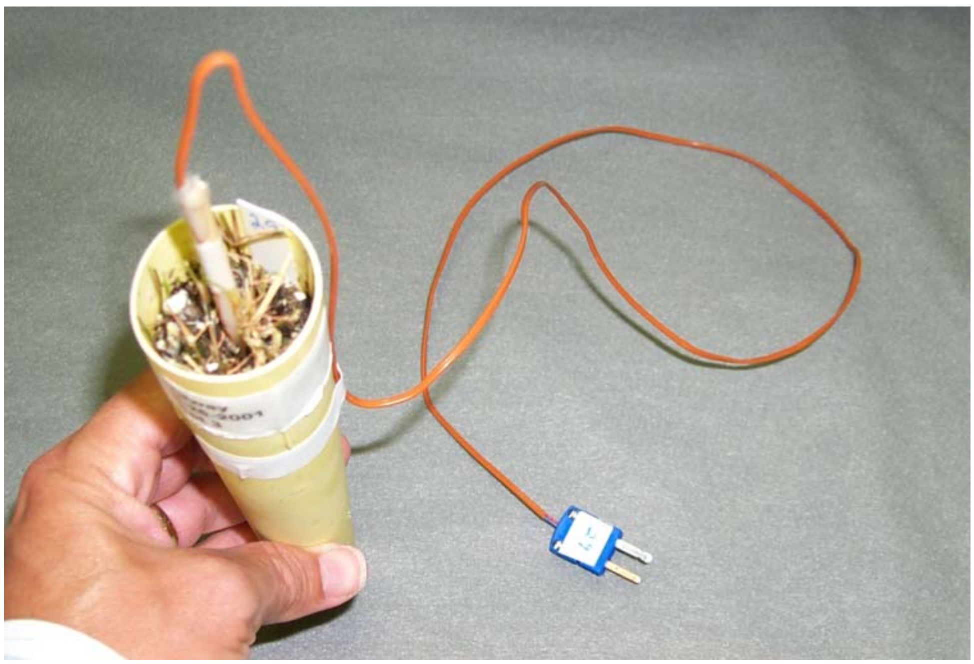
USGA

Turfgrass and Environmental Research Online

...Using Science to Benefit Golf



Oklahoma State University scientists determine relative freeze tolerance levels of recently released cultivars, advanced lines, and standard cultivars from the 2002 National Turfgrass Evaluation Program bermudagrass trials using laboratory-based methodology. A range in freeze tolerance from 22.5^{o} F (-5.3^{o} C) to 16.3^{o} F (-8.7^{o} C) was observed for seed-propagated cultivars. Most seed-propagated cultivars had a freeze tolerance level similar to 'Arizona Common' (21.2^{o} F), but four were significantly more freeze tolerant. Freeze tolerance of vegetatively-propagated cultivars ranged from 20.8^{o} F (-6.2°C) to 11.3^{o} F (-11.5°C). While three cultivars were significantly less hardy than 'Tifway', four bermudagrasses exhibited significantly greater freeze tolerance, reflecting the potential to survive in the northern boundary of the transition zone with a lower probability of winterkill.

Volume 6, Number 18
September 15, 2007

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of $29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

Editor

Jeff Nus, Ph.D.
1032 Rogers Place
Lawrence, KS 66049
jnus@usga.org
(785) 832-2300
(785) 832-9265 (fax)

Research Director

Michael P. Kenna, Ph.D.
P.O. Box 2227
Stillwater, OK 74076
mkenna@usga.org
(405) 743-3900
(405) 743-3910 (fax)

Bermudagrass Freeze Tolerance

Jeff Anderson, Charles Taliaferro, Dennis Martin, Yanqi Wu and Michael Anderson

SUMMARY

Bermudagrasses, *Cynodon spp.*, periodically experience freeze damage when grown in the transition zone for warm- and cool-season turfgrasses. Therefore, there is a need to develop and characterize bermudagrass cultivars with superior freeze tolerance, as well as other turf quality characteristics. Our objective was to determine relative freeze tolerance levels of recently released cultivars, advanced lines, and standard cultivars from the 2002 National Turfgrass Evaluation Program bermudagrass trials using laboratory-based methodology.

