Freezing Tolerance of Selected Zoysiagrass Lines in Field and Controlled Environmental Conditions

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INTRODUCTION

Zoysiagrass (*Zoysia* spp.) is a warm-season grass widely used for golf courses, athletic fields, and home lawns in the southern United States. It has been identified as one of the low-input or low-maintenance species that can be managed with low inputs of water, fertilizer, and pesticide (Beard, 1973). Zoysiagrass has superior turf quality, excellent durability and density (Turgeon, 1991), and excellent heat, drought, and pest tolerance compared to cool-season turfgrasses (Pompeiano et al., 2011). However, its ability to survive freezing temperatures is low, which limits its widespread use in the transition zone. Meyer (*Z. japonica* Steud.) is the industry standard for zoysiagrass in the transition zone because of its heat, drought and freezing tolerance (Grau, 1952; Patton and Reicher, 2007). However, Meyer is relatively slow to establish and its texture is medium coarse (Okeyo et al., 2011). Development of cultivars with enhanced tolerance to freezing temperatures would improve the adaption and management of zoysiagrass in the transition zone. The most common method to screen cold tolerance is to evaluate the regrowth of plants that have been exposed to freezing temperatures after cold acclimation either in the field or controlled environment (Anderson et al. 1993; Fry et al. 1993).

GOAL AND OBJECTIVES

Goal: To identify zoysiagrass with leaf texture finer than Meyer but with cold tolerance superior or comparable to Meyer.
Objectives: (1) To evaluate the freezing tolerance of seven selected zoysiagrass cultivars in the field and controlled environmental conditions and prediction of freezing temperature (LT_{50});
(2) To examine the relationship of LT_{50} from the field and controlled environmental conditions.

MATERIALS and METHODS

Plant Materials:

Selected zoysiagrass lines DALZ 1301, DALZ 1304-1309 and commercial check Meyer.
Target soil temperatures: -3 , -5, -7, -9, -10, -13 °C.

Field Freezing Tolerance:

Figure 1, Field sample collection

Plant materials were sampled from the replicated field plots in January (Field-1) and February (Field-2), 2014 for freezing tolerance evaluations (Figure 1). The maximum and minimum daily air temperatures were showed in Figure 2. The sampled cores were placed in the growth chamber overnight at -3°C and treated following the procedure of Anderson et al. (1993).

