Origins, Adaptive Radiation, and Evolution of Switchgrass

Michael Casler
U.S. Dairy Forage Research Center
USDA-ARS, Madison, WI
& University of Wisconsin
Geographic Distribution of Upland and Lowland Switchgrass Cytotypes
Biomass yield vs. Latitude

Northern Lowland

Southern Lowland

Northern Upland

Southern Upland

“Crash and Burn” due to reduced growth rate & early senescence

“Crash and Burn” due to winter injury
Biomass yield vs. Longitude

“Crash and Burn” due to lack of disease resistance?

“Crash and Burn” due to lack of drought tolerance?
Each “pie” represents one source-identified accession.

Each pie slice represents the probability of membership in the group identified by a specific color.
Central and Northern Great Plains 8x Upland Lineage
Origin of the ‘Carthage’ Accession
Fort Bragg: 1918 - 1939
Fort Robinson
Sand Hills Region of Nebraska
Fort Robinson
U.S. Army Remount Station, 1919-1943
Eastern edge of the Prairie Peninsula

Madison Barracks Artillery Unit & West Point Academy

Horses and Prairie Hay Shipped by Rail
Strong patterning in the Upland Accessions (North).

Weak patterning in the Lowland Accessions (South).
Distribution of Putative Hybrids
Glacial Refuge (or Refugia) for Switchgrass and Other Members of the Tallgrass Prairie
Post-Glacial Migration Routes
How Did Switchgrass Migrate Northward?
Migration, Mixing, and the Existence of Genetic Bottlenecks?

Prevailing Winds
No Genetic Bottleneck for Switchgrass
Ice Age Cycles

• Major Northern Hemisphere glaciations began ~2.7 Mya.

• Since the earliest estimated divergence between upland and lowland types, there have been about 15-20 major North American glaciation events.

• Tallgrass prairie species have undergone massive forward and reverse migrations within each cycle. Due to migration patterns and causes, most sites contain multiple haplotypes, some of widely divergent origins.
Proposed Switchgrass Gene Pools

- Cultivar recommendations for agriculture
- Target zones for breeding
- Localities for conservation and restoration
Conclusions

• We have identified one Center of Diversity in the SE USA and suspect that others exist all along the Gulf Coast and perhaps in West TX.
• Genetic diversity exists throughout the range of switchgrass; genetic bottlenecks associated with northward migration have been overcome by long-range east-west migration and hybridization.
• Phenotypic and genotypic studies have led to identification of a gene-pool concept to assist in a wide range of germplasm decisions.
Acknowledgements

• Casler lab (USDA-ARS, University of Wisconsin, & DOE Great Lakes Bioenergy Research Center)
  – Yunwei Zhang, Visiting Professor, CAU, Beijing
  – Juan Zalapa, Post-doc, GLBRC
  – Andy Jakubowski, Ph.D. graduate student
  – David Price, Ph.D. graduate student
  – Shawn Kaeppler, Professor, UW

• Brummer lab (UGA and Noble Foundation)
  – Ananta Acharya, Ph.D. graduate student
  – Yanling Wei, Post-doc, University of Georgia
Funding Sources

- USDA-ARS
- Department of Energy, Great Lakes Bioenergy Research Center (UW, MSU, ISU)
- University of Wisconsin, Agricultural Research Stations
- University of Georgia
- Department of Energy, BioEnergy Sciences Center (UGA, ORNL, Noble)
- The Samuel Roberts Noble Foundation, Ardmore, OK