Experiments were divided into vegetatively-propagated and seed-propagated cultivars. Twenty-seven seed-propagated cultivars were randomly divided into five groups with 'Arizona Common' serving as a standard in each of the five groups. 'Tifway' was used as a standard cultivar for the three vegetatively-propagated groups, facilitating comparisons of relative tolerance across groups.

A range in freeze tolerance from 22.5^{o} F (-5.3^{o} C) to 16.3^{o} F (-8.7^{o} C) was observed for seed-propagated cultivars. Most seed-propagated cultivars had a freeze tolerance level similar to 'Arizona Common' (21.2^{o} F), but four were significantly more freeze tolerant. Freeze tolerance of vegetatively-propagated cultivars ranged from 20.8^{o} F (-6.2°C) to 11.3^{o} F (-11.5° C). While three cultivars were significantly less hardy than 'Tifway', four bermudagrasses exhibited significantly greater freeze tolerance, reflecting the potential to survive in the northern boundary of the transition zone with a lower probability of winterkill. Our research findings include:

- The most freeze tolerant seed-propagated cultivars were 'CIS-CD6', 'Riviera', 'Transcontinental', and 'SWI-1014'.
- 'OKC 70-18', 'Ashmore', 'Patriot', and 'Midlawn' were the most freeze tolerant vegetatively-propagated cultivars.
- 'GN-1', 'Celebration', and 'MS-Choice' were significantly less freeze tolerant than 'Tifway'.

JEFF ANDERSON, Ph.D., Professor, Dept. Horticulture & LA, Oklahoma State University, Stillwater, OK; CHARLES TALIAFERRO, Ph.D., Emeritus Regents Professor, Dept. Plant & Soil Sciences, Oklahoma State University, Stillwater, OK; DENNIS MARTIN, Ph.D., Professor, Dept. Horticulture & LA, Oklahoma State University, Stillwater, OK; YANQI WU, Ph.D., Assistant Professor, and MICHAEL ANDERSON, Ph.D., Associate Professor, Dept. Plant & Soil Sciences, Oklahoma State University, Stillwater, OK.

Turfgrass managers spend a considerable amount of time and energy to establish and maintain turfgrasses for aesthetic, environmental, and recreational purposes. Both genetic and environmental components interact to determine how well a chosen cultivar performs in a particular location. An increasing number of fine-textured bermudagrasses are being developed and evaluated for resistance to environmental stresses. Freeze damage is a primary concern in the northern boundaries of the bermudagrass adaptation zone. Some years are relatively mild and cause little or no damage, while other winters are sufficiently severe to cause extensive winterkill. The costs, in terms of loss of use and dollars to re-establish turf following winterkill, can be substantial (6, 8). Therefore, our long-term goal is to develop seed- and vegetatively-propagated bermudagrasses with high turf quality and improved freeze tolerance (11).

A common way to compare relative freeze tolerance of a group of cultivars is to establish them in the field and wait for cold temperatures to sort them out. However, during a mild winter, temperatures may not be cold enough to kill any cultivars of interest and no progress would be achieved. If evaluations were conducted at a northern or high elevation location, low tempera-

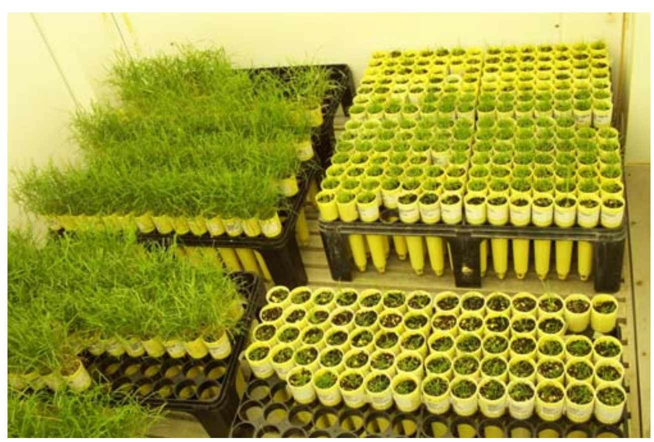


Figure 1. Seed-propagated plants during establishment in a growth chamber.