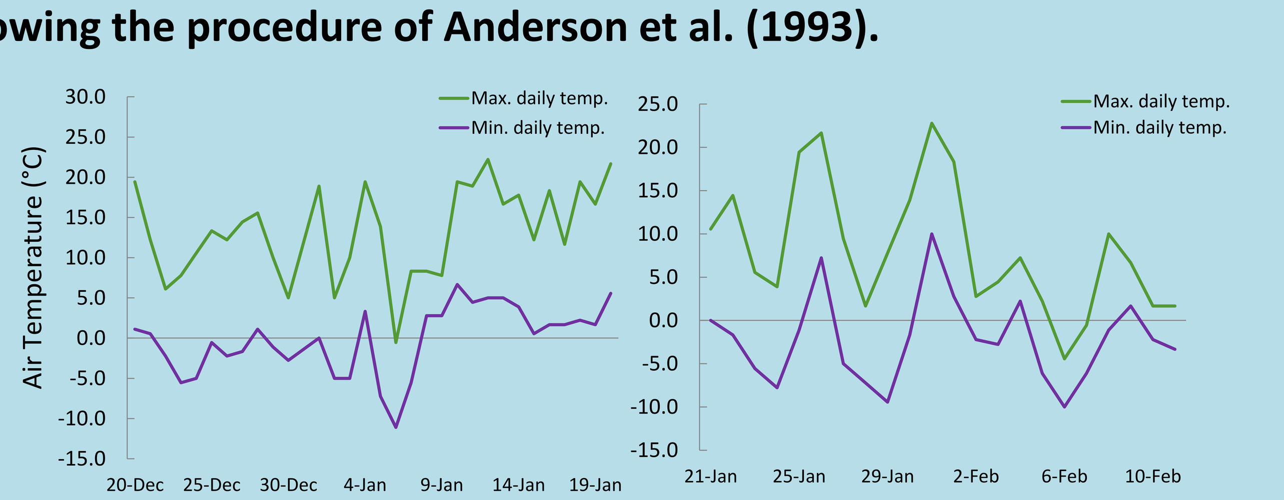


Figure 2, Air temperatures (°C) from 20 Dec. to 20 Jan. in Field-1; 21 Jan. to 10 Feb. in Field-2.

Controlled Environmental Condition---Growth Chamber Studies:

The same selected lines were propagated in 2.5 cm diameter cone-tainers (Stuewe & Sons Inc., Corvallis, OR) filled with potting-mix. Plants were acclimatized at 8/2 °C (day/night) for 4 weeks in the growth chamber (Figure 2). After acclimation, plants were tested for freezing tolerance similar to Anderson et al. (1993) (Figure 3). The experiments were repeated twice.

Study 1 (GC-1): Cone-tainers were arranged in a Randomized Complete Block (RCB) design during freezing treatments. Seven cone-tainers were removed at each target temperature.

Study 2 (GC-2): RCB was used and five replications were removed at each target temperature.

Figure 3, Growth chamber treatment (left) and responses of turfgrass treated at different freezing temperatures after 5 weeks in the greenhouse (right).

DATA ANALYSIS

Nonlinear regression was used to estimate LT_{50} by the equation adopted from Ingram and Buchanan (1984), which corresponded to the midpoint of the sigmoidal response curve of Greenup Vs. Temperature. LT_{50} values from two field studies (Field-1 and Field-2) and two controlled environmental conditions (GC-1 and GC-2) were analyzed using PROC ANOVA (SAS Institute, Cary, NC). Figure 4 Shows the sigmoidal curves for both Meyer and DALZ 1301 and the LT_{50} values in GC-1.

