Phenotypic variation of big bluestem ecotypes across the Great Plains precipitation gradient

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INTRODUCTION AND RATIONALE:

Why study grasslands and big bluestem?

37% of the US land surface is covered by grassland.

Tallgrass prairie is found in the mesic eastern portions of the Great Plains grasslands (colored portion, **Fig 1**)

Big bluestem (*Andropogon gerardii)* is the ecologically dominant grass of the Great Plains

A. gerardii occurs across a sharp precipitation gradient, ranging from 400-1200 mm of rain annually (**Fig. 6**).

Fig. 1. Distribution of tall and mixed grass prairie (red and orange)

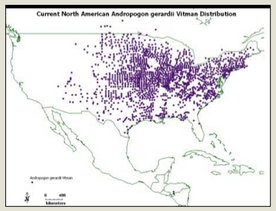


Fig. 2. Current distribution of *A.gerardii*.

QUESTIONS:

- Are there local ecotypes and are they locally adapted to drought across the precipitation gradient?
- What is the relative role of genotype and environment in controlling these differences?
- How will different ecotypes respond to precipitation changes?

HYPOTHESIS:

We hypothesize a strong precipitation gradient exerted selection for local ecotypes with distinct adaptation for drought tolerance.

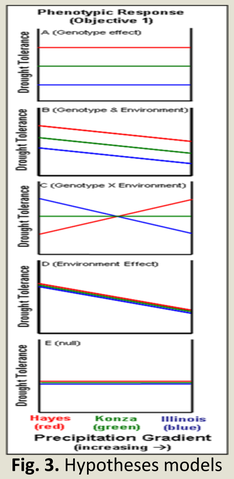


Fig. 3. Hypotheses models for possible outcomes.

SIGNIFICANCE:

Climate models predict longer periods of drought (**Fig.4**).

Understanding ecotype variation to drought will help predict response of a dominant prairie grass to fast-paced, novel environmental change.

Potential for restoration with genotypes with an increased fitness for predicted climate.

IMPLICATIONS:

Results will inform how best to restore tall grass prairie

Which ecotypes to plant to restore prairie?

Kansas contains over 3 million total acres of CRP land (**Fig.5**).

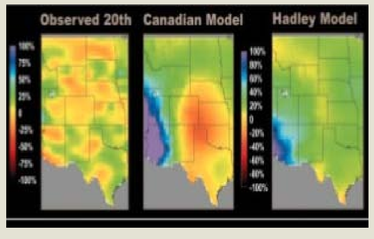


Fig. 4. Climate change due to global warming is expected to alter the timing and amount of precipitation

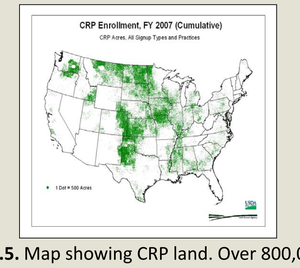


Fig.5. Map showing CRP land. Over 800,000 acres of new native grass plantings in KS in 2007 alone, 10% of total CRP enrollment

EXPERIMENTAL DESIGN : Reciprocal Transplant Gardens in single plants and seeded community

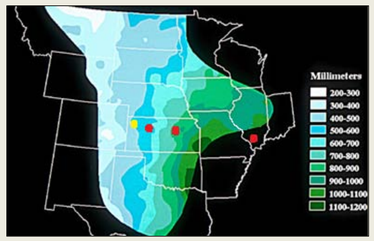


Fig. 6. Precipitation gradient, sites for reciprocal garden transplant plots. Yellow dot represents Colby our satellite site. All seeds collected from intact prairie within 50 miles of each transplant site.

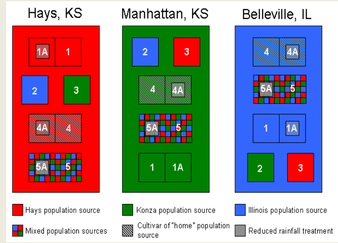


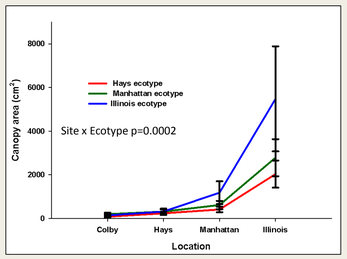
Fig. 7. Reciprocal garden transplant design. Each block replicated four times. Colby site not shown.