Figure 2. Acclimated plants trimmed of shoots and placed in a programmable freeze chamber for exposure to sub-freezing temperatures.

tures may kill most or all of the bermudagrasses. Therefore, several years of observation may be required to experience temperature conditions that distinguish different levels of freeze tolerance within a group of bermudagrass cultivars. Since the prevailing weather conditions before a freeze can vary and may have a profound influence on the acclimation state of the plants, relying on test winters makes it difficult to repeat studies over time and across climatic locations.

Another factor that comes into play during natural freezes is the nature of the freeze itself. Differences in freezing rate or duration, even with the same minimum exposure temperature, could result in different plant responses (4). Whether or not a snow cover is present can have marked influences on plant survival due to insulation effects. Developmental and morphological features can also be factors in winter survival. The presence of rhizomes can contribute to freeze avoidance by being sufficiently deep in the soil profile to avoid temperature extremes. The well-documented susceptibility of newly seeded bermudagrasses may involve physiological and/or morphological factors such as stolon density (10).

Year-round Winter Indoors

To overcome the unpredictable occurrence of test winters and to extend evaluations year-round, laboratory-based methods to measure freeze tolerance have been developed. One approach has been to acclimate plants naturally in the field, followed by laboratory-based exposure to sub-freezing temperatures (7). Studies have also been conducted entirely indoors, with plant materials established and acclimated in growth chambers, followed by exposure to a range of temperatures in a freeze chamber (2). Laboratory-based freeze-tolerance evaluations generally correspond well with field observations (9) and have provided useful information on relative freeze tolerance of turfgrasses.

Our objective was to quantify freeze tolerance of advanced lines, recently released cultivars, and standard varieties entered in the 2002 National Turfgrass Evaluation Program (NTEP) bermudagrass trial using laboratory-based methods. Standardized, quantitative information on bermudagrass freeze tolerance is vital to scientists to track progress in developing new cultivars. Freeze tolerance data are also beneficial to turfgrass managers selecting turfgrasses for the transition zone.

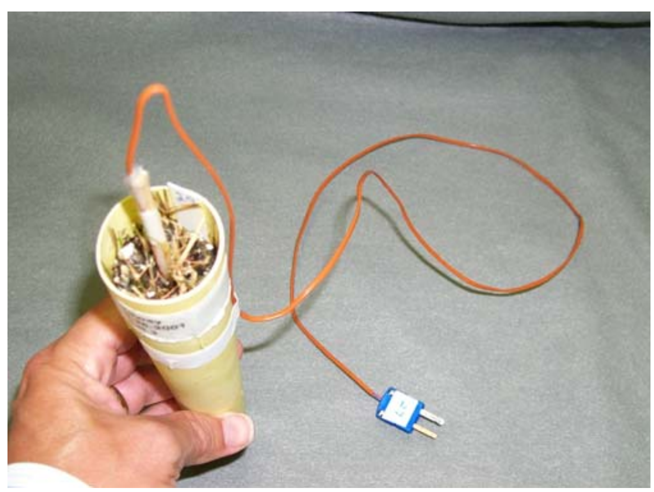


Figure 3. Bermudagrass plant showing thermocouple temperature sensor.