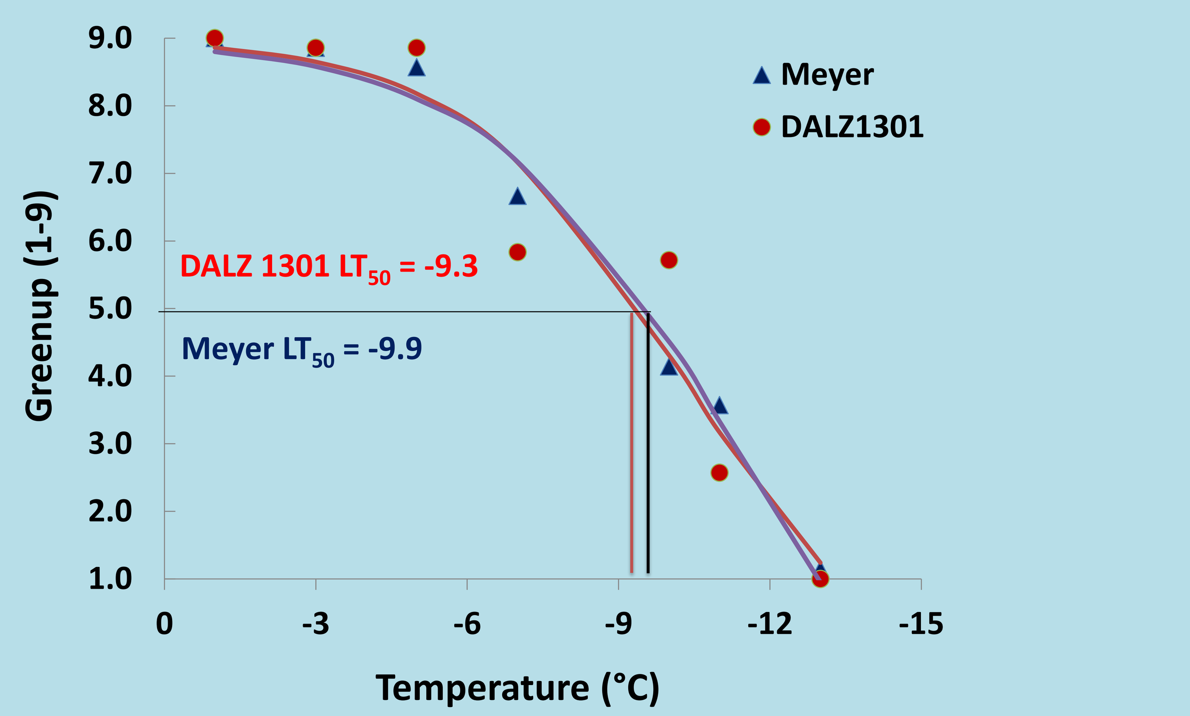


Figure 4, Sigmoidal curve fit to visual green-up rating of Meyer and DALZ 1301 in GC-1

RESULTS

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

Table 1, LT_{50} values of zoysiagrass lines from Field, GC-1 and GC-2.

		LT_{50} (°C)		
Cultivars	Species	Field	GC-1†	GC-2
Meyer	*Z. japonica*	-9.3 c‡	-9.9 d	-9.4 d
DALZ 1301	*Z. matrella*	-8.5 c	-9.3 d	-8.5 d
DALZ 1304	*Z. matrella*	-6.2 ab	-1.6 a	-4.8 a
DALZ 1305	*Z. matrella*	-6.0 ab	-4.7 b	-5.7 ab
DALZ 1306	*Z. matrella*	-6.6 b	-7.6 c	-7.1 c
DALZ 1307	*Z. matrella*	-5.5 a	-4.3 b	-5.5 ab
DALZ 1308	*Z. matrella*	-6.0 ab	-1.9 a	-6.7 ab
DALZ 1309	*Z. matrella*	-5.7 ab	-2.6 a	-6.8 bc

† GC-1: Growth Chamber study 1 in Feb. 2014; GC-2: Growth Chamber study 2 in Aug. 2014.
‡ Different letters following values within a column indicate a significant difference at P < 0.05.