Fig. 8. Reciprocal gardens of individual plants, grown from seed and planted across the precipitation gradient (Colby, Hays, Manhattan, Illinois)

Fig. 9. Reciprocal gardens of seeded artificial communities (Colby, Hays, Manhattan, Illinois)

PHENOTYPIC VARIATION IN SINGLE PLANTS SHOW ADAPTATION TO DROUGHT

Reduced canopy area in Hays ecotype ⟶ reduction in transpiration



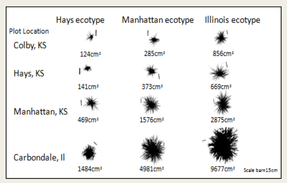


Fig. 10. Canopy area calculated using Image J (NIH program), pictures taken May-June 2010.

Reduced height in Hays ecotype ⟶ reduction in transpiration

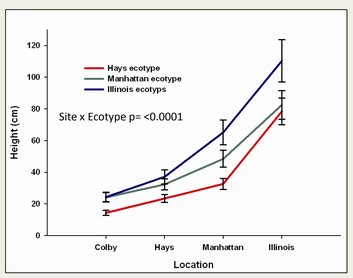
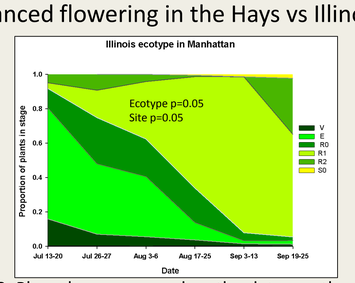


Fig. 11. Taut height measured in June 2010.

Advanced flowering in the Hays vs Illinois ecotype ⟶ adaptation to drought



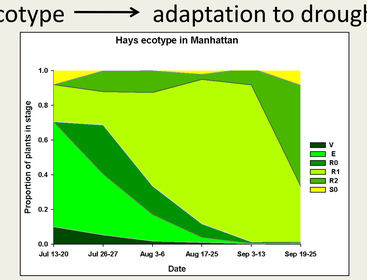


Fig. 12. Phenology measured on the dates on the x-axis. V=vegetation; E=elongation; R0=reproductive stalk; R1= flower emergence; R2= turkey foot; S0= seed ripening

HAYS ECOTYPE EXHIBITS DIFFERENTIAL COVER IN SEEDED PLOTS PLANTED IN DRY END OF GRADIENT

These results also corroborated by higher photosynthesis rates

All ecotypes persist equally well in Manhattan relative to other locations

All ecotypes established and persisted uniformly poorly in Illinois

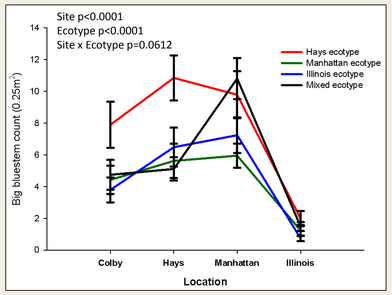


Fig. 13. Establishment of the ecotypes was measured after the first growing season (2009) by tiller counts per 0.25m².

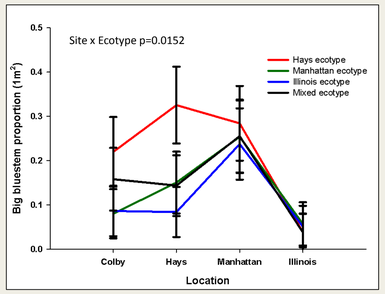


Fig. 14. Ecotype cover was measured across the sites using a point frequency method in a 1m² quadrat.

CONCLUSIONS

--Phenotypic variation in single plants demonstrate a strong phenotypic cline in drought tolerance. The westernmost ecotype, Hays, exhibits drought adapted features in height, canopy area and phenology.

--Preliminary data demonstrate an interaction between ecotype and planting location (G x E).

--In seeded plots, establishment of the 3 ecotypes across the gradient illustrate that in the dry planting locations (Hays and Colby), the Hays ecotype has increased plant establishment and cover compared to the Manhattan and Illinois ecotypes, thus suggesting local adaptation.

FUTURE DIRECTIONS

In the 2011 growing season, rainout shelters will be erected and will intercept 50% of rainfall events (**Fig. 15**). Measurements on big bluestem cover will be made across sites before and after rainfall interception treatments. Tissue will be collected from rainout and control plots for each ecotype to compare the drought transcriptome.

Fig. 15. Seeded plot underneath rainout shelter in Illinois.

Big bluestem has chromosomes in sets of 6x and 9x. Ploidy level of ecotypes will be determined by chromosome counts (**Fig. 16**) and flow cytometry to probe ploidy effects on plant performance. We will determine the role of genome size on how the ecotypes are sorting across the precipitation gradient.

Fig. 16. Chromosome preparation; red= propidium nuclear counterstain ; FITC (green)= 18s ribosomal DNA

ACKNOWLEDGEMENTS

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