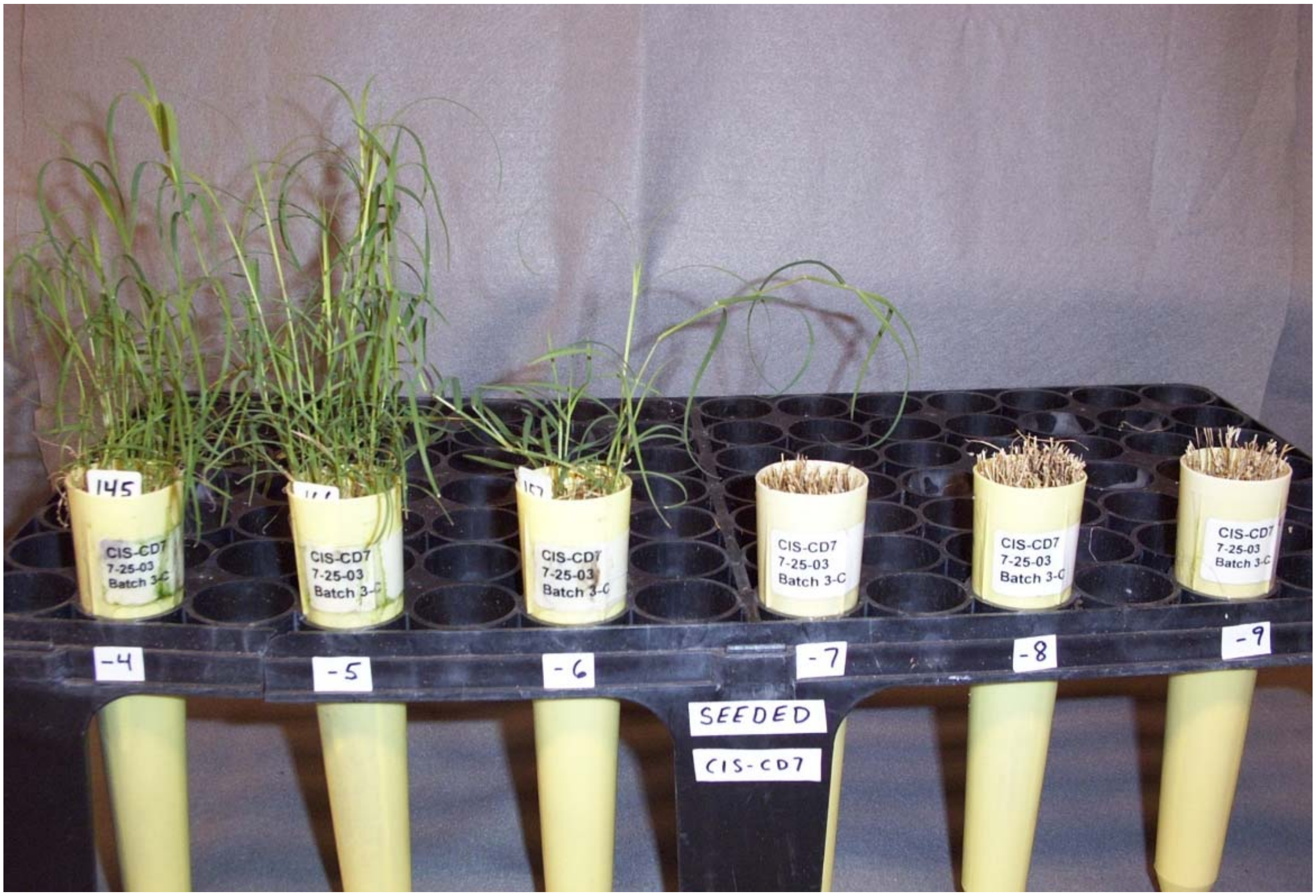


Figure 4. Regrowth of 'CIS-CD7' seeded bermudagrass after exposure to a range of sub-freezing temperatures.

Bermudagrass plants were established and maintained in growth chambers (Figure 1) as previously described (5). For studies with seed-propagated cultivars, seed from the lots used in the 2002 NTEP bermudagrass trial was obtained from the sponsors. Twenty-seven of the twenty-nine seed-propagated entries were included in this study. Due to space limitations in the freeze chamber, experiments with seed-propagated bermudagrasses were divided into five groups. Entries were randomly selected and assigned to groups with 'Arizona Common' included as a standard in each, allowing the potential for comparisons across groups. Vegetative cultivars were propagated from individual phytomers using 'Tifway' as the standard cultivar in each of the three groups. Experiments were conducted on three dates for each group, constituting replications in time, with staggered plantings allowing uniform establishment periods and plant age.