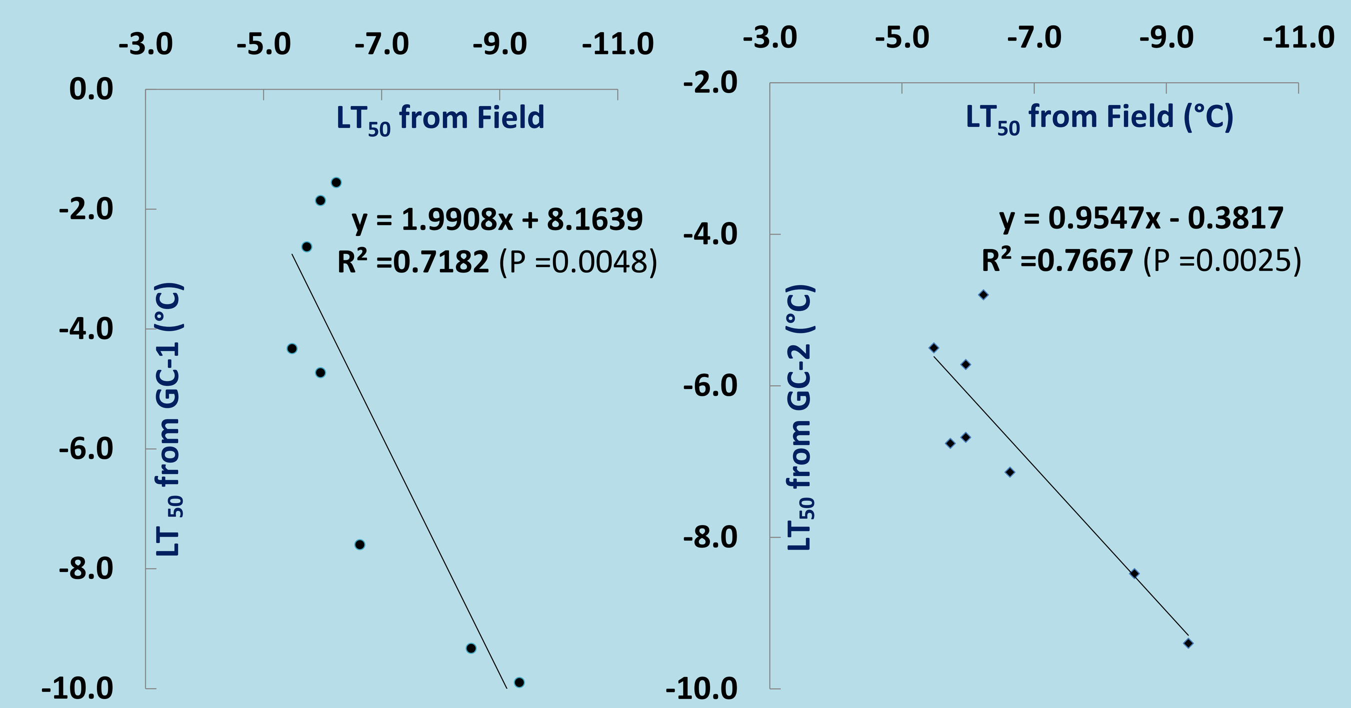
- There is no significant difference for LT_{50} from Field-1 and Field-2. Therefore, means of LT_{50s} from Field-1 and Field-2 were pooled together (Field) to show in the Table 1. Significant differences for LT_{50} of selected lines were found under GC-1 and GC-2. The data for both GC-1 and GC-2 is presented (Table 1).

RESULTS CONT.

- The average LT_{50} of Meyer in field condition was -9.3 °C. This is within the ranges -7 to -14.3 °C of the previous finding (Zhang et al., 2009); but the average of LT_{50} of Meyer from growth chamber is a little bit higher than the previous finding (Patton and Reicher, 2007).
- Lethal temperature treatments resulting in 50% survival (LT_{50}) scored after 5 weeks in the greenhouse ranged from -5.5 for DALZ 1307 to -9.3 °C for Meyer in the field; and LT_{50} ranged from -1.6 for DALZ 1304 to -9.9 °C for Meyer in GC-1, and -4.8 for DALZ 1304 to -9.4 °C for Meyer in GC-2. Meyer and DALZ 1301 have significantly superior freezing tolerance than DALZ 1304 to DALZ 1309 (*Z. matrella*) in both field and growth chamber studies.
- Meyer has been the standard among zoysiagrasses for cold hardiness in the transition zone. Our results show that Meyer and DALZ 1301 has no significant difference in freezing tolerance from field and growth chamber studies.

The relationship of freezing tolerance (LT_{50}) between field acclimation and growth chamber acclimation.

- The field freezing tolerance was highly correlated to the freezing tolerance from controlled environment. Coefficient of determination (R^2) of LT_{50} between field and GC-1 was 0.7182, and 0.7667 between field and GC-2. This is consistent with the trend observed by Patton and Reicher (2007), which showed the positive relationship between the cold stress simulator and winter injury in the field for LT_{50}.



CONCLUSIONS

- DALZ 1301 (*Z. matrella*) has finer leaf texture and better quality characteristics than Meyer (*Z. japonica*).
- Based on our field and growth chamber studies, the freezing tolerance of DALZ 1301 is comparable to Meyer.
- The freezing tolerance of tested zoysiagrass lines under field conditions was positively correlated to the freezing tolerance from controlled environmental studies.

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