

Freeze tolerance of Zoysiagrass Cultivars

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Objectives

Evaluate the freeze tolerance of zoysiagrass cultivars using controlled environment acclimation and freezing procedures.

Rationale

Although many newer zoysiagrass cultivars have either previously appeared or are currently in field trials, conditions necessary for separating cold hardiness among cultivars may occur only once per decade. As a result, NTEP cultivar trials lasting five years are usually insufficient to separate differences in cold hardiness among cultivars. In addition to testing for winter injury in field plots, it is necessary to identify a standardized method to determine the relative freeze tolerance of zoysiagrass cultivars since winter injury can result in substantial reestablishment costs and loss of use.

Materials and methods

A cold stress simulator was constructed by modifying a 0.55 m³ chest freezer similar to the method of James B. Beard et al.. The freezer was modified by adding an elevated rack inside the chamber with attached 120 mm diameter computer cooling fans (Philmore Manufacturing Company, Inc., Rockford, IL) to circulate air within the chamber. A programmable controller (Watlow 981, Watlow Electric Manufacturing Co., St. Louis, MO) and a type T Teflon tipped thermocouple (ThermoWorks, Alpine, UT) connected to the controller were used to control temperature inside the chamber. Soil temperatures are more important than air temperatures when assessing freezing stress (Beard et al., 1991), so the thermocouple was inserted 2.5 cm into the potting-mix to control temperature.

Zoysiagrass plant material was collected in the fall of 2003 and propagated in the greenhouse in pots filled with fritted clay (Turface, Profile Products LLC, Buffalo Grove, IL). Vegetatively established cultivars were planted into trays as plugs or stolons and seeded cultivars were seeded (49 kg ha⁻¹) into trays. Plants were established in 2.5 cm diameter Ray Leach cone-tainers (Stuewe & Sons, Inc., Corvallis, OR) filled with potting-mix (BM-2, Berger Peat Moss Ltd., Canada) using a phytomere containing root, crown, and shoot material starting in the fall of 2005. One or more zoysiagrass cultivars with low, medium, and high winter injury were selected from each group (*Z. japonica* cultivars established vegetatively, *Z. japonica* cultivars established from seed, and *Z. matrella* cultivars established vegetatively) of commonly used zoysiagrass cultivars based on winter injury results from the spring of 2005. 'Midlawn' bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) and 'Pennncross' creeping bentgrass (*Agrostis stolonifera* L.) were used as controls in this experiment because their freeze tolerances were known. After 10 wks of establishment in the greenhouse (25 ±5°C), plants were cold acclimated for 4 wks using a controlled-environment chamber (PGR15, Controlled Environments Inc., Pembina, ND) set at 8/2°C day/night cycles and a 10-h photoperiod of 300 μmol m⁻² s⁻¹ photosynthetically active radiation based upon the procedure of Anderson et al. at Oklahoma State Univ.

Plants were placed in the cold stress simulator to test for relative freeze tolerance of each cultivar after 4 wks of acclimation. The cold stress simulator was programmed to cool 1°C h⁻¹ after 15 h at -3°C similar to Anderson et al. Target soil temperatures (1°C intervals, -6 to -15°C) covered a range anticipated to span the limits from complete survival to complete mortality based upon preliminary testing. To increase sample size near the anticipated freeze tolerance, six cone-tainers were removed at each test

temperatures from -8 to -12°C for each cultivar, and only three cone-tainers were removed for each cultivar for test temperatures -6 and -7 where complete survival was expected and at -13, -14, and -15°C where complete mortality was expected. Plants were thawed in a walk-in refrigerator (5°C) overnight after freezing. Plants were then transferred to a greenhouse (26 ±6°C) and evaluated for regrowth for a period of 4 wks after freezing. The temperature resulting in no regrowth from 50% of the plants (LT₅₀, freeze tolerance) was determined by nonlinear regression using an equation also used to predict survivability of bermudagrass, seashore paspalum, buffelgrass and *Rhododendron* spp., respectively. Freeze tolerance was determined by the following equation:

$$\text{Survival} = a + (b-a)/(1 + e^{c(T_m-T)})$$

where a is the base line of survival, b is the maximum survival, c is a function of the slope of the line at the inflection point, T_m is the temperature at the inflection point which is also the LT₅₀, and T is the treatment temperature. This experiment was conducted six times. Data were fit to sigmoidal curves using PROC NLIN (Gauss-Newton method) (Fig. 1) and LT₅₀ values were analyzed using PROC ANOVA (SAS Institute, Cary, NC). Means were separated using Fisher's protected least significant difference when *F* tests were significant at α= 0.05.

Results

- Freeze tolerance (LT₅₀) of zoysiagrass cultivars ranged from -8.4°C (Diamond) to -11.5°C (Meyer and Zenith) with a mean of -10.2°C (Table 1).
- *Zoysia matrella* cultivars Diamond, Royal, and Zorro and the *Z. japonica* cultivar Victoria had poor tolerance to freezing.
- *Zoysia japonica* cultivars Meyer, Zenith, Palisades, El Toro, Companion, and J-36 had good freeze tolerance and were all similar.
- The LT₅₀ of the experimental control Midlawn bermudagrass was -8.6°C.
- Pennncross creeping bentgrass had a LT₅₀ outside of the range of temperatures we tested (<-15°C).
- Freeze tolerance of Meyer (LT₅₀ = -11.5°C) in our study was similar to a previous report of -11.1 to -12.8°C and consistent with studies showing rhizome survival at -11°C.

Our freeze tolerance testing produced similar trends to winter injury in the field. Freeze tolerance does not always reflect absolute cold hardiness due additional environmental factors in the field such as snow cover, soil moisture, and temperature fluctuations.

Table 1. Freeze tolerance (LT_{50} , temperature resulting in no regrowth from 50% of the plants) of zoysiagrass plants as determined by nonlinear regression.

Cultivar	Species and Type†	LT_{50} (°C)	
Diamond	ZMV	-8.4	a‡
Royal	ZMV	-8.5	a
Zorro	ZMV	-9.0	ab
Victoria	ZJV	-9.3	abc
DALZ0101	ZMV	-10.0	bcd
DALZ0102	ZJV	-10.2	cd
Cavalier	ZMV	-10.3	cd
Companion	ZJS	-10.8	de
J36	ZJS	-10.8	de
El Toro	ZJV	-10.8	de
Palisades	ZJV	-11.0	de
Zenith	ZJS	-11.5	e
Meyer	ZJV	-11.5	e

† ZJV, *Zoysia japonica* commercially/experimentally available as vegetative propagules; ZJS, *Zoysia japonica* commercially/experimentally available as seed; ZMV, *Zoysia matrella* commercially/experimentally available as vegetative propagules.

‡ Within columns, means followed by the same letter are not significantly different according to Fisher's protected LSD ($\alpha=0.05$).