After plants had acclimated to fall-like temperatures, they were trimmed of top-growth and placed in a freeze chamber (Figure 2) with a temperature sensor in each pot (Figure 3). The chamber was programmed to slowly cool the plants, allowing them to be removed over a range of temperatures. Ideally, no damage would occur at the warmest temperatures, and all plants would be killed by exposure to the coldest temperatures. After being removed from the freeze chamber, plants were thawed and returned to the growth chamber to observe regrowth (Figure 4). Non-frozen controls were treated the same, except without freeze chamber exposure. Evaluating the temperature-survival curve allowed estimation of a T_{mid} value, similar to the LD_{50} (lethal dose for 50% of the subjects) in a toxicity screen. Data were combined into seeded and vegetative types. Performance relative to the standard cultivar ('Arizona Common' or 'Tifway') was determined

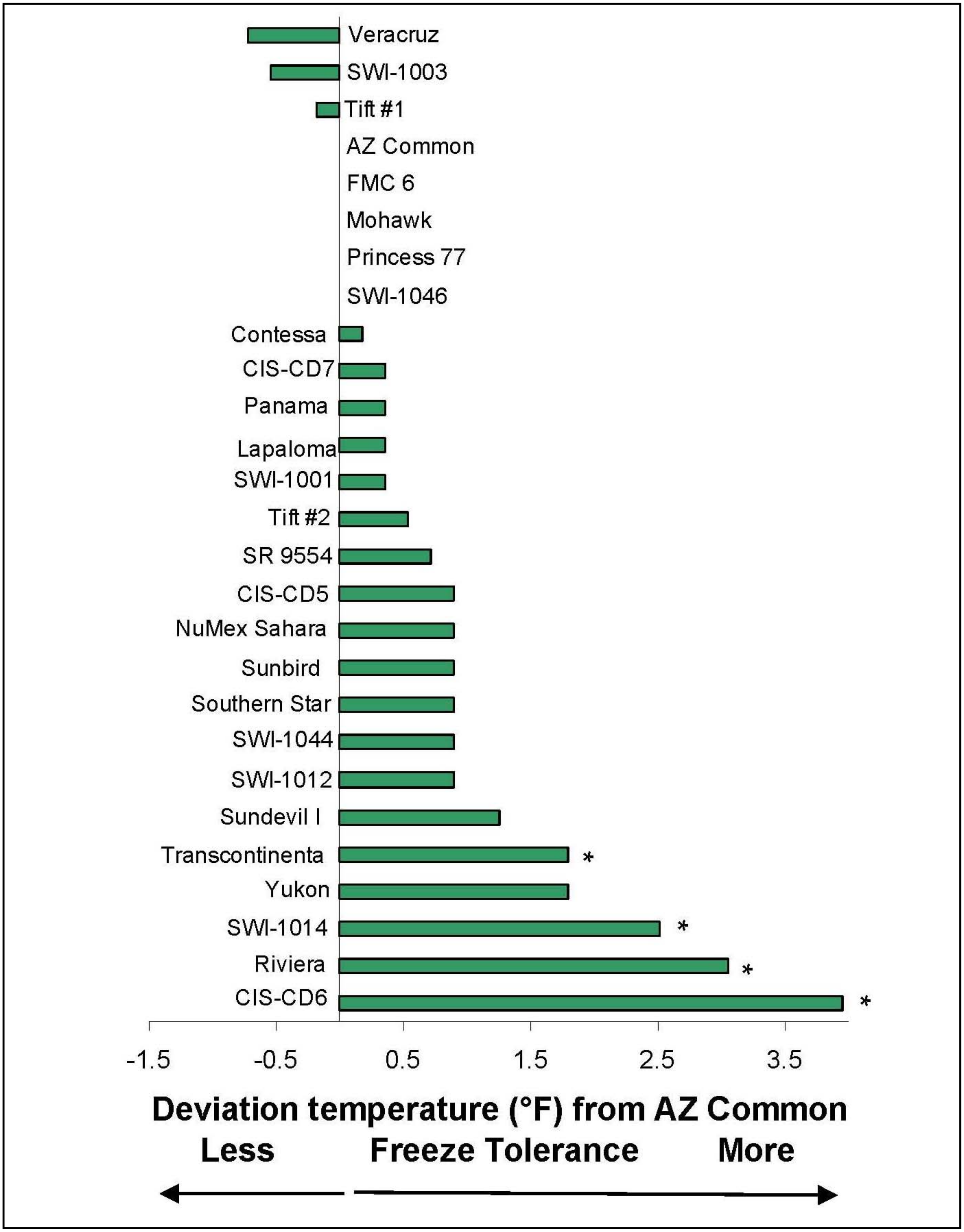


Figure 5. Freeze tolerance of seed-propagated bermudagrasses relative to 'Arizona Common'. Deviation temperatures represent the Tmid value (midpoint of the survival-temperature response curve) of the cultivar minus the Tmid value for 'Arizona Common'. Cultivars significantly different from 'Arizona Common' are indicated by asterisk. Adapted from Anderson et al. (5).

