.

Table 1. Effects of perennial ryegrass cultural treatments on 'Riviera' bermudagrass coverage in October, and monthly turfgrass quality.[z]

| | Coverage (%)[y] | Turf quality[x] | | | |
|---|---|---|---|---|---|
| Treatment | October | July | August | September | October |
| Glyposate | 100 a[w] | 1.1 d | 7.3 a | 8.7 a | 9.0 a |
| Scalping | 87 b | 5.3 b | 7.1 a | 7.1 b | 6.5 b |
| MinD seeder | 41 d | 5.9 b | 7.1 a | 5.2 c | 5.3 c |
| MinD seeder + glyphosate overspray | 56 c | 3.5 c | 4.5 b | 5.0 c | 4.0 d |
| Untreated | 12 e | 7.9 a | 7.8 a | 7.1 a | 6.5 b |

[z]Riviera bermudagrass was seeded at 1.5 lbs/1000 $ft^2$ in glyphosate-treated, scalped, and untreated plots on 2 July 2002 after core-aerating and verticutting plots. The MinD seeder created 4, 2-in. wide rows 15 in. apart in each plot. The glyphosate overspray in MinD seeder plots was used to eliminate ryegrass up to 1 in. on either side of each row.

[y]Coverage was determined using a vertical point quadrant method. Numbers represent the mean of four replications.

[x]Turf quality was rated on a 0 to 9 scale, 9 = best. Numbers represent the means of four replicates averaged over 4 or 5 dates each month.

[w]Means followed by the same letter in a column are not statistically different ($P < 0.05$).

Table 2. Comparison of broadcast seeding vs. use of the MinD seeder for 25 acres of golf course fairways, assuming a seeding rate of 65.3 lbs PLS per acre.

| Method | Area | Total PLS required (lbs)[z] | Cost per pound of PLS[y] | Total Cost |
|---|---|---|---|---|
| Broadcast | 25 acres | 2612 | $ 27.90 | $ 45,533 |
| MinD seeder | 25 acres | 218 | $ 27.90 | $ 6,082 |

[z] Based upon a per acre rate of 65.3 lbs PLS per acre for the broadcast method and 8.7 lbs PLS per acre for the MinD seeder.

[y] Based upon an estimated cost of $12 per lb of seed with 51% purity and 85% germination.

# Turfgrass Research 2003



**Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan, KS 66506**

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