Ecotypic Responses of Indiangrass (Sorghastrum nutans) to Varying Water Regimes

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Introduction
Less than 5% of the tallgrass prairie ecosystem remains undisturbed from agriculture and other human impacts. Tallgrass prairie is widely restored throughout the Midwest, however there are uncertainties about the persistence of these restorations if climate changes. Geographical and climatic conditions should be considered when selecting species and population sources for use in restoration (Hufford & Mazer 2003). Seeds are often collected locally because plants are considered adapted to the nearby environment (Lesica & Allendorf 1999). However, adaptation to changing environmental conditions is a slow process, and use of non-local native species has been proposed for consideration in restoration if rapid environmental change may occur (Harris et al. 2006).

Climate change is expected to occur (IPCC 2007), although the degree and trajectory of change are highly uncertain for the Midwest (Harris et al. 2006). Climate change models for this region are also uncertain, as the Midwest could experience an increase or decrease in amount of and variability in precipitation. Dominant prairie grasses occur across a precipitation gradient from western Kansas to Illinois and these dominant grasses regulate the function of native and restored prairie (Baer et al. 2002, Smith & Knapp 2003). Understanding the response of dominant species from different regions and climate is needed to identify which population sources or ecotypes are best adapted to different precipitation regimes to predict sources that should be used to restore prairie under different climate scenarios. Ultimately, the long-term success of a restoration may depend on selecting population sources best suited for future conditions (Lande & Shannon 1996, Lesica & Allendorf 1999).

Objectives & Hypotheses
The overall objective of this project was to demonstrate whether single ecotype or mixed population sources of a dominant prairie grass, Indiangrass (Sorghastrum nutans), perform differently under a range of watering regimes.

H1: Ecotypes from dry climates (Hays and Konza Prairie sources from Kansas) will perform better (i.e., higher photosynthesis rates and biomass production) in the lowest watering treatment and ecotype from.

H2: Mixed ecotypes will perform better under drought conditions than single ecotypes from the wetter climate (i.e., southern Illinois sources).

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Methods

Design and Treatments
Indiangrass seeds were collected from three sites that receive approximately 400 mm (Hays, KS), 800 mm (Konza Prairie, KS), and 1200 mm (southern Illinois) of precipitation annually. The seeds were germinated in vermiculite and 6 seedlings were planted in pots with a 1:1 sand/soil ratio according to 12 treatments resulting from a combination of 4 ecotype sources (Hays, Konza, IL and mixed) and 3 watering treatments (300, 600, and 900 mm). Each pot was thinned to 3 seedlings. Mixed ecotype pots contained 1 seedling from each source. Each treatment was replicated 5 times (n=60). Greenhouse lights were on for 8 hrs/d and temperatures ranged from 21-29°C. The experiment was conducted for 12 weeks and plants were watered every 4 days.

Plant Responses
• Net photosynthesis was measured after 12 weeks of growth using the LI-6400. Photosynthetically active radiation (PAR) in the LI-Coer leaf chamber was set to approximate conditions in the greenhouse.
• At the end of the experiment each plant was clipped, dried at 55°C, and weighed to calculate the aboveground biomass. Roots were separated from the soil, washed, dried at 55°C, and weighed to determine belowground biomass. Total biomass was calculated from the sum of above and belowground biomass.

Data Analyses
Net photosynthesis rates and plant biomass data were analyzed using the mixed model procedure in SAS (SAS Inst. 2003), with number of plants/pot as a random effect.

Results

Figure 1. Average aboveground biomass (± standard error) of each source of Indiangrass in all watering treatments. Letters A-C represent differences among ecotypes in each treatment; letters x-y represent differences between watering treatments within an ecotype. Means with the same letter were not significantly different (a=0.05).

• Above and belowground biomass were similar among the sources; as collected across the precipitation gradient exposed to the highest watering treatment (Figs. 1 & 2).
• Most differences in above and belowground biomass among the sources occurred in the 300 and 600 mm watering treatments (Figs. 1 & 2), but were not consistent among the sources in the 300 and 600 mm watering treatments.
• Aboveground biomass in pots containing all sources (“mixed pots”) or just plants from Hays were the least variable across the three watering treatments (Fig. 1).
• Belowground biomass was most consistent in the “mixed ecotype” pots across all watering treatments (Fig. 2).
• Belowground biomass in pots containing all sources (“mixed pots”) or just plants from Hays were the least variable across the three watering treatments (Fig. 1).

Figure 2. Average belowground biomass (± standard error) of each source of S. nutans in all watering treatments. Letters A-C represent differences among ecotypes in each treatment; letters x-y represent differences between watering treatments within an ecotype. Means with the same letter were not significantly different (a=0.05).

Conclusions
• Few studies have documented ecotypic variation in native prairie grasses (but see McMillan 1959, 1965). Differences in physiological performance of Indiangrass collected from different source populations grown in a common soil and controlled environment demonstrates ecotypic variation in this commonly co-dominant prairie grass exists.
• Biomass did not increase with an increase in water supply as predicted due to high productivity in the lowest water treatment. This may be explained by the high water use efficiency of prairie grasses (Knapp et al. 1998, 2002) and adaptation to drought in species across the precipitation gradient.
• The least variation in biomass among ecotypes of Indiangrass occurred in the highest watering treatment. Thus, ecological consequences for ecotypic variation in a dominant species may vary with climate.
• Using broad collections of species has been recommended for restorations where suitability of population sources is unknown due to novel or changing conditions (Harris et al. 2006). The mixed ecotype pots showed no variation among sources in biomass across watering treatments or photosynthesis when all sources were planted together. These results suggest that combining ecotypes may stabilize productivity under a wider range of precipitation regimes, but field tests are needed to predict whole ecosystem response.