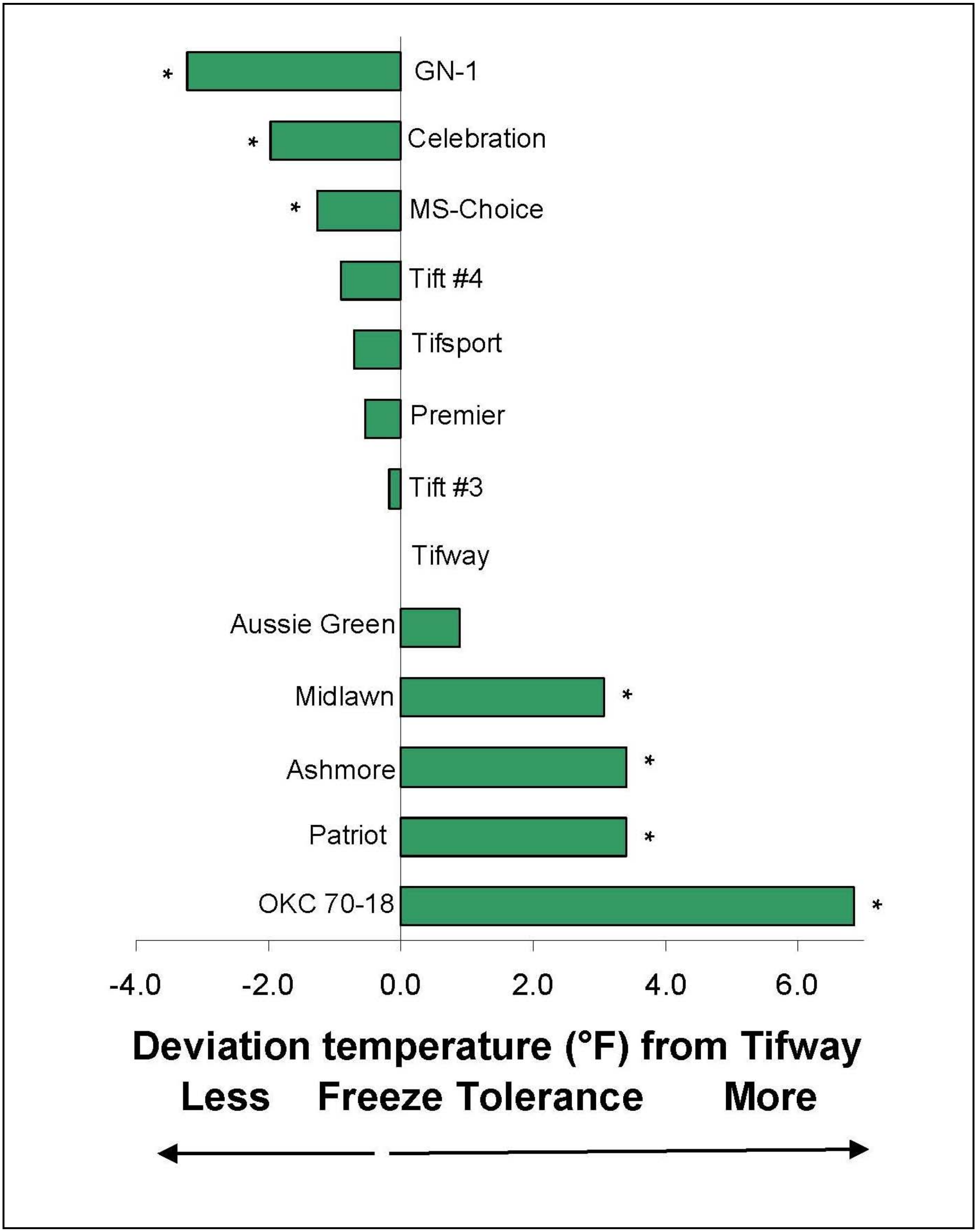


Figure 6. Freeze tolerance of vegetatively-propagated bermudagrasses relative to 'Tifway'. Deviation temperatures represent the Tmid value (midpoint of the survival-temperature response curve) of the cultivar minus the Tmid value for 'Tifway'. Cultivars significantly different from 'Tifway' are indicated by asterisk. Adapted from Anderson et al. (5).

by subtracting the T_{mid} for each cultivar from the T_{mid} value for the standard in that group. Mean comparisons within each experiment were conducted as appropriate using LSD (P = 0.05) following analysis of variance.

Bermudagrasses Can Vary Considerably in Freeze Tolerance

Seed-propagated bermudagrasses ranged in freeze tolerance from 22.5^{o} F (-5.3^{o} C) ('SWI-1003') to 16.3^{o}F (-8.7^{o}C) ('CIS-CD6'). Even though three cultivars were numerically less freeze tolerant than 'Arizona Common', none of the three were significantly different (Figure 5). 'FMC 6', 'Mohawk', 'Princess 77', and 'SWI-1046' were identical in freeze tolerance to 'Arizona Common'. Fifteen cultivars had numerically greater, yet non-significant differences in freeze tolerance relative to the standard. 'Transcontinental', 'SWI-1014', 'Riviera', and 'CIS-CD6' were significantly more cold hardy than 'Arizona Common'. Although 'Yukon' and 'Transcontinental' differed from 'Arizona Common' by the same amount, the difference was not significant for 'Yukon' at the 5% level due to greater variability in data from 'Yukon'. A previous study that included these two cultivars found 'Yukon' to be significantly more freeze tolerant than 'Arizona Common' (1).

