

# DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Sun Grant/DOE Regional Biomass Feedstock Partnership:  
Herbaceous Energy Crops and CRP Land for Biomass  
Production (Award # GO85041; WBS 7.6.2.5)

23-27 March 2015

Technology Area Review: Feedstock Supply and Logistics

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North Central Sun Grant Center  
South Dakota State University

# Goal Statement

- Development of more accurate cost supply information and improved communication with partners in the biomass feedstock supply chain
  - Replicated field trials across regions to determine the impact of residue removal on future grain yield.
  - Replicated field trials to develop energy crops within geographical regions.
  - Regional assessment of feedstock resources which can be used to determine supply curves.
- Long term field data is the best and most direct way to determine commercial viability

# Quad Chart Overview (Herbaceous Crops)

## Timeline

- Project start date: 01/15/2007
- Project end date: 12/31/2015
- Percent complete: 90%

## Barriers

- Ft-A: Feedstock availability and cost
- Ft-B: Sustainable production
- Ft-C: Feedstock genetics and development

## Budget

(energycane, mixtures on CRP land, *M. x giganteus*, switchgrass)

|  | Total Costs<br>FY 07 –FY 12 | FY 13<br>Costs | FY 14 Costs | Total<br>Planned<br>Funding (FY<br>15-Project<br>End Date |
|--|-----------------------------|----------------|-------------|---|
| <b>DOE<br/>Funded</b>                      | \$3,451,324                 | \$541,094      | \$667,241   | \$995,483   |
| <b>Project<br/>Cost Share<br/>(Comp.)*</b> | \$1,182,573                 | \$220,784      | \$146,471   | \$0   |

## Partners

- Sun Grant Initiative
- 18 Land-Grant Universities
- USDA-ARS
- Oak Ridge National Lab
- Idaho National Lab

# 1 - Project Overview

- Development of regional and national yield estimates for sustainable biomass supply systems for herbaceous crops
- Perform replicated field trials of diverse herbaceous biomass feedstocks at different locations for assessing potential expansion of these feedstocks as a bioenergy resource

## 2 – Approach (Technical)

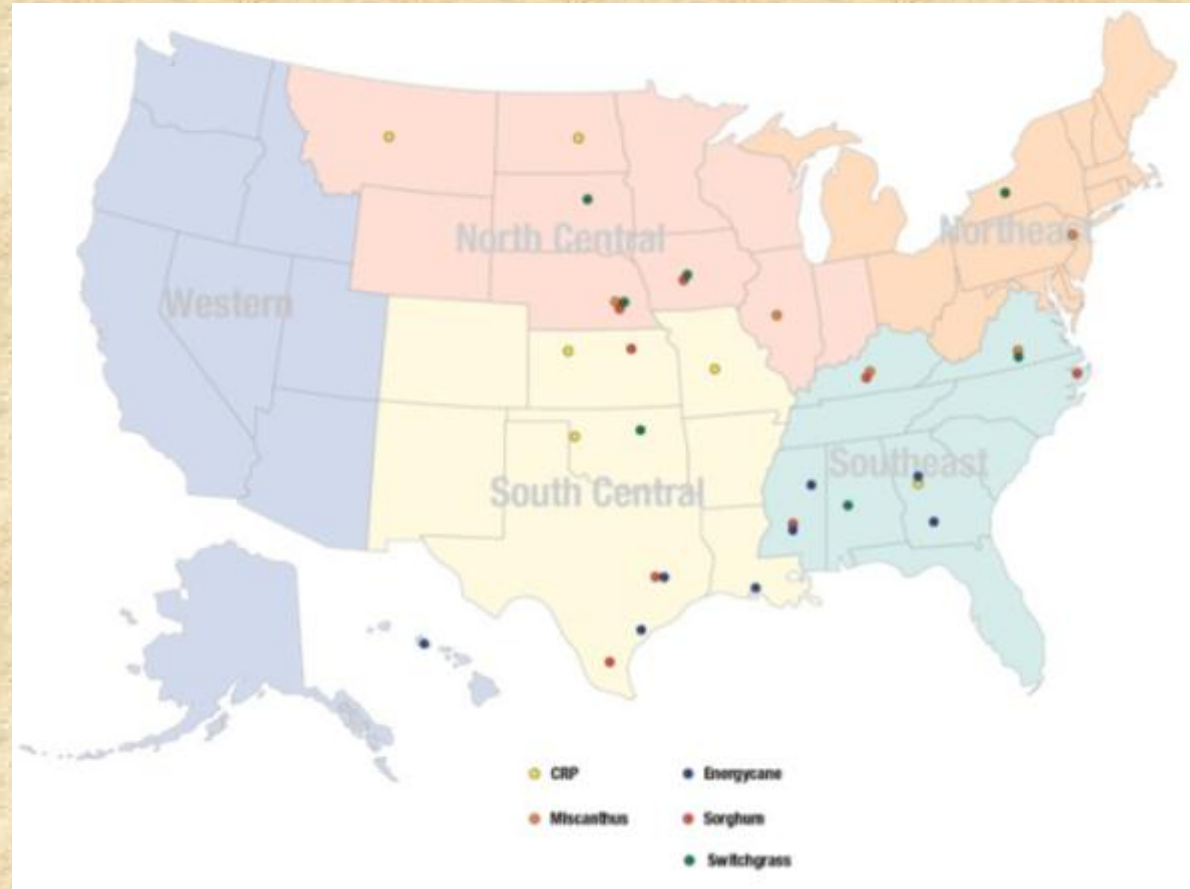
- Selected species and scale of trials (field or small plot)
  - Energycane (small plot—10 x 6 m plots)
  - CRP (field scale—0.5-1 ha plots)
  - Miscanthus x giganteus (small plot—10 x 10 m plots; sustainability site at Illinois)
  - Switchgrass (field scale—0.5-1 ha plots; sustainability site at South Dakota)
- Determine geographic distribution of trials for each species

## 2 – Approach (Management)

- Management approach: herbaceous group lead (Vance Owens), species leads (shown in section for each species), field trial PIs (varies with each species)
- Long-term trials of selected species are not commonly done; up to 6 years of data for some locations/species
- Establishment variability for perennials presented key challenge (one switchgrass and one miscanthus site required replanting due to establishment failure)

# 3 - Technical Accomplishments/Progress/Results

- Establishment of 34 ( $\pm$ ) replicated field trials across US
  - Energycane (8)
  - CRP (6)
  - Miscanthus (5)
  - Switchgrass (6)
- Sustainability trials
  - Miscanthus (1)
  - Switchgrass (1)



# Energycane

- Hybrid of sugarcane and wild cane (*Saccharum spontaneum*)
- Bred for high fiber, high biomass
- Tolerance to cold weather
- Fermentable sugars



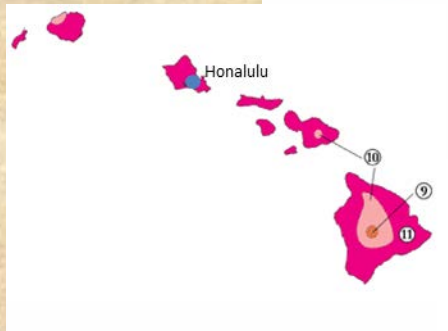
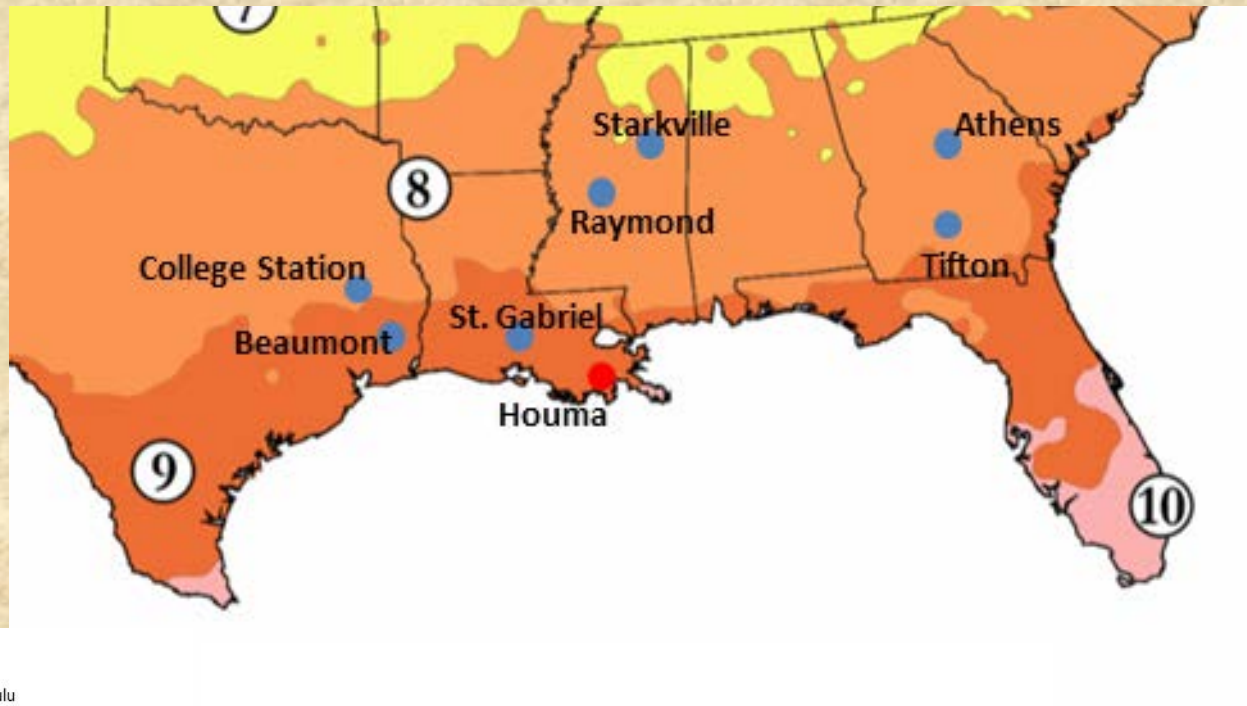


# Energycane Collaborators and Locations

(All planted in 2008 unless otherwise noted)

- Mississippi: Brian Baldwin (Species Lead; MSU, Starkville)
- Mississippi: Bisoondat Macoon (MSU, Raymond)
- Georgia: Bill Anderson/Wayne Hanna (USDA and UGA, Tifton)
- Georgia: Charlie Brummer, Joe Bouton (UGA, Athens)
- Hawaii: Goro Uehara, Richard Ogoshi (U Hawaii, Waimanalo; planted in 2010)
- Louisiana: Kenneth Gravois (LSU, St. Gabriel)
- Louisiana: Anna Hale, Ed Richard (ARS-SRU, Houma)
- Texas: Jurg Blumenthal, Ronnie Schnell (TAMU, College Station)
- Texas: Ted Wilson (TAMU, Beaumont)

# Energycane Locations



# Energycane Approach

- Plots 10 x 6 m (limited size based on germplasm availability)
- Four replicates at each location
- Five genotypes common to all locations



Planting seed cane



Energycane one year after planting



Energycane harvest (Tifton, GA)

# Energycane Technical Progress/Results to Date



Energycane (Starkville, MS)

Switchgrass

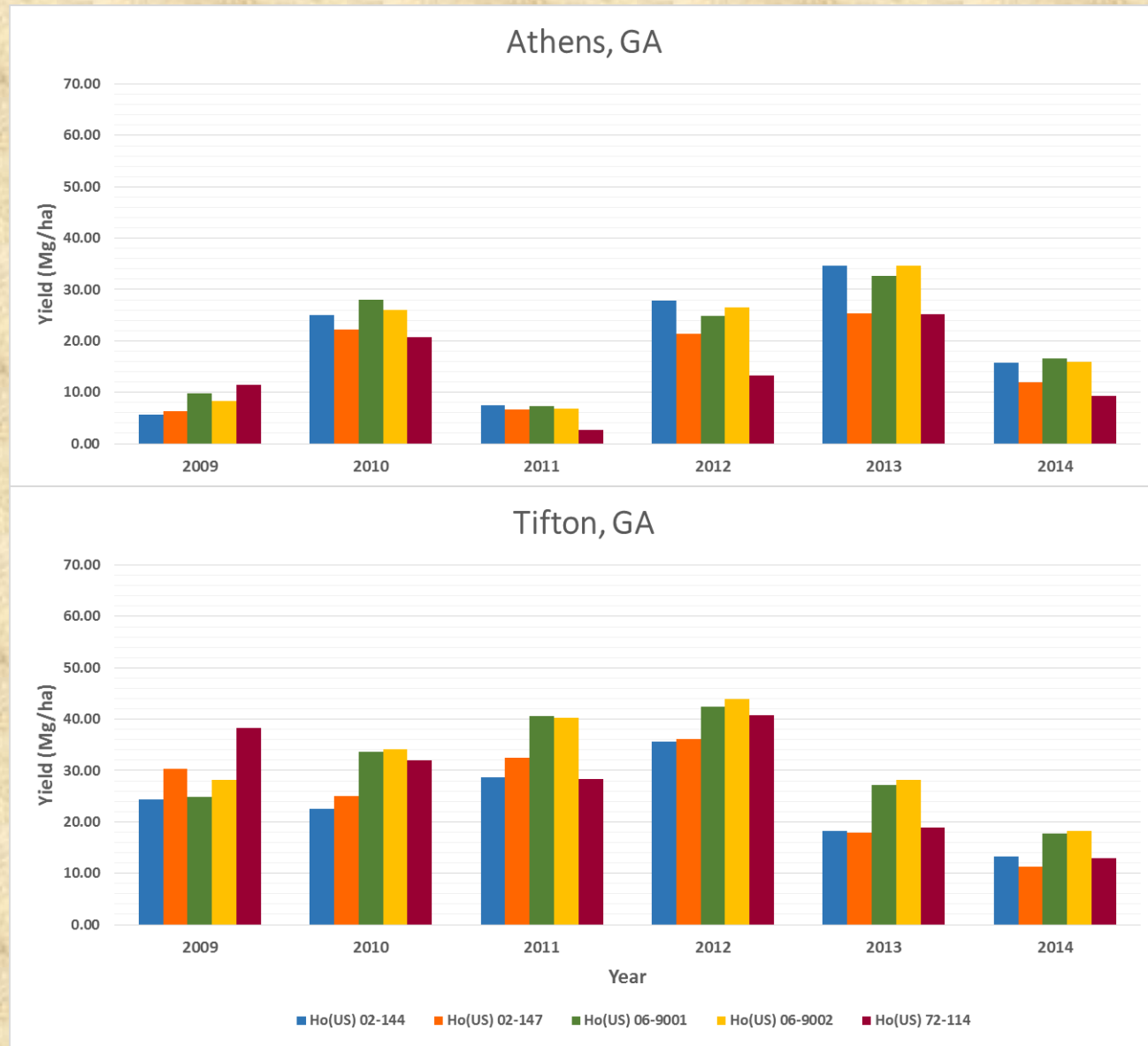
# Energycane production in Georgia

## Athens:

- Delayed planting in 2008
- Cold damage during winter 2010/11

## Tifton:

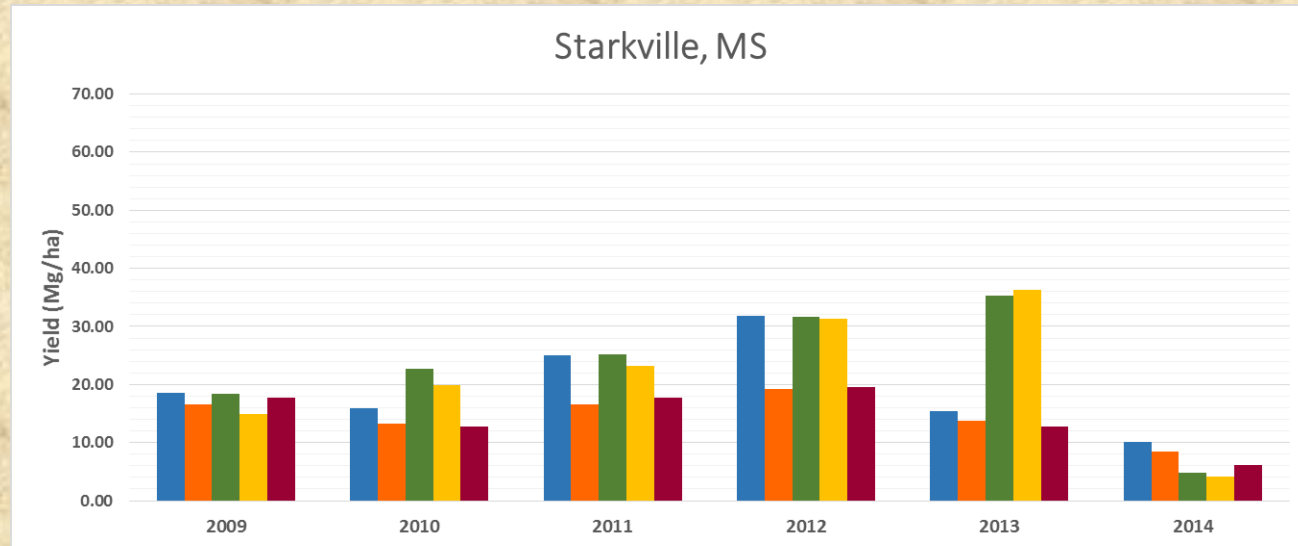
- Yields declining due to stand age and soil pathogen
- 9001 and 9002 among highest yielding across years at both sites



