TITLE: Membrane Lipid Composition and Heat Tolerance in Kentucky Bluegrass, Tall Fescue, and a Hybrid Bluegrass

OBJECTIVES: 1) Investigate mechanisms at the cellular level that may explain differences in heat tolerance among three cool-season turfgrasses; 2) Identify and quantify specific lipid compositional changes under heat stress; 3) and to discover relationships of specific lipid compositions (or ratios) under optimum and high temperatures.

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Introduction

New HBG, which are genetic crosses between KBG (*Poa pratensis* L.) and native Texas bluegrass (*Poa arachnifera* Torr.), have the appearance of KBG but may be able to withstand higher temperatures and extended drought without going dormant. Heat stress may damage cell membranes in cool-season turfgrasses, causing leakage of cytoplasm and consequently, tissue damage or death. Lipid molecules are structural building blocks of cellular membranes that, among other things, modulate membrane trafficking of select chemicals, are precursors of intracellular signaling molecules, and participate in the regulation and control of cellular function and response to stresses or injury through signal transduction processes. In this study, lipids were profiled in HBG ('Thermal Blue'), KBG (Apollo) and TF (*Festuca arundinacea* Schreb.) (Dynasty) in a growth chamber study.

Materials and Methods

Sods of each turfgrass were transferred from the field into containers, maintained in a greenhouse for three weeks, and then moved into a growth chamber for three months. Daily temperatures were maintained at 22^{o}C for 14 h under lighted conditions and then at 15^{o}C for 10 h in darkness. Turfgrasses were mowed once a week at 6.5 cm and well-watered (i.e., every three days to replace 100% of evapotranspiration, which was determined gravimetrically). Leaf tissue was sampled in each turfgrass for lipids profiling at the Kansas Lipidomics Research Center at Kansas State University at the end of the three month period. Although the temperature was thereafter increased to induce heat stress for later lipids profiling, this report includes only results from the initial sampling. Results from the post-heat treatment lipids profiling are not yet available but will be included in next year's report.

Data were analyzed using principle component (PC) analysis, which simplified an otherwise complex process by reducing 149 molecular species into 14 principal components. These 14 components were then evaluated to determine the amount of variance they accounted for in the data. The most significant PCs were then evaluated for their "loadings", which refers to the individual lipids species within each PC group. Loadings of the most significant PC groups may indicate which individual lipid species determine heat tolerance in cool-season turfgrasses. Consequently, these species may represent potential biomarkers for heat tolerance in turfgrasses.

Results and Discussion

Two of the 14 PCs explained more than 56% of the variance in the dataset (Fig. 1). The biggest differences were between TF and the bluegrasses (i.e., HBG and KBG), which were separated along the PC1 axis; PC1 explained over 41% of the variance of the dataset. Although HBG and KBG were the same on the PC1 axis, they clearly were separated along the PC2 axis (PC2 explained approximately 15% of the variance). Inspection of the loadings of PC1 and PC2 revealed 40 individual species which separated the more heat-tolerant bluegrasses from TF (Table 1; bluegrasses were more heat tolerant in a previous growth chamber study, see *Comparison of the heat and drought tolerances of a Texas bluegrass hybrid compared with Kentucky bluegrass and tall fescue: A growth chamber study*. p. 53 *in* 2005 K-State Turfgrass Research Report, Report of Progress 946). Therefore, we concluded there is a high probability that these 40 species are potential biomarkers for genetic modification, or enhancement of heat tolerance in turfgrasses. Further experiments are needed, however, particularly where these turfgrasses are exposed to higher temperatures to determine whether these lipid species are actual physiological mechanisms for heat tolerance.

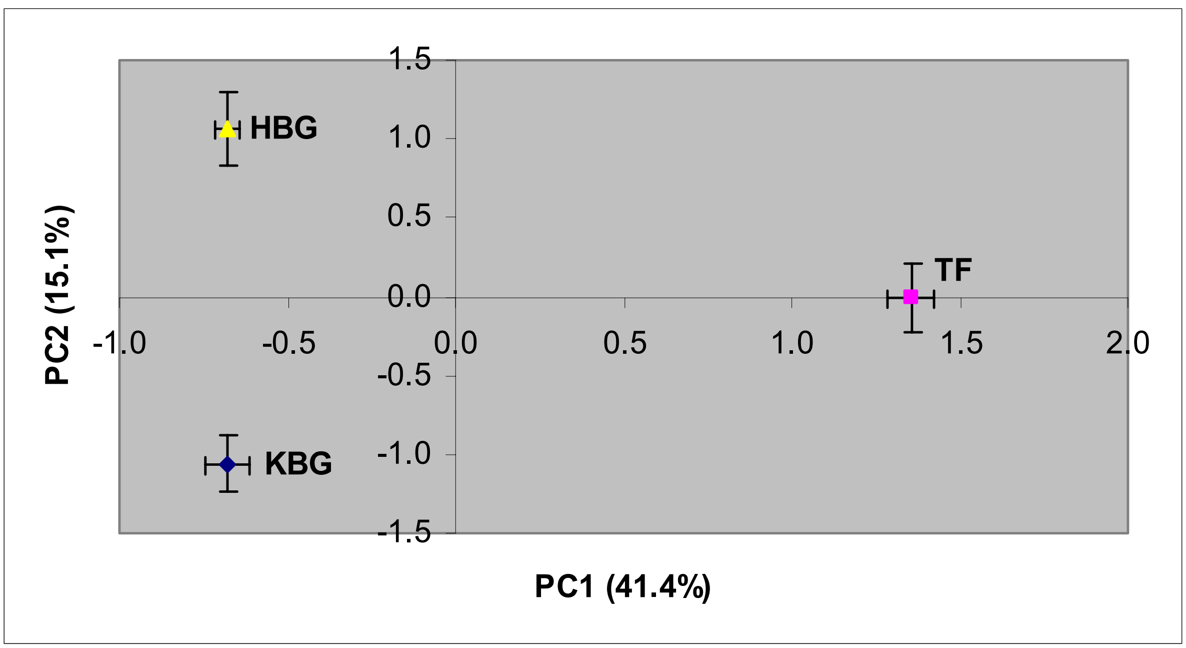

Figure 1. Principal component (PC) analysis of 149 lipid species in tall fescue (TF), hybrid bluegrass (HBG), and Kentucky bluegrass (KBG). PC1 and PC2 accounted for 41.4 and 15.1%, respectively, of the variance of the dataset, for a total of about 56%.

High lipid species in heat-tolerant turfgrasses[†]			
DGDG 34:2	PE 34:2	PS 38:2	PG 34:4
MGDG 34:2	MGDG 36:5	PS 34:2	LysoPC 18:2
PE 38:2	PC 34:2	PC 38:2	MGDG 36:4
PE 36:4	DGDG 36:2	PS 36:2	PS 40:2
DGDG 36:5	PG 34:2	PI 34:2	PC 36:4
Low lipid species in heat-tolerant turfgrasses			
DGDG 36:3	PS 42:4	PS 38:3	PC 36:6
PC 36:5	DGDG 36:6	PE 34:4	PE 34:3
PC 38:6	MGDG 34:4	PE 36:5	PS 42:3
PS 36:5	PC 34:4	PI 34:3	PS 40:3
DGDG 34:1	PC 34:3	DGDG 34:4	PE 36:6

Table 1. Forty molecular species that were significantly different in the bluegrasses compared to tall fescue. These lipids represent potential biomarkers for genetic modification or enhancement of heat-tolerance in bluegrasses.

[†] Hybrid and Kentucky bluegrasses were more heat tolerant than tall fescue in a previous growth chamber study at Kansas State University.