Vegetatively-propagated bermudagrasses ranged in freeze tolerance from 20.8^{o} F (-6.2^{o} C) ('GN-1') to 11.3^{o} F (-11.5^{o} C) ('OKC 70-18'). Three cultivars, 'GN-1', 'Celebration', and 'MS-Choice' were significantly less freeze tolerant than 'Tifway' (Figure 6). 'Tift #4', 'Tifsport', 'Premier', 'Tift #3', and 'Aussie Green' had cold hardiness levels similar to 'Tifway'. 'Midlawn', 'Ashmore', 'Patriot', and 'OKC 70-18' were significantly more freeze tolerant than 'Tifway'.

Although we have not previously examined this combination of bermudagrass cultivars, freeze tolerance estimates generally corresponded well with previous experience (3). Both 'Midlawn' and 'Patriot' exhibited greater freeze tolerance than 'Tifway' as previously reported (4). Greater freeze tolerance of 'Riviera' than 'Princess 77' is consistent with earlier findings (8, 12). In a previous report (3), we also found 'GN-1' to be significantly less freeze tolerant than 'Midlawn'.

It is important to distinguish between T_{mid} temperatures determined in the laboratory and air temperatures experienced during a natural freeze. In the laboratory, conditions are set up to ensure that plants reach the target temperatures. Critical tissues, such as crowns, of plants in the field will usually be considerably warmer than air temperature due to the thermal buffering capacity of the soil.