# Energycane production in Mississippi

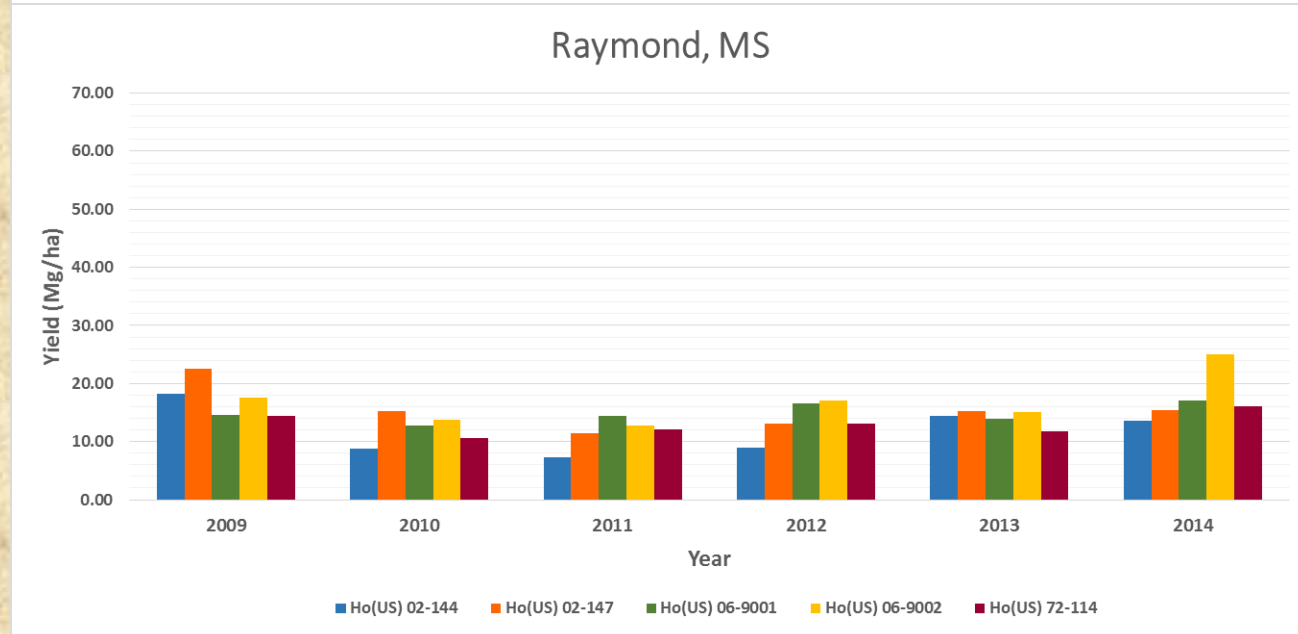
## Starkville:

- Most northern site
- Cold damage during 2012/13 and 2013/14



## Raymond:

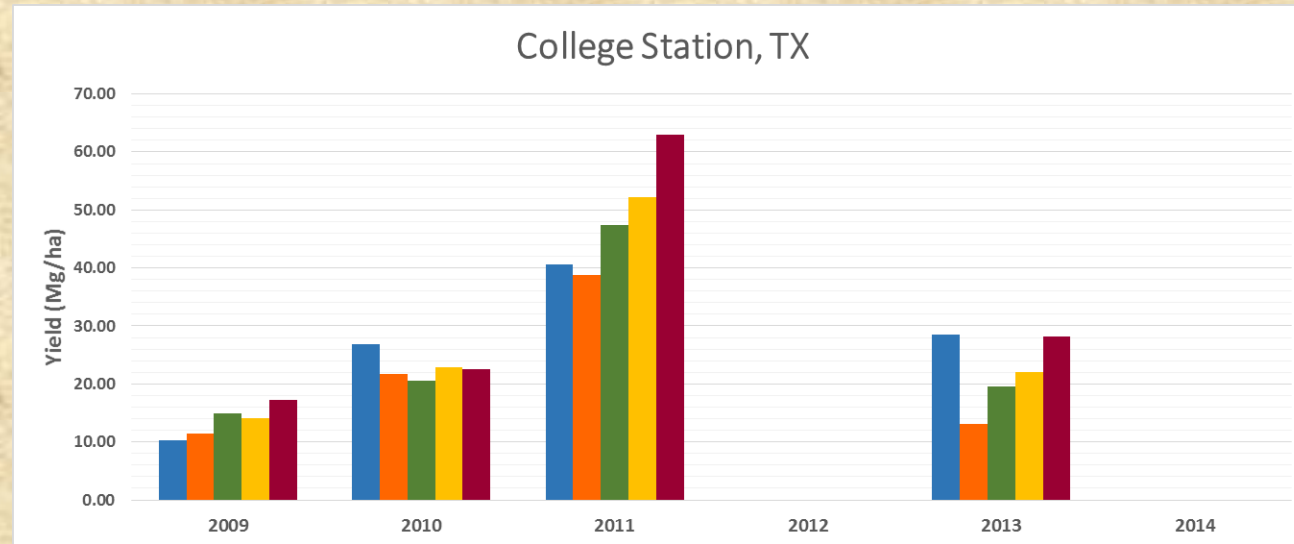
- No difference among entries
- Wetter field site
- One of lowest yielding sites on average



# Energycane production in Texas

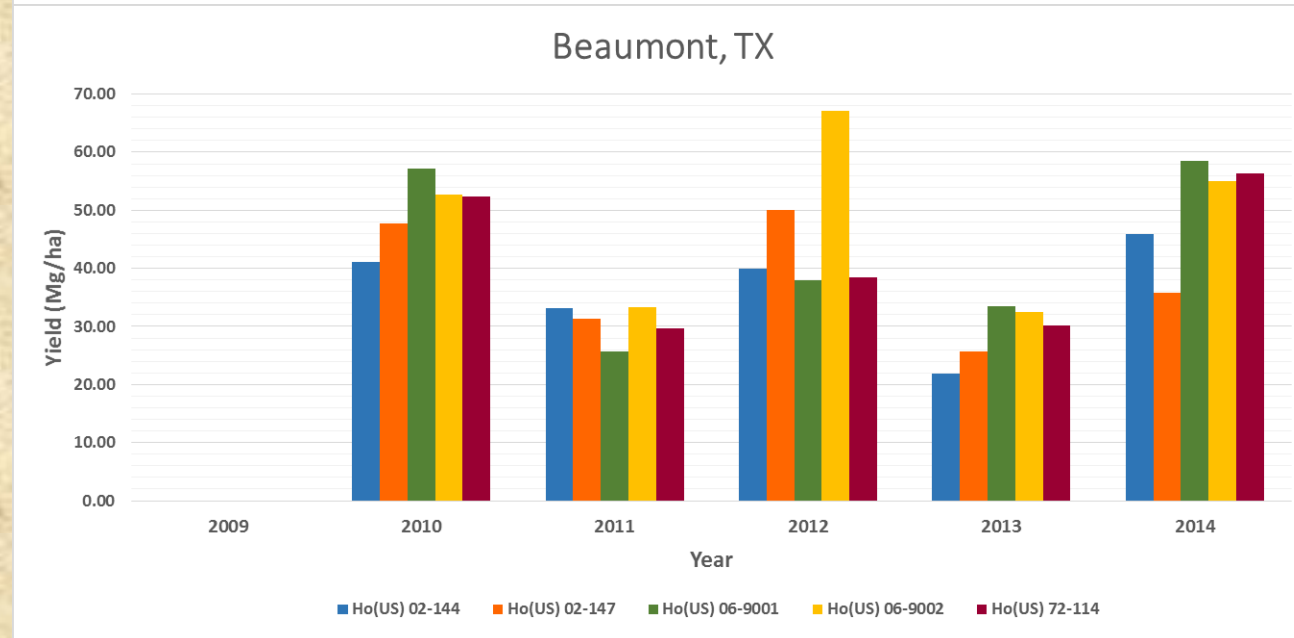
## College Station:

- Irrigated in 2010 to keep crop alive
- No data in 2012; awaiting 2014 data
- 144 and 114 best across years



## Beaumont:

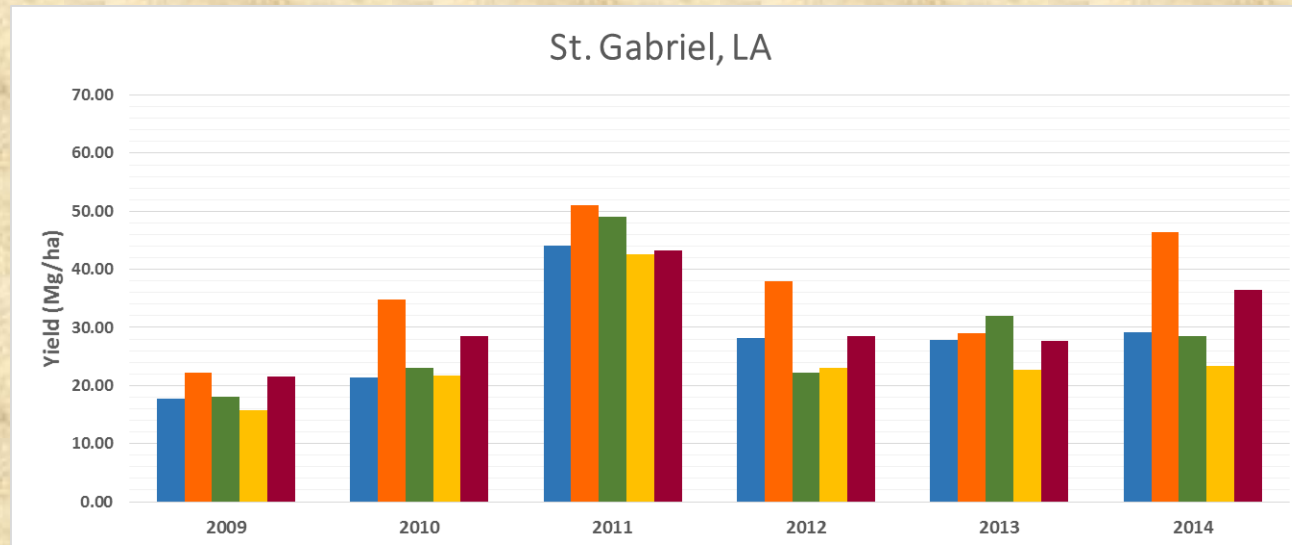
- No yield in 2009 due to tornado
- Among highest yielding sites (sugarcane region)
- 9001 and 114 best across years



# Energycane production in Louisiana (top) and Hawaii (bottom)

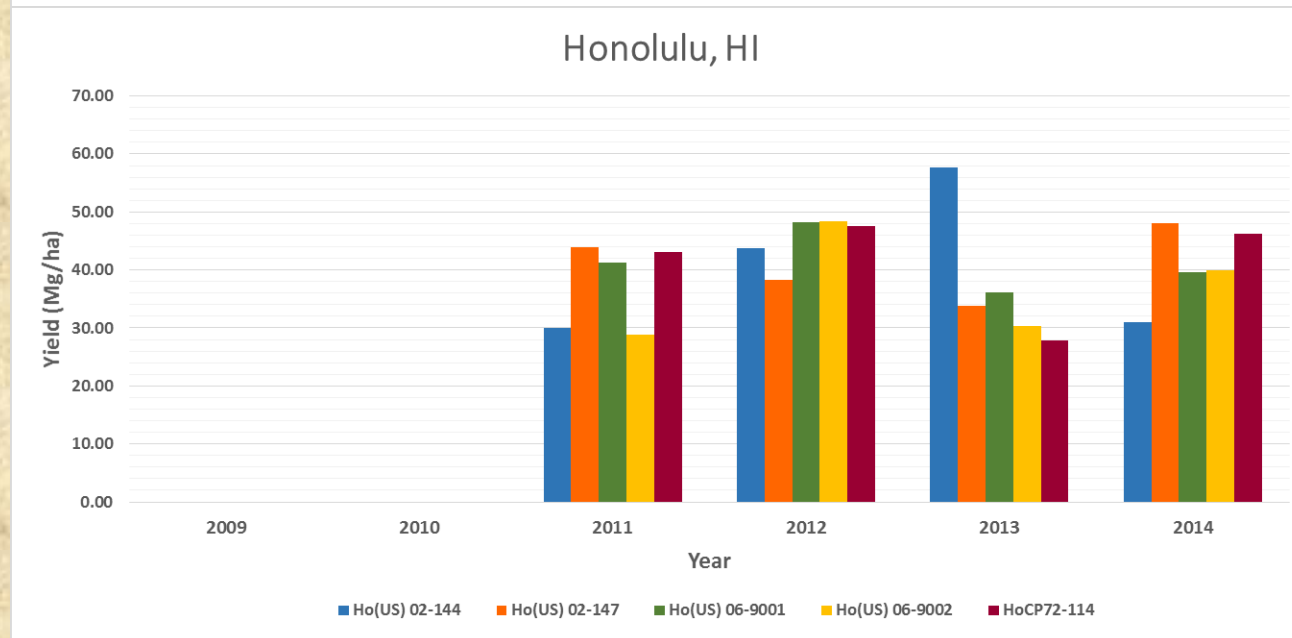
## St. Gabriel, LA:

- Among highest yielding sites (sugarcane region)
- 147 best yielding across years



## Honolulu, HI:

- Seed cane quarantined in 2009
- Planted in field in 2010
- Among highest yielding sites
- 147 and 114 best across years



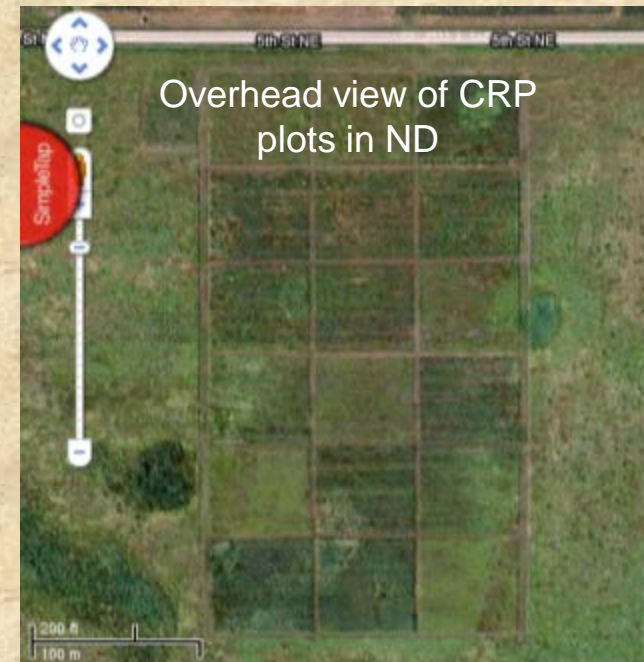


# Summary

- It took six years to show the limitations of the crop
  - Cold winter in the North
  - Pathogen buildup at Tifton, GA and St. Gabriel, LA
- At the northern locations, other crops (switchgrass and giant miscanthus, sometimes sweet sorghum) yield as much
- At Athens and Tifton, GA genotypes 9001 and 9002 yielded among the greatest
  - (at Beaumont, TX it was 9001 and 114)
- At St. Gabriel, LA and Honolulu, HI 147
  - (114 also yielded the greatest at Honolulu)
- At Starkville, MS and College Station, TX 144 yielded the greatest
  - (with 114 also highest at College Station)

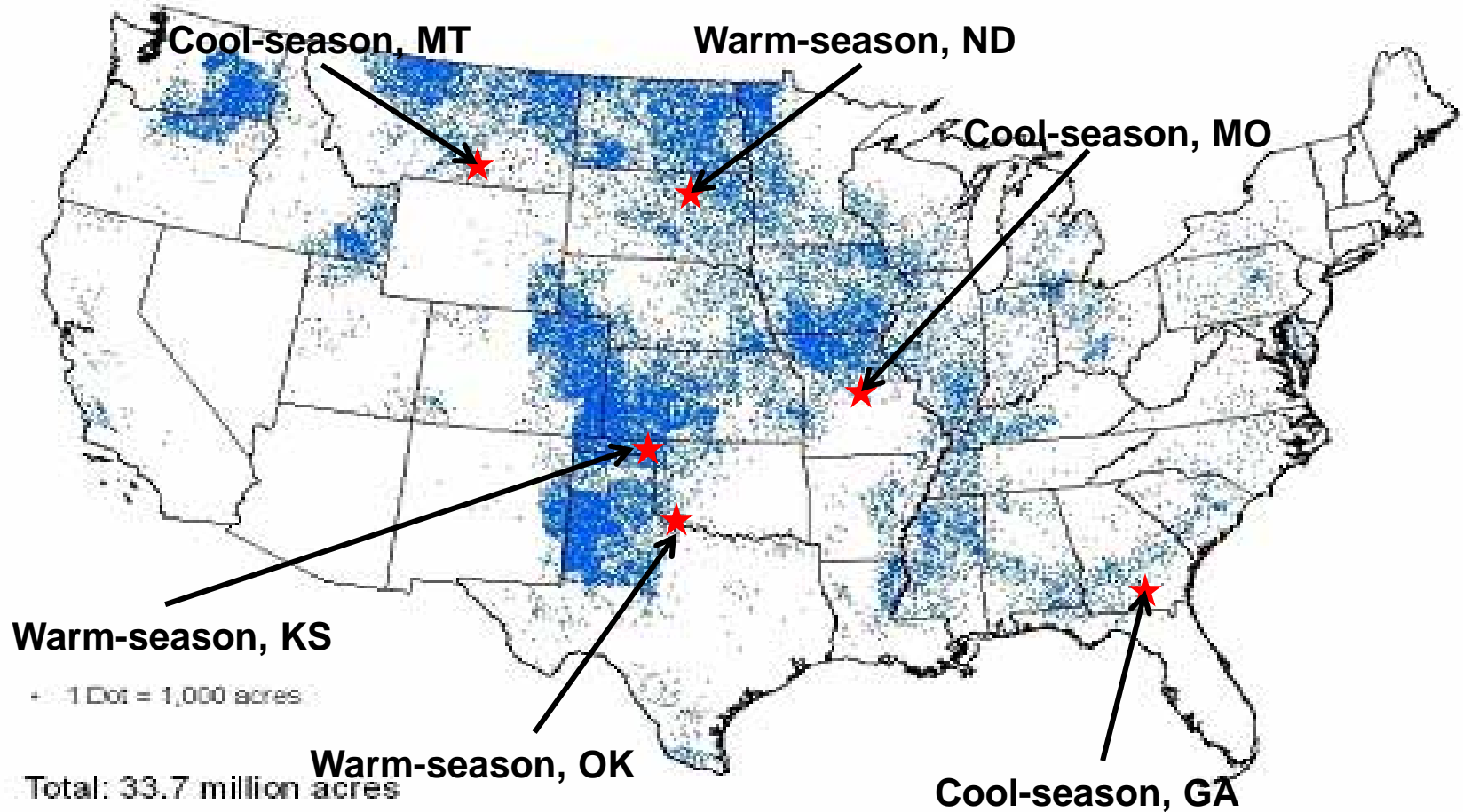
# CRP Trial Locations (DK Lee-UI, Species Lead; Adler-ARS)

- North Dakota: Ezra Aberle (NDSU)
- Kansas: Keith Harmoney (KSU)
- Montana: Chen Chengci (MSU)
- Georgia: Carl Jordan (UGA)
- Missouri: Rob Kallenbach (UMO)
- Oklahoma: Gopal Kakani (OSU)



# CRP Research Sites

## FY 2009 CRP Enrollment



Source: USDA FSA

# CRP Technical Progress/Results to Date

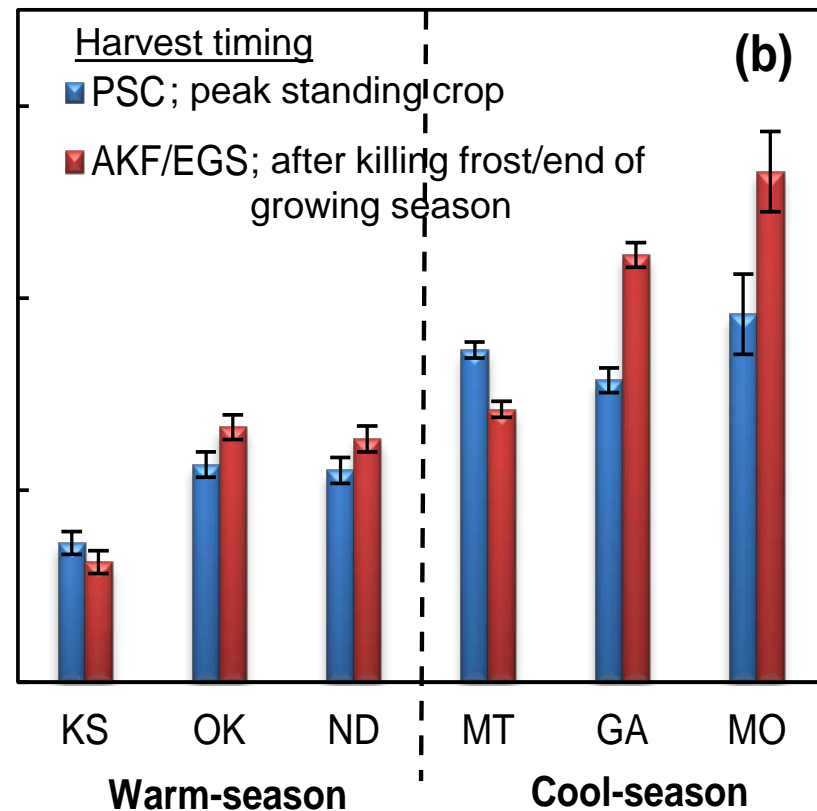
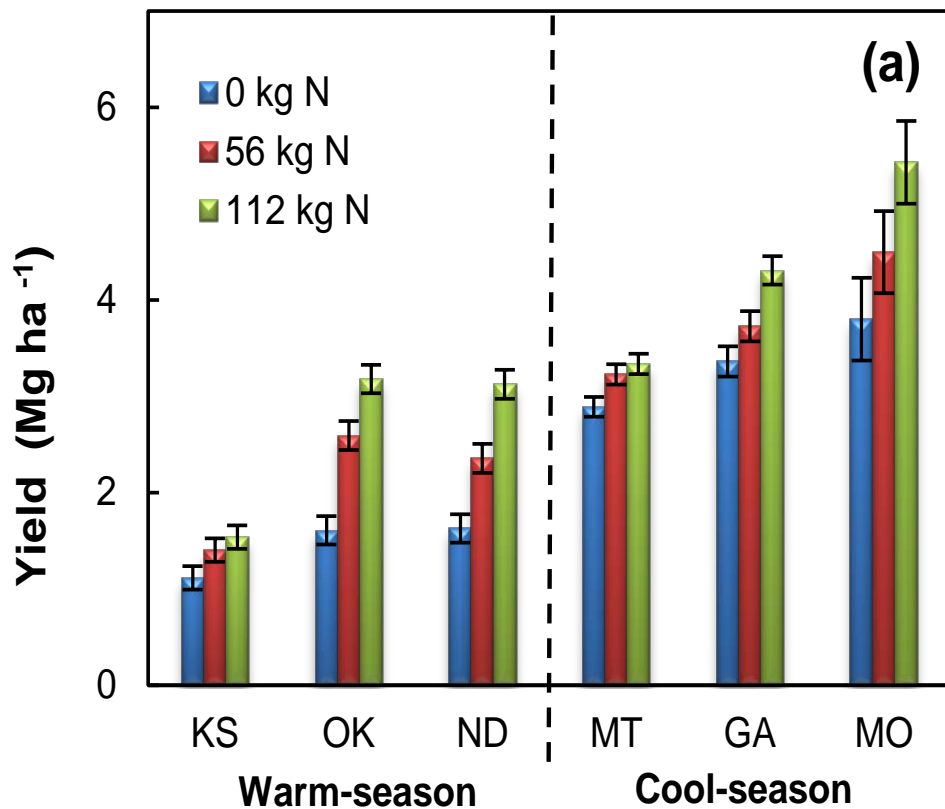
Harvesting CRP plots (warm-season mixtures) in ND in 2011



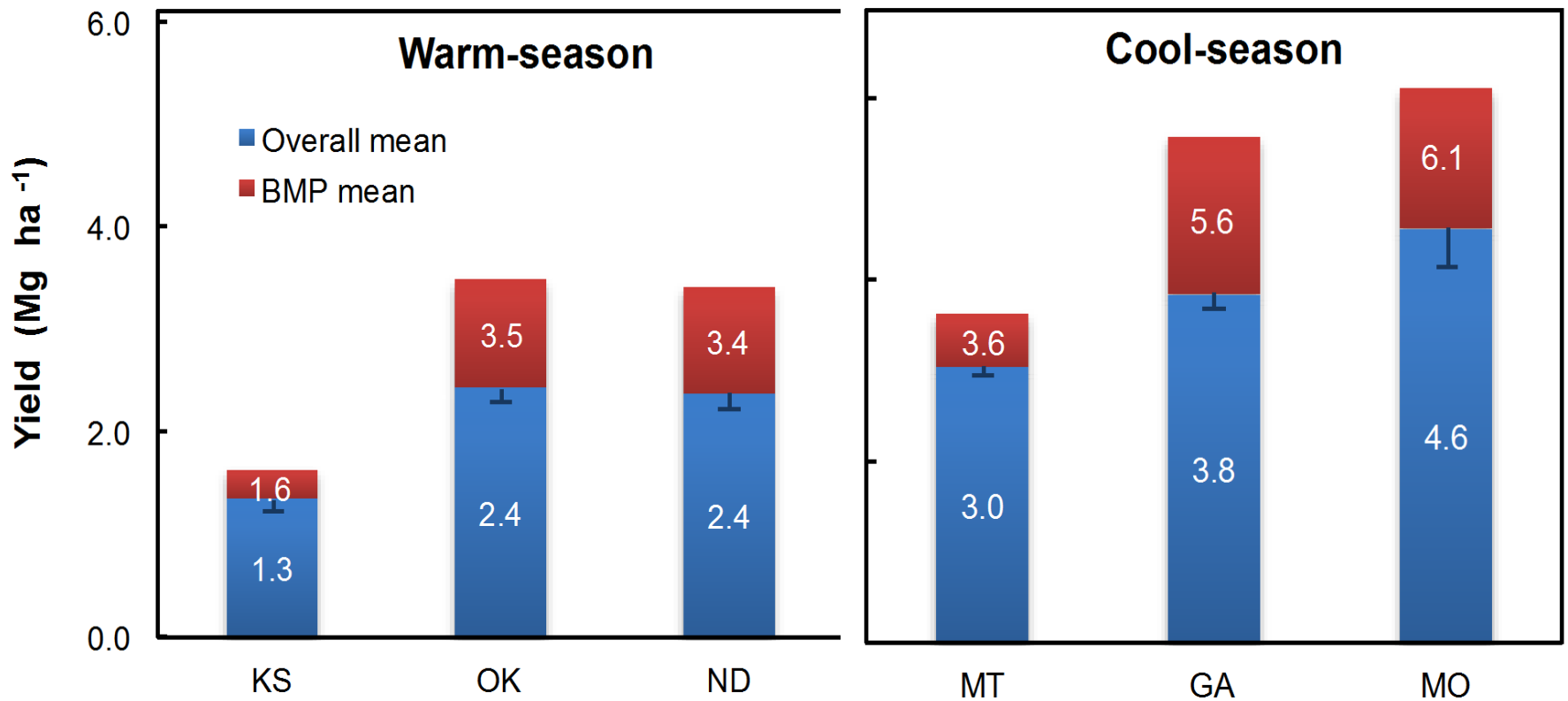
# CRP Project Progress

- Completed field study: 2008-2013
- Field scale (0.4 to 0.5 ha experimental units)
- Field setup: Spring 2008 on active CRP lands
  - Baseline soil sampling: completed in 2008
  - Fertilization (0, 56, 112 kg N ha<sup>-1</sup>): every spring since 2008
- Biomass harvest: every summer and fall since 2008
  - Biomass yield and dry matter
  - Biomass samples to INL
- Species composition: every year since 2008