Substantial progress is being made by turfgrass breeders to develop seed-propagated and vegetatively-propagated bermudagrasses with improved freeze tolerance. Although many factors in addition to freeze tolerance will be assessed in making cultivar selections, choices are now available with freeze tolerance suitable for areas of the transition zone requiring superior winter hardiness. However, cultivars with limited freeze tolerance may still be excellent choices for locations that do not experience severe winters.

Acknowledgments

The authors wish to thank the USGA's Turfgrass and Environmental Research Program and the Oklahoma Agricultural Experiment Station for their support. The authors also gratefully acknowledge the contributions of Shakuntala Fathepure and Xi Xiong and use of the Oklahoma State University Controlled Environment Research Laboratory. Approved for publication by the Director, OAES.

Literature Cited

1. Anderson, J., C. Taliaferro, M. Anderson, D. Martin, and A. Guenzi. 2005. Freeze tolerance and low temperature-induced genes in bermudagrass plants. *USGA Turfgrass and Environmental Research Online* 4(1):1-7. (TGIF Record 100502)

2. Anderson, J.A., C.M. Taliaferro, and D.L. Martin. 1993. Evaluating freeze tolerance of bermudagrass in a controlled environment. *HortScience* 28:955. (TGIF Record 56254)

3. Anderson, J.A., C.M. Taliaferro, and D.L. Martin. 2002. Freeze tolerance of bermudagrasses: vegetatively propagated cultivars intended for fairway and putting green use, and seed-propagated cultivars. *Crop Sci.* 42:975-977. (TGIF Record 79907)

4. Anderson, J.A., C.M. Taliaferro, and D.L. Martin. 2003. Longer exposure durations increase freeze damage to turf bermudagrasses. *Crop Sci.* 43:973-977. (TGIF Record 86297)

5. Anderson, J.A., C.M. Taliaferro, and Y.Q. Wu. 2007. Freeze tolerance of seed- and vegetatively-propagated bermudagrasses compared with standard cultivars. *Appl. Turfgrass Sci.* Online doi:10.1094/ATS-2007-0508-01-RS. (TGIF Record 124630)

6. Fry, J.D. 1990. Cold temperature tolerance of bermudagrass. *Golf Course Manaagement* 58:26, 28, 32. (TGIF Record 18902)

7. Maier, F.P., N.S. Lang, and J.D. Fry. 1994. Evaluation of an electrolyte leakage technique to predict St. Augustinegrass freezing tolerance. *HortScience* 29:316-318. (TGIF Record 31119)

8. Munshaw, G. C., E.H. Ervin, D. Parish, C. Shang, S.D. Askew, X. Zhang, and R.W. Lemus. 2006. Influence of late-season iron, nitrogen, and seaweed extract on fall color retention and cold tolerance of four bermudagrass cultivars. *Crop Sci.* 46:273-283. (TGIF Record 109577)

9. Qian, Y.L., S. Ball, Z. Tan, A.J. Koski, and S.J. Wilhelm. 2001. Freezing tolerance of six cultivars of buffalograss. *Crop Sci.* 41:1174-1178. (TGIF Record 74665)

10. Richardson, M.D., D.E. Karcher, and J.W. Boyd. 2004. Seeding date and cultivar affect winter survival of seeded bermudagrasses. *USGA Turfgrass and Environmental Research Online* 3(13):1-8. (TGIF Record 97550)

11. Taliaferro, C.M., D.L. Martin, J.A. Anderson, M.P. Anderson, and A.C. Guenzi. 2004. Broadening the horizons of turf bermudagrass. *USGA Turfgrass and Environmental Research Online* 3(20):1-9. (TGIF Record 98496)

12. Zhang, X., E.H. Ervin, and A.J. LaBranche. 2006. Metabolic defense responses of seeded bermudagrass during acclimation to freezing stress. *Crop Sci.* 46:2598-2605. (TGIF Record 119198)