# Management Effects on Biomass Production (averaged across six growing seasons; 2008-2013)



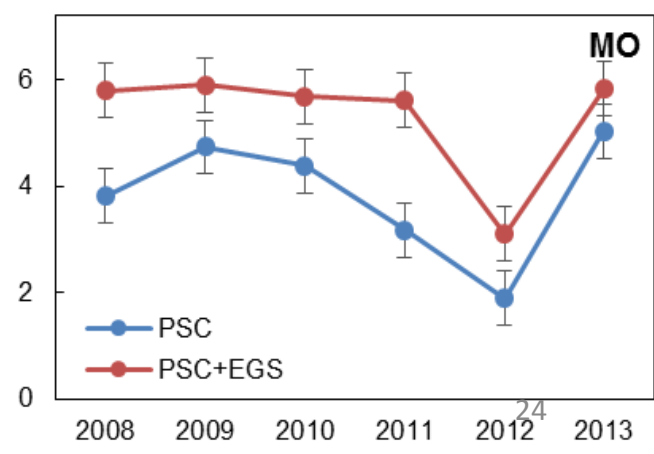
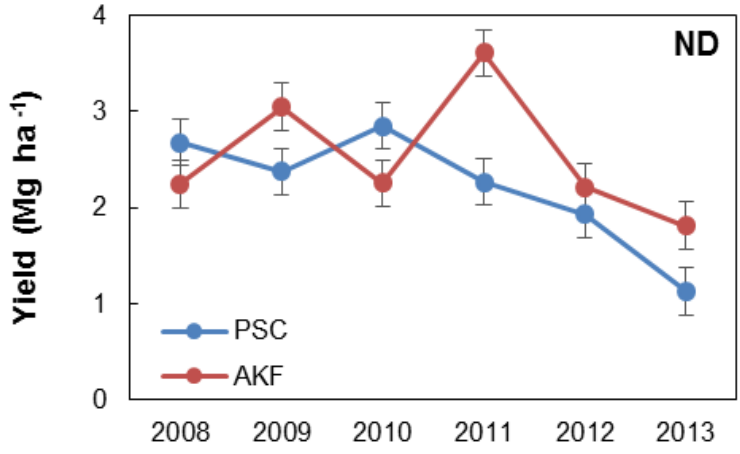
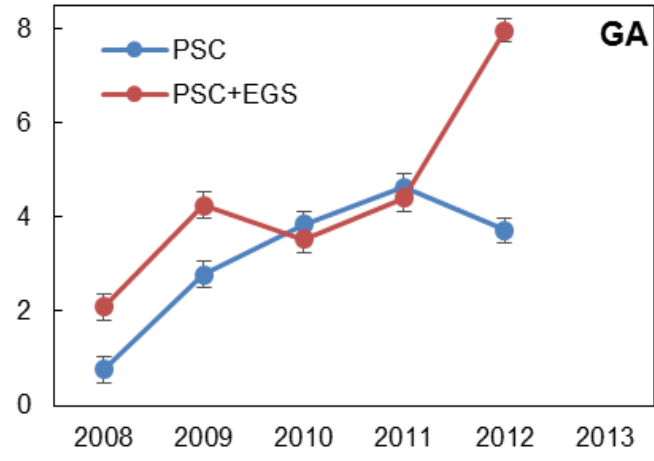
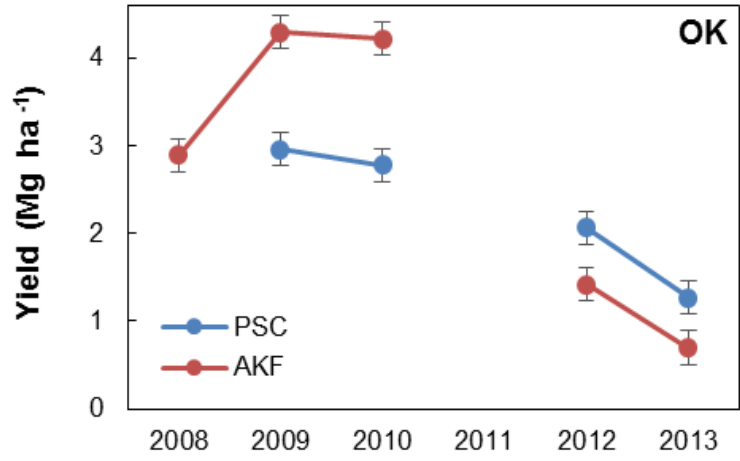
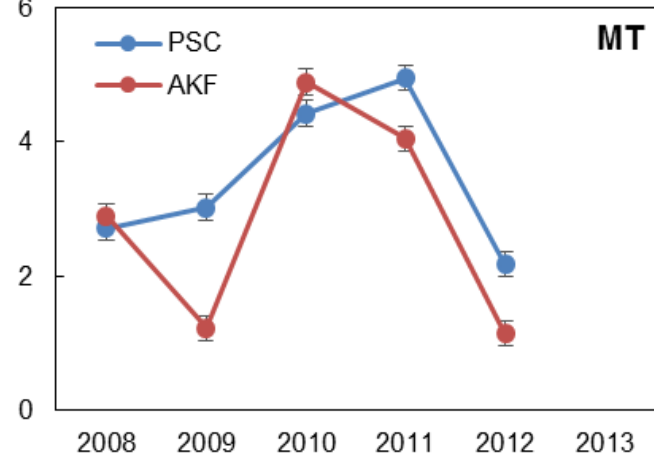
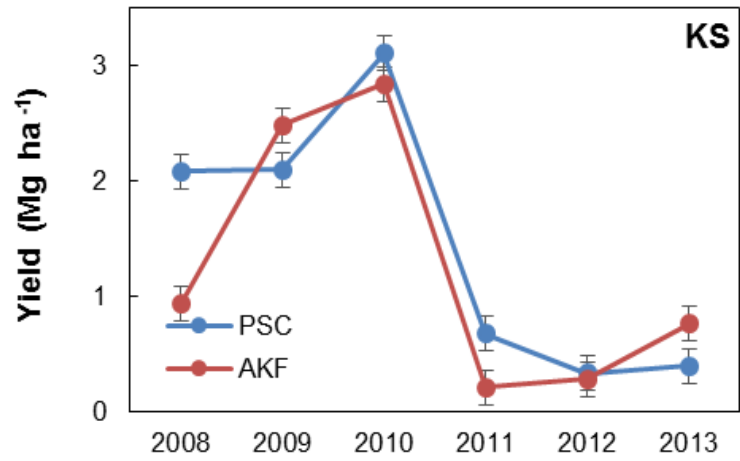
# Average Biomass Production at CRP Sites 2008-2013



BMP; Best Management Practices (considered to be 112 kg N/a and harvested after a killing frost or at end of growing season)

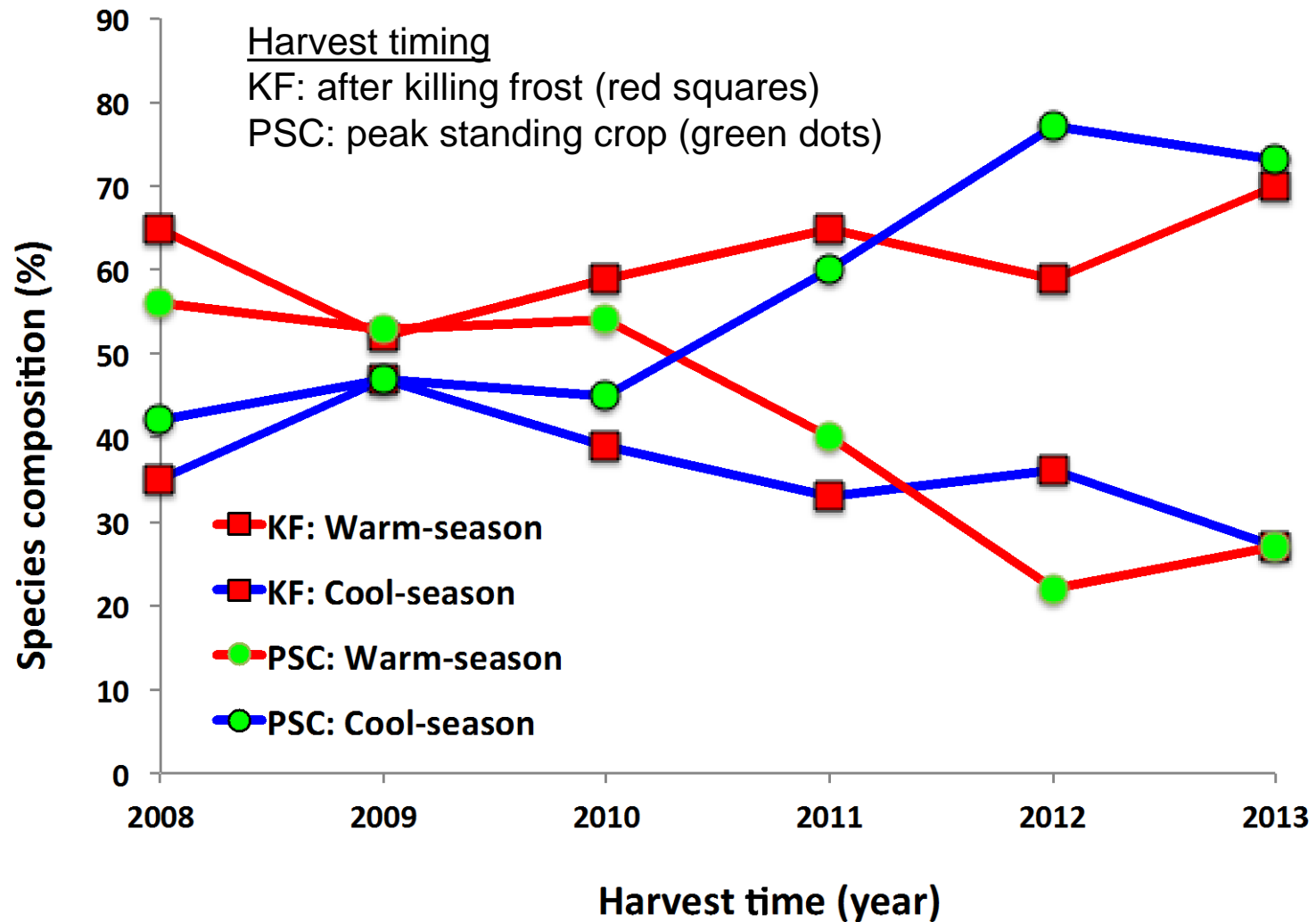
# Importance of Long-term Field Evaluation to see Variability

Harvest timing  
 PSC: peak standing crop  
 AKF: after killing frost





# Harvest Timing Effect on Species Composition



# CRP Summary (2008-2013)

- This farm scale field experiment demonstrated the potential of sustainable biomass feedstock production on CRP lands estimated in the 2005 Billion Ton Study. However, sustainable management practices are required to maximize biomass production
  - Nitrogen (N) fertilization significantly increased biomass feedstock production and adequate N application is crucial to obtaining the yields outlined by the Billion-Ton study, especially in systems where non-leguminous species are prevalent.
  - Harvest management, or timing of biomass harvest, did not have much impact on stand health or long-term biomass production. However, early season harvest for warm-season species dominant mixtures had adverse impacts on changes in species composition. Because of this, delaying harvest until after a killing frost or at the end of growing season is recommended for stand longevity.
- Our six-year field research demonstrated the importance of long-term farm-scale research for accurate estimation of biomass feedstock production potential of CRP grassland.
- These results provide base information
  - for a projection of feedstock production on CRP land.
  - for a thorough economic analysis associated with production of biomass on CRP land.

# *Miscanthus x giganteus* Trial Locations (Voigt-UI; Davis-ARS)

- Illinois: Tom Voigt (Species Lead, UII)
- Kentucky: David Williams (UKY)
- Nebraska: Roch Gaussoin (UNL)
- New Jersey: Stacy Bonos (Rutgers)
- Virginia: John Fike (VT, added in 2010)



# ***Miscanthus x giganteus* Approach**



**Sample Plot  
Layout**

- 12-10 m x 10 m plots with 100 plants on 1-m spacing
- 4 replications at each location
- Annual N fertility treatments (0, 60, 120 kg N ha<sup>-1</sup>) using urea
- Plants in IL, KY, NE, and NJ planted in 2008 (75% IL replanted in 2009); VA planted in 2010

# *Miscanthus x giganteus* Measurements

- Biomass yield at harvest
- Soil moisture
  - moisture probes were installed at 10, 30, and 50 cm (starting in 2009 at the IL site and 2012 at all sites)
- Changes in Soil N and C in IL, KY, NE, NJ
  - comparison of soil samples from at planting and after 4 years at depth of 0-10 and 10-30 cm
- Inorganic N leaching
  - resin lysimeters were installed at 50 cm and collected on a yearly basis (starting in 2009 at the IL site and 2012 at all sites)
- N<sub>2</sub>O emissions (Illinois)
  - Measured using static chambers following the USDA GRACENET protocol
  - Samples were taken throughout the growing season with increased measurements around fertilization periods
- CO<sub>2</sub> emissions (Illinois)
  - Measured using a LI-COR® LI-8100 Automated flux system



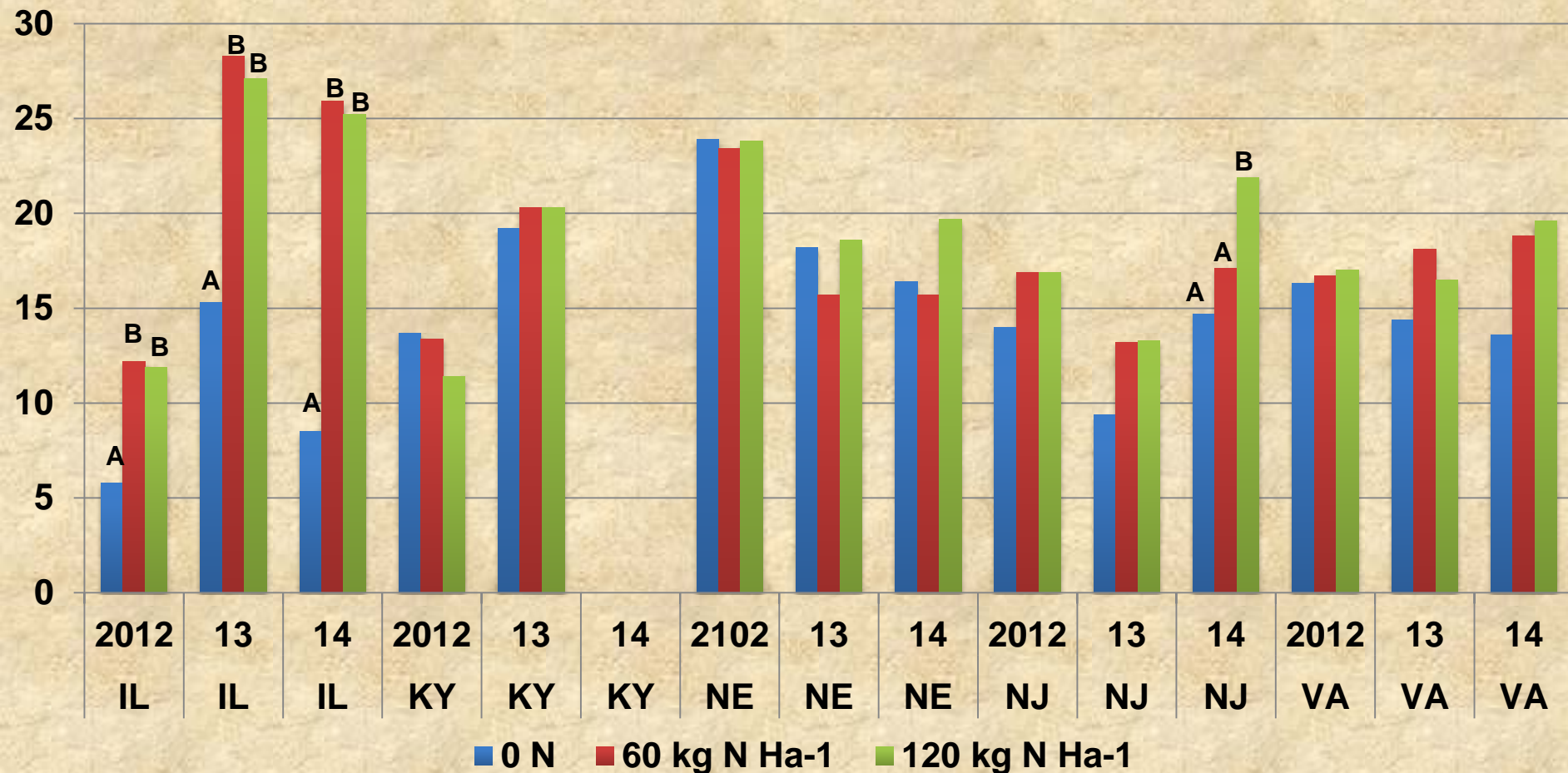
Davis et al. 2014. GCB -Bioenergy. doi: 10.1111/gcbb.12217.

2009 – 2014 *Miscanthus x giganteus* Biomass Yields  
Averaged Across N Rates (Dry Mg ha<sup>-1</sup>)

| Location   | 2009 | 2010 | 2011 | 2012  | 2013  | 2014  |
|------------|------|------|------|-------|-------|-------|
| Illinois   | 3.0  | 15.6 | 20.6 | 10.0* | 23.6* | 19.9* |
| Kentucky   | 17.1 | 19.0 | 19.0 | 12.8  | 19.9  | -     |
| Nebraska   | 15.6 | 27.4 | 31.2 | 23.7  | 17.5  | 17.3  |
| New Jersey | 16.9 | 9.7  | 18.6 | 15.9  | 12.0  | 17.9* |
| Virginia   | -    | -    | 9.4  | 16.7  | 18.1  | 17.3  |

\* Significant yield differences based on N application rates

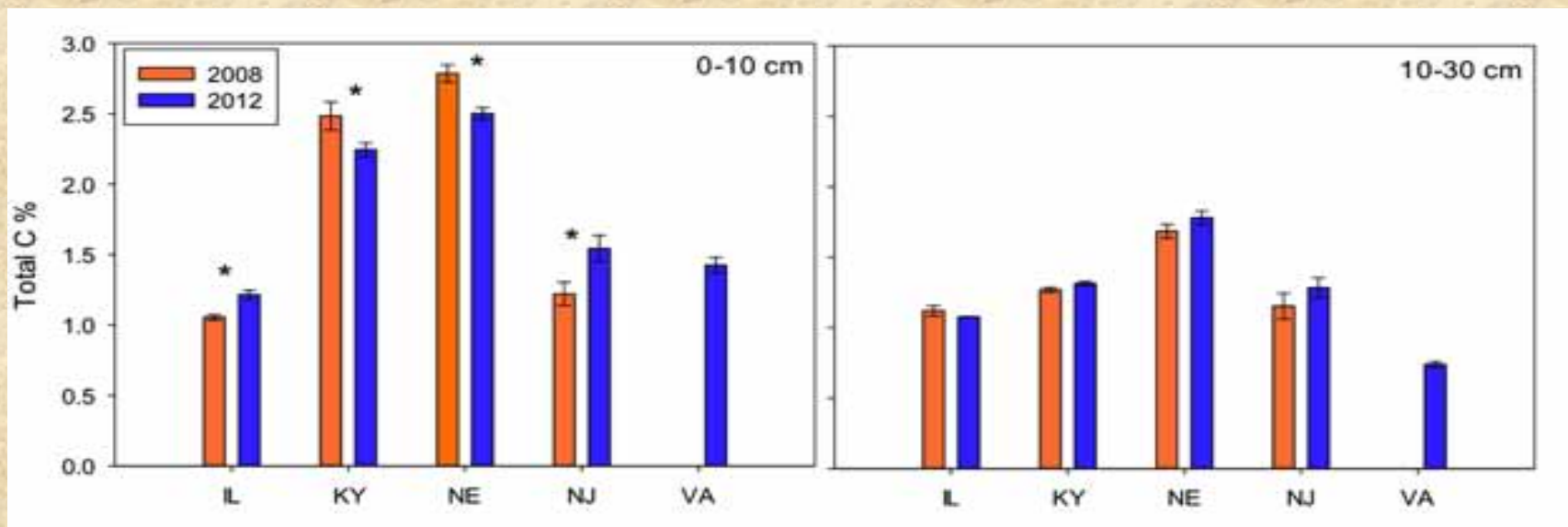
# 2012 - 2014 *Miscanthus x giganteus* Feedstock Partnership Yields (Dry Mg ha<sup>-1</sup>)



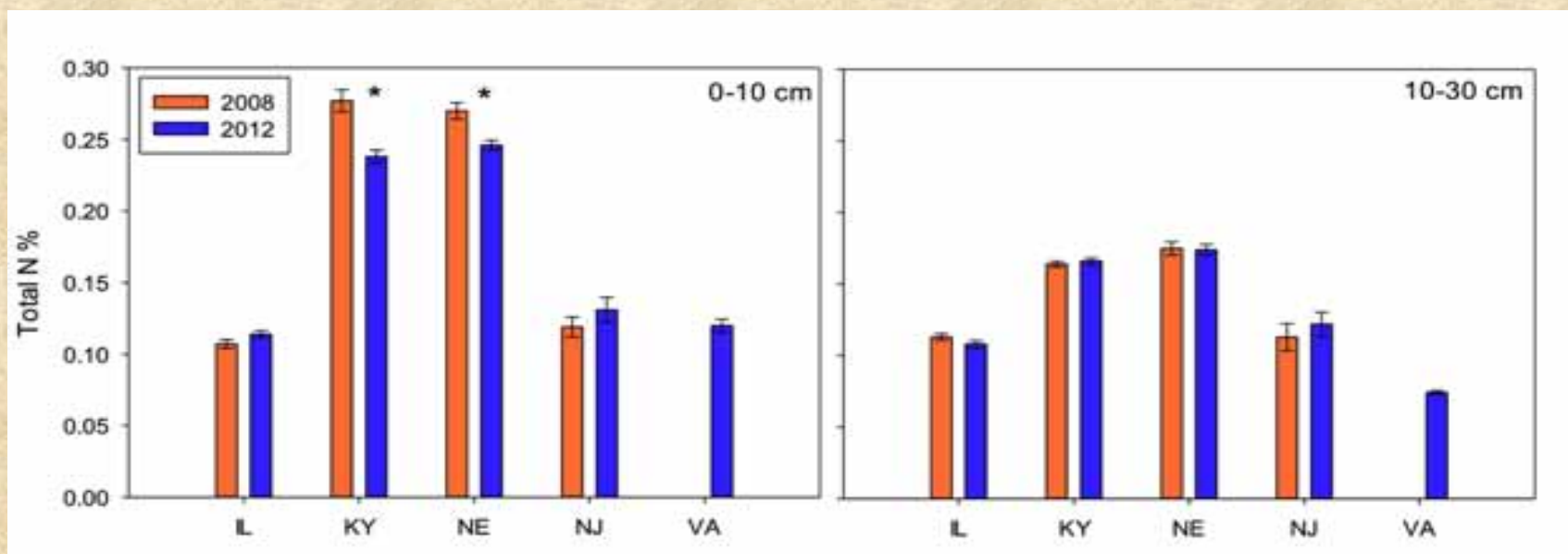
Drought of 2012: extreme drought conditions in Illinois and Nebraska; moderate drought conditions in Kentucky; abnormally dry conditions in Virginia

Hurricane Sandy: New Jersey experienced lodging from snowfall after storm surge of Sandy

# Total Soil Carbon

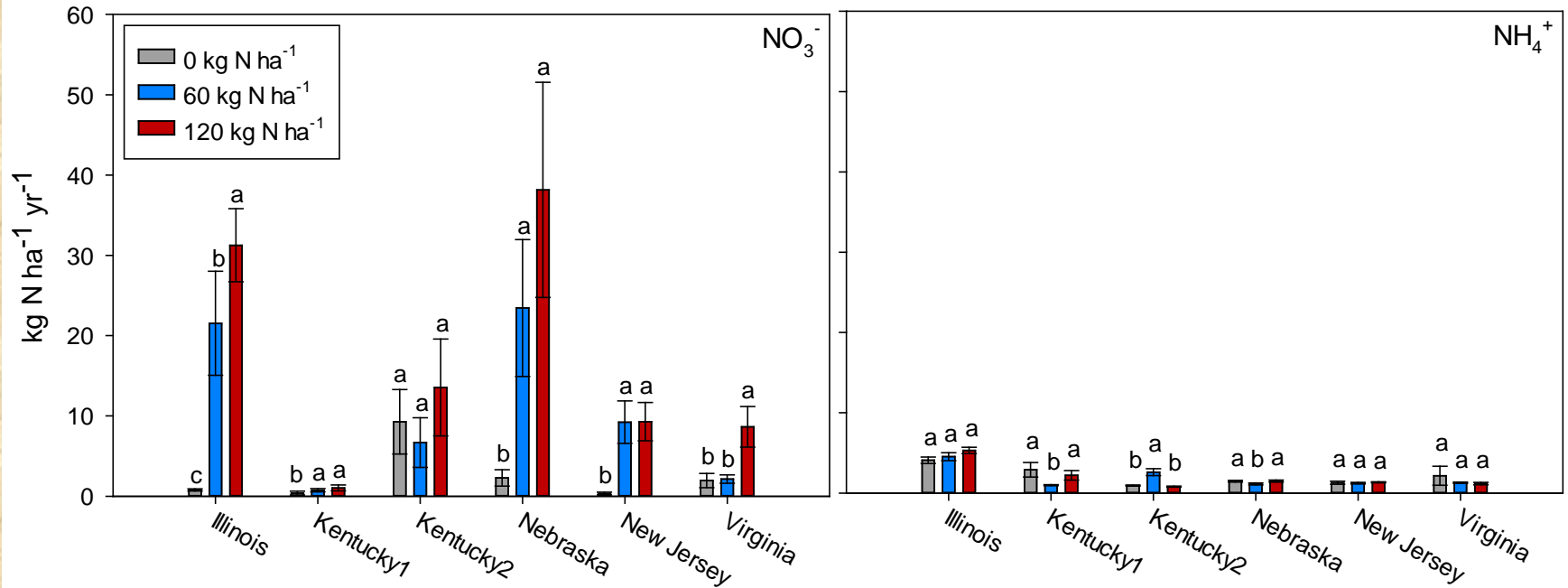


# Total Soil Nitrogen

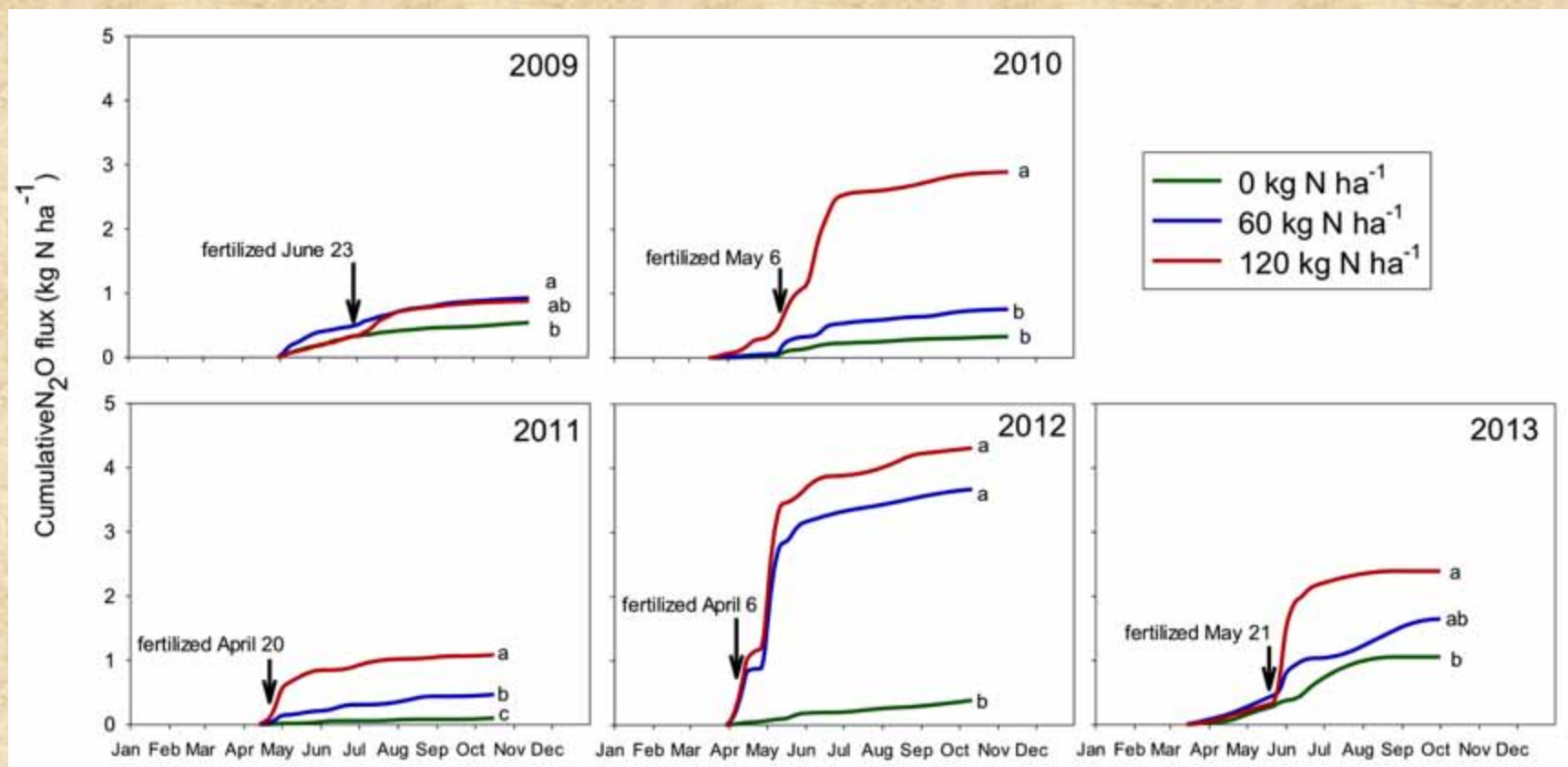




# Cumulative Nitrate and Ammonium Leaching from Spring 2012 - Spring 2013 in *M. x giganteus*



# Annual Cumulative N<sub>2</sub>O Emissions in *M. x giganteus* in Illinois



# *Miscanthus x giganteus* Conclusions

- N fertilizer rates have affected biomass yields in Illinois in 2012 and 2013, and in IL and NJ in 2014 (both have sandy soils)
- Poor soil moisture affected yields in 2012 at several locations
- Some soil changes occurred at the 0-10 cm depth
  - Soil N levels dropped at NE and KY
  - Soil carbon levels increased at NE and KY, and decreased at IL and NJ

# *Miscanthus x giganteus* Conclusions (cont.)

- Fertilizing *M. x giganteus* usually increased N losses
  - nitrate leaching is greater under fertilized plots across the eastern US
  - losses were usually greatest in the 120 (kg N ha<sup>-1</sup> yr<sup>-1</sup>) plots at all sites
  - fertilized plots had a larger N<sub>2</sub>O fluxes, and greater yearly emissions
- CO<sub>2</sub> more related to temperature and moisture than N fertilization

# Switchgrass Trial Locations (Owens-SDSU; Mitchell-ARS)

- South Dakota: Vance Owens (Species Lead; SDSU)
- Virginia: John Fike (Species Lead; VT)
- Alabama: David Bransby (Auburn, 2010)
- New York: Don Viands (Cornell)
- Oklahoma: Rodney Farris(OSU)
- Iowa: Emily Heaton (ISU, 2009)
- Nebraska: Rob Mitchell (USDA ARS)



South Dakota harvest 2010

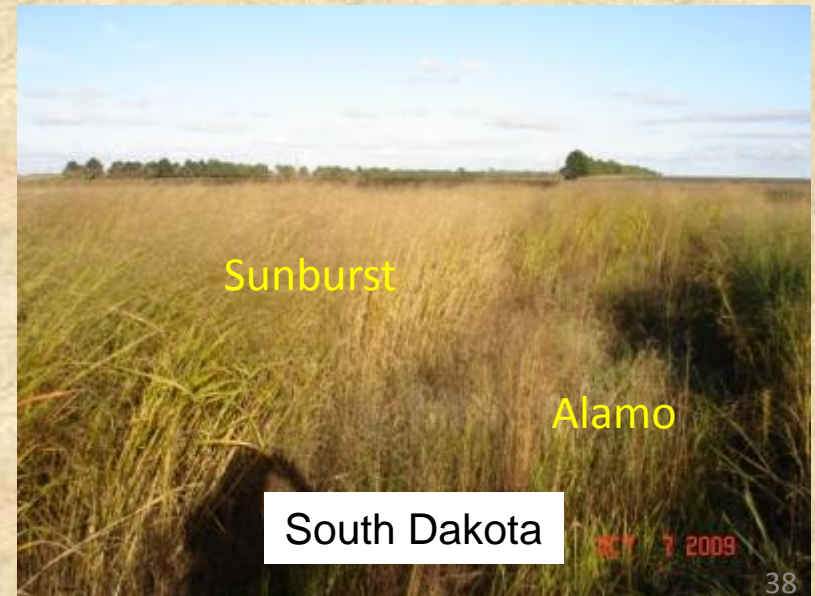
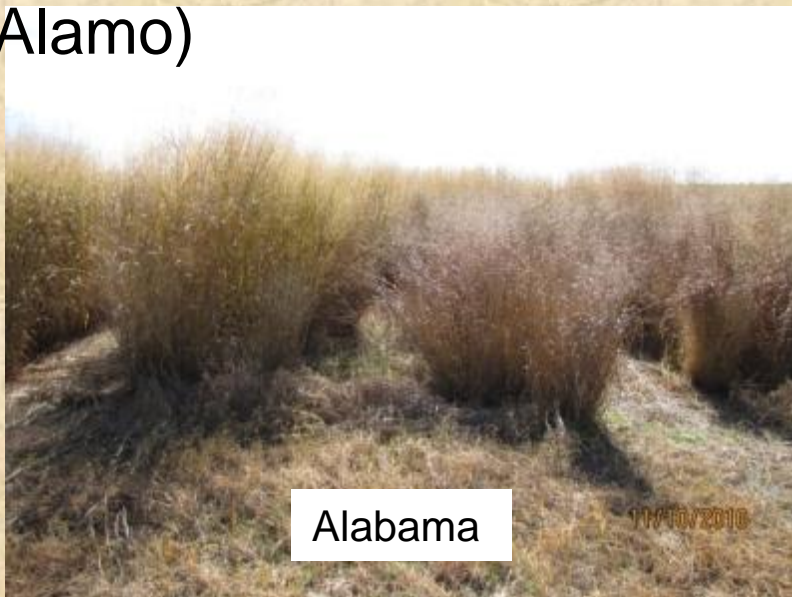


Iowa planting 2009



# Switchgrass Approach

- Field scale (0.4 to 0.8 ha experimental units)
- Four replicates across landscape
- Nitrogen (0, 56, 112 kg ha<sup>-1</sup>) applied annually beginning the year after planting at all locations (except AL where application began two years after planting)
- Locally adapted cultivar at each location (AL-Alamo, IA-Cave-In-Rock, NY-Cave-In-Rock, OK-Blackwell, SD-Sunburst, VA-Alamo)



# Switchgrass Progress/Results to Date

- Initial soil characteristics utilizing minimum soil data set
  - Total organic carbon; soil pH; Total N; Bulk density; Soil-test P and K
- Yield using standard, farm-scale equipment available at each location
- Biomass collected from plots for chemical characterization
  - Samples from windrow and/or bales sent to INL
  - Samples analyzed locally for other estimates of biomass quality



# Switchgrass harvest and collection

Windrowed switchgrass in SD  
(note wet areas at bottom of slope)



Baled switchgrass in SD (note dark area in bale resulting from wet field conditions)



Switchgrass stubble  
after cutting (AL)

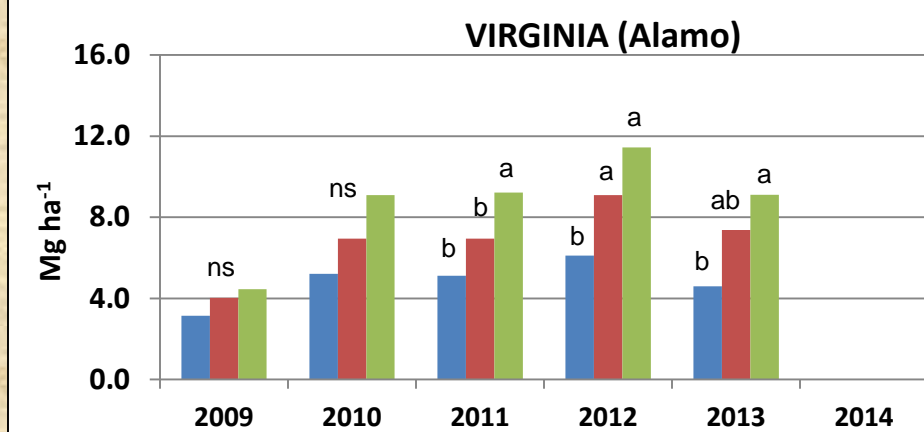
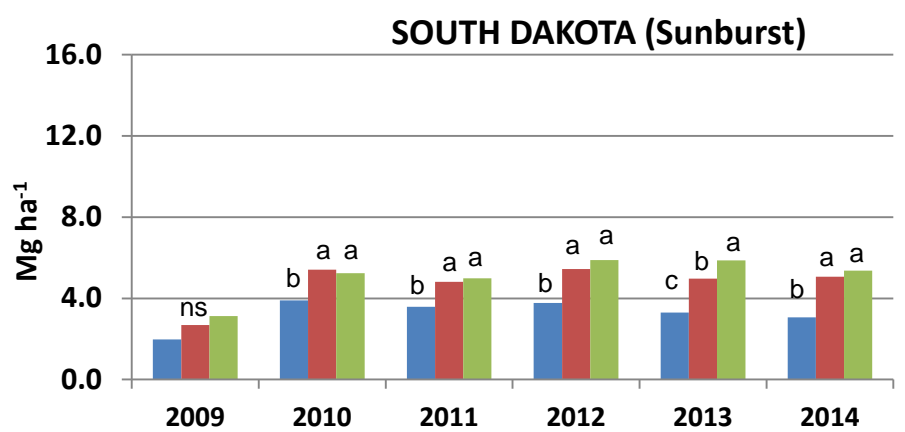
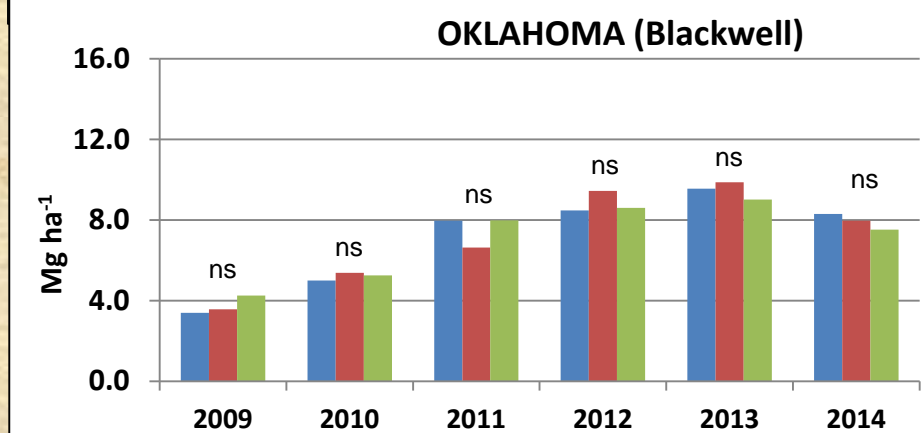
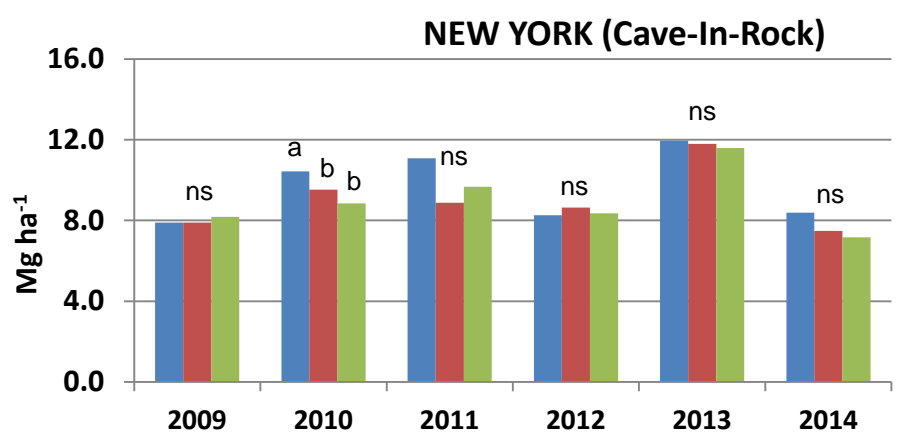
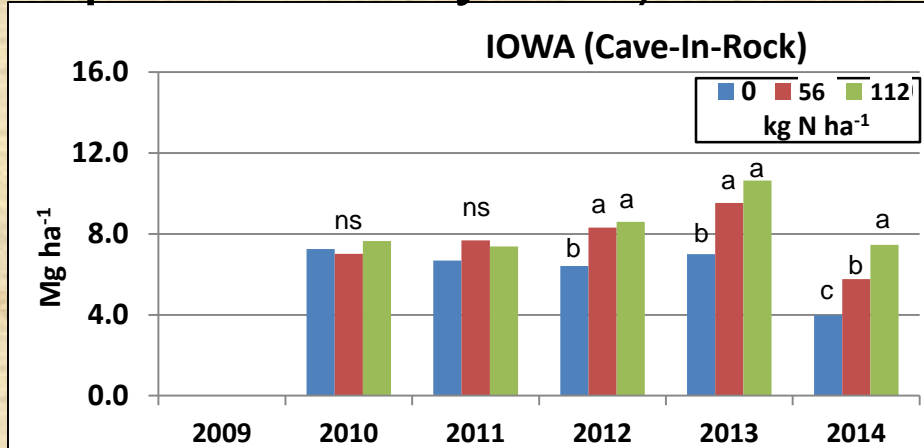
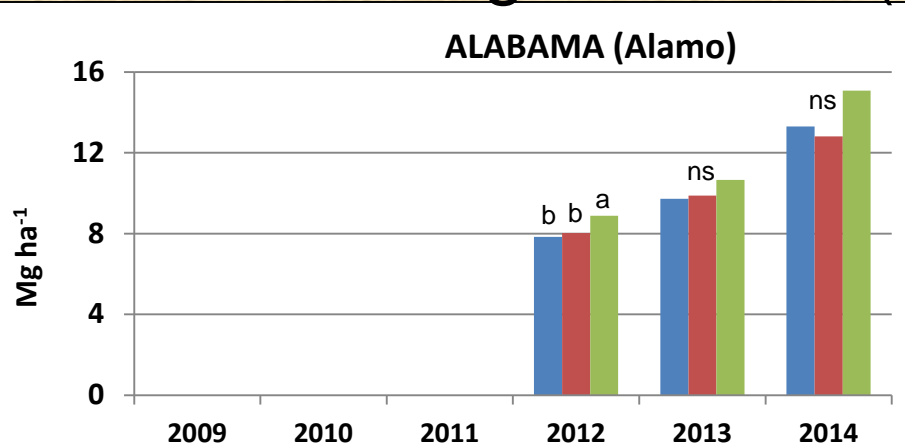


Windrowed switchgrass in SD  
(2014-6<sup>th</sup> growing season)



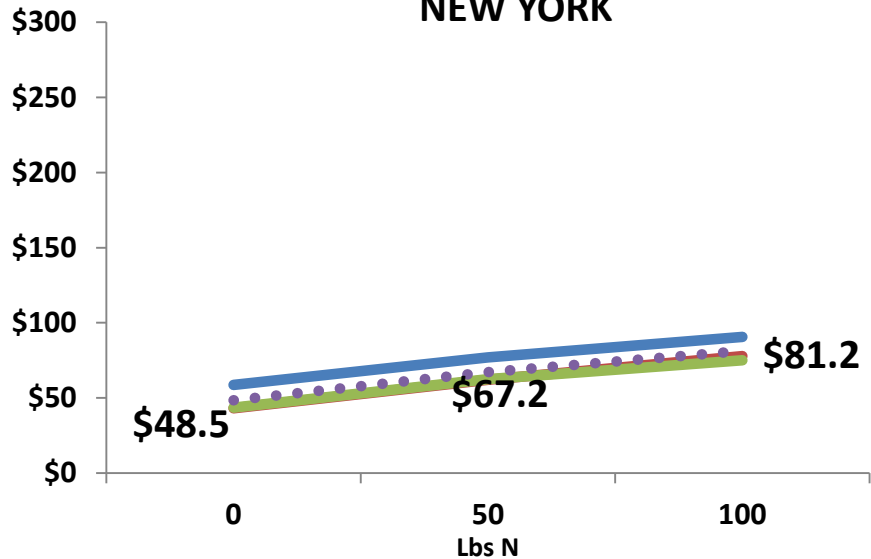


# Switchgrass Yield (3-6 production years)

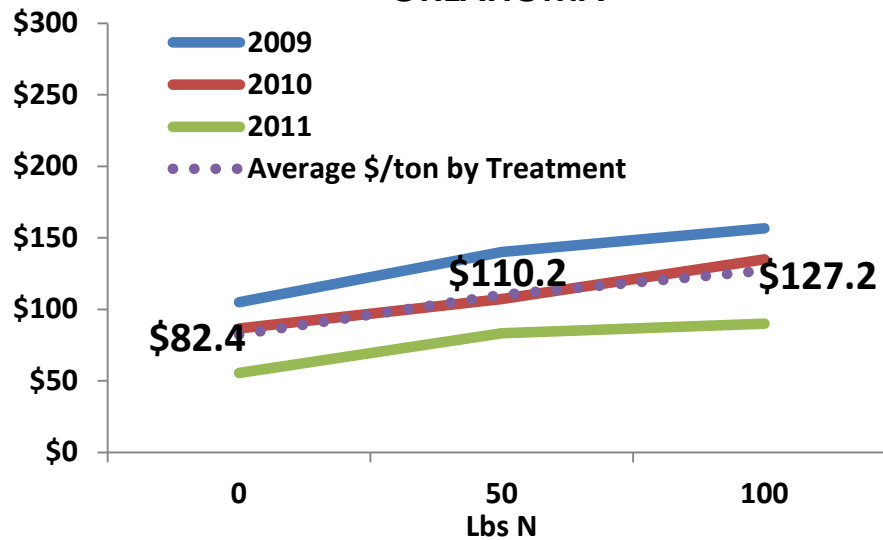


# Production costs (\$/dry ton) in 2009, 2010, 2011 for sites planted in 2008. Establishment costs included in 2009 data.

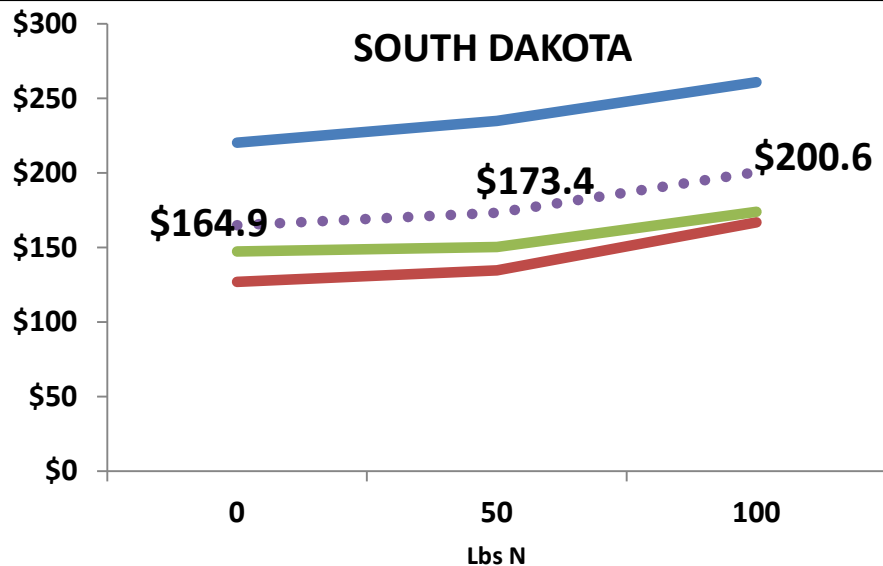
## NEW YORK



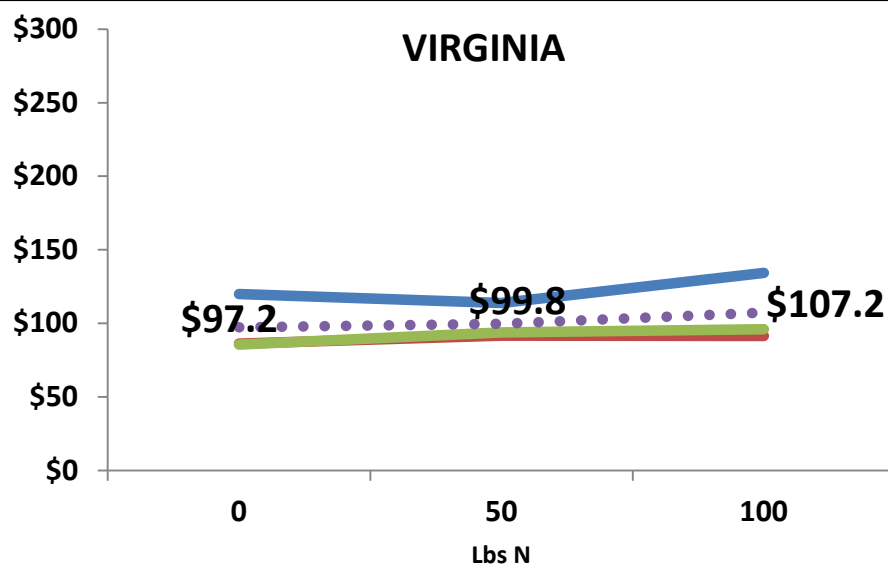
## OKLAHOMA



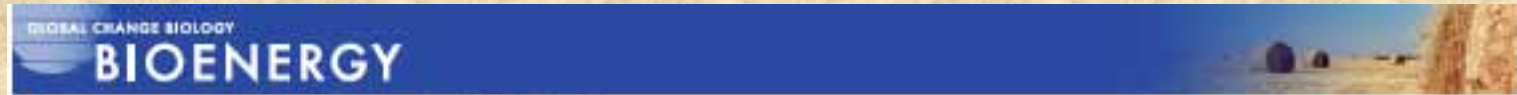
## SOUTH DAKOTA



## VIRGINIA



# Switchgrass Sustainability Results (South Dakota)

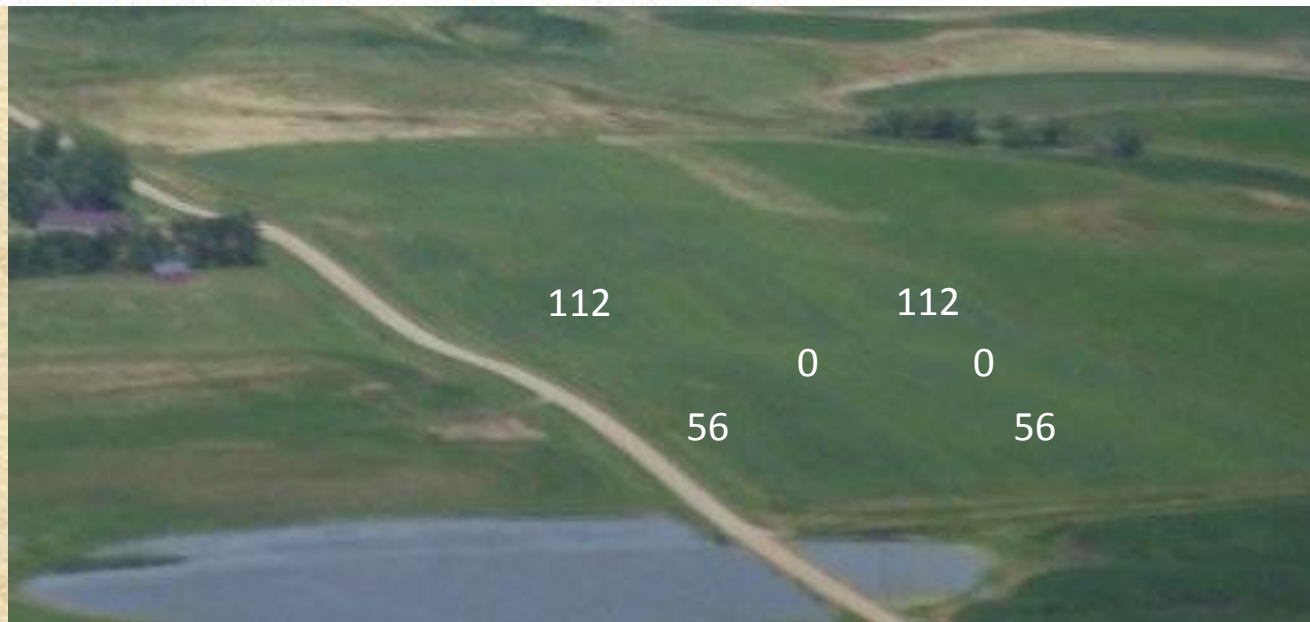


GCB Bioenergy (2014), doi: 10.1111/gcbb.12187

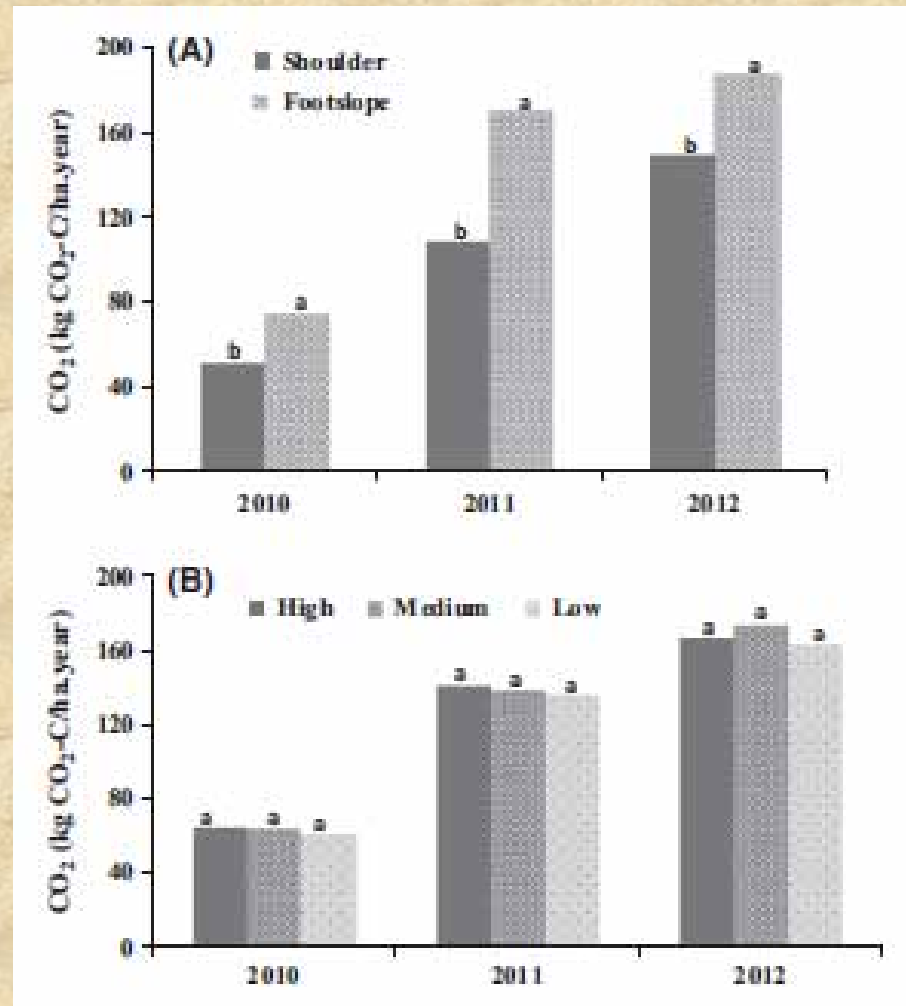
## Nitrogen fertilizer and landscape position impacts on CO<sub>2</sub> and CH<sub>4</sub> fluxes from a landscape seeded to switchgrass

ERIC G. MBONIMPA<sup>1</sup>, CHANG O. HONG<sup>2</sup>, VANCE N. OWENS<sup>1</sup>, R. MICHAEL LEHMAN<sup>3</sup>, SHANNON L. OSBORNE<sup>3</sup>, THOMAS E. SCHUMACHER<sup>1</sup>, DAVID E. CLAY<sup>1</sup> and SANDEEP KUMAR<sup>1</sup>

<sup>1</sup>Department of Plant Science, South Dakota State University, Brookings, SD, USA, <sup>2</sup>Pusan National University, Busan, South Korea, <sup>3</sup>United States Department of Agriculture, Brookings, SD, USA



Average annual soil CO<sub>2</sub> fluxes for 2010, 2011, and 2012 from switchgrass production in South Dakota as influenced by two landscape (shoulder and footslope) positions (A), and three nitrogen rates (Low-0 kg N/ha; Medium-56 kg N/ha; and High-112 kg N/ha) (B).



(Mbonimpa et al. 2014)

# Switchgrass Summary

- Switchgrass production has varied annually in response to:
  - Establishment (With exception of IA, yield the year after planting was lower than succeeding 2-3 years)
  - Weather (drought, floods, etc.)
  - Stand age (Yield decreased slightly in the fifth or sixth production year in IA, NY, OK, VA; remained steady in SD)
  - Harvest conditions (e.g. weather related delays)
- Based on the annual variability, 2015 production data will be very important
- Switchgrass yield not consistently affected by N application
- Production costs varied by location, but primarily affected by yield
- Landscape position: In general, CO<sub>2</sub> and CH<sub>4</sub> fluxes were higher at the footslope position than at the crest
- N rate did not impact CO<sub>2</sub> and CH<sub>4</sub> fluxes
- Cumulative N<sub>2</sub>O emissions affected by N application and season of growth
- Nitrate leaching higher with high N rate

## 4 – Relevance

- Multi-year, region-specific, yield and composition data for potential feedstocks to help with construction of feedstock supply curves to better understand ability to meet future biomass production goals.
- Developing baseline productivity estimates for various species across regions; have 3-6 years data for nearly all field trial sites after 2014; this data has been used extensively in the GIS mapping process.
- Selected sites are gathering environmental sustainability data, along with yield data, to better understand effect of feedstock production and management on soil C, water use, and GHG
- Field trial data being submitted to KDF and will be made available for public use as publications continue to be completed
- All of this is highly relevant to industry as biorefineries are sited and to policy makers as they evaluate bioenergy practices

## 5 - Future Work

- Develop final reports for each herbaceous species and meld with synthesis report being developed for overall Partnership
- Submit all field trial data to KDF using species-specific templates (includes meta data, annual yield data, site descriptions, etc.)
- Manuscript preparation; working on herbaceous manuscript as part of Regional Feedstock Partnership proposed special publication
- Revise national yield potential maps in conjunction with OSU PRISM group
- Depending on funding, continuing/expanding field trials based on results obtained thus far (i.e., What is the outlook for long-term sustainable production of these, and possibly other, biomass feedstocks?)

# Summary

- Location (i.e., environment) and genetics influence production
- Challenges exist: weather, moisture, harvestable biomass, long-term persistence
- Critical baseline, multi-year data gathered for these species is providing empirical evidence of yield potential
- Management practices affect sustainability
- Long-term evaluation critical in order to really understand crop performance and sustainability impacts



# Additional Slides

# Response to Previous Reviewers' Comments

- Reviewer comment: “This overview of herbaceous energy crops included Energycane, miscanthus, switchgrass, and mixtures on CRP ground. The team was well distributed across the US and included many of the leading researchers. However, some key researchers and long term research sites were missed. The non-competitive nature of team assembly was likely a factor in this limitation.”
- Response: Sites and researchers were selected based on a desire to have appropriate geographical distribution and experience with specific species. Although we would have liked to have had more sites and more investigators, funding limited the number we could feasibly operate.
- Reviewer comment: “Sustainability data collection should have started earlier.”
- Response: Regarding the start of sustainability measurements: no funds were provided to this project to begin gathering sustainability data when the project started. This is why these measurements began approximately one year later.
- Reviewer comment: “Need more years of data before predictions can be projected. Rather than plot data, need field trial information.”
- Response: Field scale information is critical. We hope that future work can include field scale trials on all species, not just switchgrass and CRP.

## Publications and Presentations—Energycane

### Peer reviewed manuscripts

- Knoll, Joseph E., William F. Anderson, Edward P. Richard Jr., Joy Doran-Peterson, Brian Baldwin, Anna L. Hale, Ryan P. Viator. 2013. Harvest date effects on biomass quality and ethanol yield of new energycane (*Saccharum* hyb.) genotypes in the Southeast USA. *Biomass and Bioenergy* 56:147-156.

### Proceedings

- Owens, Vance, Brian Baldwin, D.K. Lee, Tom Voigt. 2013. Perennial Herbaceous Energy Crops and CRP Land for Biomass Production in the USA: A Five Year Regional Feedstock Partnership Report. Tenth Anniversary World Congress on Industrial Biotechnology. Montréal, Québec. 16-19 June.
- Knoll, J.E. W. F. Anderson, B. Baldwin, E. Richard. 2010. Harvest date effects on biomass yield and quality of new energycane (*Saccharum* hybrid) genotypes in the southeastern USA. ASA/CSSA/SSA Meetings. Long Beach, CA. 31 Oct - 4 Nov.

### Presentations

- Baldwin, B. et al. 2013. At Mississippi State, this work was presented to U.S. Secretary of Agriculture, Tom Vilsack during his visit to the Starkville, MS campus on September 25th, 2013.
- Baldwin, B. et al. 2013. At St. Gabriel, the work was mentioned and displayed at the research station field day on July 17, 2013.
- Baldwin, B., W. Anderson, J. Blumenthal, E.C. Brummer, K. Gravois, A. Hale, and L.T. Wilson. 2013. Energycane (*Saccharum* spp) sugarcane goes North. 245th National Meeting of American Chemical Society, Carbohydrates Division. Biofuels, bioproducts, and biomass from sugar feedstocks. New Orleans, LA. 8 Apr .
- Baldwin, B.S., W. Anderson, C. Brummer, J.R. Parish, K. Gravois, L.T. Wilson, J. Blumenthal, A. Hale. 2013. Southeast regional evaluation on energycane (*Saccharum* spp) genotypes as a potential bioenergy crop. SEC Conf. Atlanta GA. 10-12 Feb. <http://www.youtube.com/watch?v=nlkf8NZSzc>
- Baldwin, Brian. 2011. The southeastern U.S.: Biomass powerhouse. Soil and Water Conserv. Soc. Ann. Conf. Washington, D.C. 17 July.
- Baldwin, Brian S., J. Brett Rushing, Edward Richard, Thomas Tew, Anna Hale, 2010. Energycane: Sugarcane gone North. Seventh Annual Bioenergy Feedstock Symposium. Champaign, IL. 11-12 Jan
- Baldwin, B., D.K. Lee, V. Owens, W. Rooney, and T. Voigt. 2009. U.S. Dept. of Energy Regional Biomass Feedstocks Partnership. Bioenergy Symposium, AAIC. Termás de Chillán, Chillán Chile. 15-19 Nov.
- Rushing, J.R., B.S. Baldwin, E.P. Richard, T.L. Tew. 2009. Evaluation of cellulosic energy feedstocks for production in northcentral Mississippi USA. Fiber and Cellulosics Division AAIC. . Termás de Chillán, Chillán Chile. 15-19 Nov.
- Baldwin, B. et al. 2010. The Species Lead presented 2009 growth and yield results at the Sun Grant/DOE Regional Feedstock Partnership Report and Planning Meeting held February 23 - 24, 2010 in San Antonio, Texas.

## Publications and Presentations (CRP)

### Peer reviewed manuscripts

- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, G. Kakani, R.L. Kallenbach, and J.C. Castro. 2012. Nitrogen and harvest management of Conservation Reserve Program (CRP) grassland for sustainable feedstock production. *GCB bioenergy*, 5:6-15.
- Mohammed, Y.A., C. Chen, and D.K. Lee. 2014. Harvest time and nitrogen fertilization to improve bioenergy feedstock yield and quality. *Agronomy Journal*. 106:57-63.
- Porter, T.F., C. Chen, J.A. Long, R.L. Lawrence, and B.F. Sowell. 2014. Estimating biomass on CRP pastureland: A comparison of remote sensing techniques. *Biomass and Bioenergy*. 66:268-274.

### Outreach publications

- A publication summarizing results of the Kansas site from 2008-2010 was written for our research center annual Roundup 2011 Report of Progress 1050 and is available on-line at: <http://www.ksre.ksu.edu/library/lvstk2/srp1050.pdf>.
- A publication summarizing results of the Kansas site was written for our research center annual Roundup 2011 Report of Progress 1050 and is available on-line at: <http://www.ksre.ksu.edu/library/lvstk2/srp1050.pdf>.
- Evaluation of CRP for Cellulosic Biomass Production, 2010 NDSU-CREC Annual Report Volume 51
- Evaluation of CRP for Cellulosic Biomass Production, 2012 NDSU-CREC Annual Report Volume 53

### Proceedings

- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, G. Kakani, and R. Kallenbach. 2012. Conservation Reserve Program (CRP) grassland for sustainable biomass production. Proceeding of the 2012 Sun Grant National Conference; Science for Biomass Feedstock Production and Utilization. New Orleans, LA, Vol. 1- 3.12
- Chengci Chen, Johnna Hesel, Tucker Porter, and D.K. Lee. 2012. Nitrogen application and harvest timing affect biomass yield and composition on CRP grassland. Proceeding of the 2012 Sun Grant National Conference; Science for Biomass Feedstock Production and Utilization. New Orleans, LA, Vol. 1- 3.14
- Tucker Porter, Chengci Chen, Rick Lawrence, and Bok Sowell. 2012. Effect of fertilization and growing season on CRP pastureland as a biofuel feedstock. The Proceeding of The Science and Engineering for A Biobased Industry and Economy Committee Meeting and Symposium. Washington D.C. pp. 55.

### Presentations

- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, V.G. Kakani, R. Kallenbach, & J. Castro. 2010. Conservation Reserve Program (CRP) grassland for sustainable biomass feedstock production-Regional Biomass Feedstock Partnership. In International Annual Meeting abstracts. 56-35. ASA, CSSA, SSSA, Madison, WI.

## Publications and Presentations (CRP-continued)

### Presentations (continued)

- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, G. Kakani, R.L. Kallenbach. 2011. Utilization of Conservation Reserve Program (CRP) grass land for sustainable biomass production." First Annual World Congress of Bioenergy, Dalian, China, April 25-30, 2011
- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, G. Kakani, R.L. Kallenbach. 2012. The Regional Biomass Feedstock Partnership: Herbaceous Energy Crops and CRP Land for Biomass Production Across Environmental Gradients, CRP Land for Biomass Energy Production in the US." The Sixth Annual Conference of the World Congress on Industrial Biotechnology and Bioprocessing, Montreal, Canada, July 19-22, 2009
- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, G. Kakani, and R. Kallenbach. 2012. The Regional Biomass Feedstock Partnership: Herbaceous Energy Crops and CRP Land for Biomass Production in the USA: A Five Year Regional Feedstock Partnership Report, CRP Land for Biomass Energy Production." The tenth Annual Conference of the World Congress on Industrial Biotechnology and Bioprocessing, Montreal, Canada, June 16-19, 2013.
- Lee, D.K., E. Aberle, C. Chen, J. Egnolf, K. Harmony, V.G. Kakani, R. Kallenbach, & J. Castro. 2014. Conservation Reserve Program (CRP) grassland for sustainable biomass feedstock production-Regional Biomass Feedstock Partnership. *Biomass 201: Growing the Future Bioeconomy. Washington, DC. July 29-30, 2014.*

### M.S. Thesis

- Porter, T.F. 2013. Comparison of three remote sensing techniques to measure biomass on crop pastureland. M.S. Thesis. Montana State University.

## Publications and Presentations (*Miscanthus x giganteus*)

### Peer reviewed manuscripts

- Davis, M.P., M.B. David, T.B. Voigt, and C.A. Mitchell. 2014. Effect of nitrogen addition on *Miscanthus x giganteus* yield, nitrogen losses, and soil organic matter across five sites. *GCB -Bioenergy*. doi: 10.1111/gcbb.12217.
- Arundale, R.A., F.G. Dohleman, T.B. Voigt, and S.P. Long. 2014. Nitrogen fertilization does significantly increase yields of stands of *Miscanthus x giganteus* and *Panicum virgatum* in multiyear trials in Illinois. *BioEnergy Research*. 7:408-416.
- MORGAN P . DAVIS , MARK B. DAVID, THOMAS B. VOIGT and COREY A. MITCHELL. 2014. Effect of nitrogen addition on *Miscanthus x giganteus* yield, nitrogen losses, and soil organic matter across five sites. *GCB Bioenergy*, doi: 10.1111/gcbb.12217
- Behnke, G.D., M.B. David, and T.B. Voigt. (2012 - In Press) Greenhouse gas emissions, nitrate leaching, and biomass yields from production of *Miscanthus x giganteus* in Illinois, USA. *BioEnergy Research*. DOI 10.1007/s12155-012-9191-5. (<http://www.springerlink.com/content/n2t6552hw14257g4/fulltext.pdf>)

### Theses and Dissertation

- Maughan M, Bollero G, Lee DK, Darmody R, Bonos S, Cortese L, Murphy J, Gaussoin R, Sousek M, Williams D, Williams L, Miguez F, Voigt T. *Miscanthus x giganteus* productivity: The effects of management in different environments. *Global Change Biology – Bioenergy* 2012 (In Press) DOI: 10.1111/j.1757-1707.2011.01144.x.
- Morgan Davis. 2014. A biogeochemical analysis of *Miscanthus x giganteus* under nitrogen fertilizer treatments and across multiple soil types. M.S. Thesis. University of Illinois at Urbana-Champaign.
- Gevan D. Behnke. 2011. Greenhouse gas emissions from production of *Miscanthus x giganteus* on a Mollisol. M.S. Thesis. University of Illinois at Urbana-Champaign.
- Matthew W. Maughan. 2011. Evaluation of switchgrass, *M. x giganteus*, and sorghum as biomass crops: effects of environment and field management practices. Ph. D. Dissertation. University of Illinois at Urbana-Champaign.

### Proceedings/Abstracts

- Davis, M.P., M. B. David, T. B. Voigt, and E. H. DeLucia 2013. A multi-state analysis of *Miscanthus x giganteus* with nitrogen fertilization. In Annual Meetings Abstracts. Tampa, FL. November 3-6. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.
- Voigt, T. et al. 2012. 2012 Sun Grant National Conference: Science for Biomass Feedstock Production and Utilization. *Miscanthus x giganteus* Biomass Feedstock Production and Sustainability Studies in the Eastern U.S. Oct. 4. New Orleans, LA.
- Davis, M.P., M. B. David, T. B. Voigt, and C. Mitchell. 2012. Changes in potential soil carbon and nitrogen mineralization: A multistate analysis of *Miscanthus x giganteus* under nitrogen fertilizer treatments. In Annual Meetings Abstracts. Cincinnati, OH. October 21-24. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

## Publications and Presentations (*Miscanthus x giganteus*; continued)

### Proceedings

- Behnke, G., M. David, T. Voigt, and E. Acosta. 2010. Greenhouse gas emissions from production of *Miscanthus x giganteus* on Mollisols. In Annual Meetings Abstracts. Long Beach, CA. October 31-November 4. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.
- Maughan M., F. Miguez, T. Voigt, S. Bonos, J. Murphy, R. Gaussoin, D. Williams, and G. Bollero. 2009. *Miscanthus x giganteus* growth and survival in IL, IN, KY, NE, and NJ. In Annual Meetings Abstracts. Pittsburgh, PA. November 1-4. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.

### Book Chapters

- Lee, D.K., A. Parrish, and T. Voigt. (2013). Switchgrass and Giant *Miscanthus* Agronomy. In Yogendra Shastri et al. (eds.) Biomass Feedstock Production Engineering. Springer. (in press)

### Presentations

- U. of I/EBI Energy Farm Field Day, Energy Biosciences Institute Feedstock Production Agronomy Program Spring Review. 2014.
- Multiple lectures in Crop Sciences 215- The Prairie and Bioenergy. 2014
- Energy Biosciences Institute Feedstock Production Agronomy Program Spring Review. 2014.
- Voigt, T. U. of I. Energy Farm Field Tours. Energy Biosciences Institute Retreat, The 2013 International Symposium on C4 and CAM Plant Biology, Energy Biosciences Institute Feedstock Symposium.
- Voigt, T. et al. 2013. Tunica, MS. Sun Grant Feedstock Partnership Annual Meeting. *Miscanthus x giganteus* Update. February 14, 2013.
- Davis, M.P., M.B. David, T.B. Voigt, and E.H. DeLucia. 2013. A multi-state analysis of *Miscanthus x giganteus* with nitrogen fertilization. In Annual Meetings Abstracts. Tampa, FL. November 3-November 6. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.
- Voigt, T. 2012. IL High School Agriculture Instructor Energy Farm Field Tour showing Sun Grant *Miscanthus x giganteus* Study. June 18, 2012. Urbana, IL.
- Voigt, T. et al. 2012. Sun Grant/DOE Herbaceous Feedstock Partnership Meeting. *Miscanthus x giganteus* Productivity. Indianapolis, IN.
- Voigt, T. et al. 2011. *Miscanthus x giganteus* productivity: The effects of management in different environments. 2011 Regional Sun Grant/DOE Biomass Feedstock Partnership Meeting. Knoxville, TN
- Voigt, T. October 8, 2011; Reported on DOE/Sun Grant M. x *giganteus* plots in M. x *giganteus* lecture in Crop Sciences 415 (Bioenergy Crops).

## Publications and Presentations (*Miscanthus x giganteus*; continued)

### Presentations (continued)

- Voigt, T. 2010. Illinois Energy Farm Field Tours to view Sun Grant/DOE *Miscanthus x giganteus* Bioenergy Field Trials: Argentinian U.S. Farm Tour, October 2; Energy Farm Open House, Oct. 10.
- Voigt, T. October 26; Visit to DOE/Sun Grant *M. x giganteus* field plots as part of the Sustainability of Biomass Production for Bioenergy workshop.
- Voigt, T. American Chemical Society. Establishing and Managing *Miscanthus x giganteus* and *Panicum virgatum* Feedstocks in the Temperate U.S. New Orleans, LA.
- Voigt, T. World Congress on Industrial Biotechnology. Sun Grant Feedstock Partnership *Miscanthus x giganteus* Group. Montreal, Quebec, CA.
- Voigt, T. et al. The Species Lead presented the *Miscanthus x giganteus* Bioenergy Field Trials at Kentucky and Nebraska Turfgrass Field Days and the Illinois Energy Farm Field Day.
- Voigt, T. The Species Lead presented, "Bioenergy Crops," to annual meeting of Association of Education and Research Greenhouse Curators.
- Voigt, T. The Sun Grant/DOE Herbaceous Feedstock Partnership *Miscanthus x giganteus* Bioenergy Field Trial was presented at the University of Illinois Master Gardener Convention Energy Farm Tour, University of Illinois Energy Farm Field Day, and Association of Applied Biologists Energy Farm Tour.
- Voigt, T. Urbana, IL. University of Illinois Center for Advanced Bioenergy Research Seminar. Is *Miscanthus x giganteus* A Commercial Crop? January 28.
- Taught Horticulture 215, Grasses for Managed Settings, a two-hour course focused on the identification, selection, and management of turfgrasses, landscape ornamental grasses, prairie grasses, pasture grasses, and bioenergy grasses. A field tour of the Energy Farm included viewing and discussion of the Feedstock Partnership *Miscanthus x giganteus* plots.
- Taught Crop Sciences 215, The Prairie and Bioenergy, a eight-week, three-hour course focused on the prairie environment, renewable and alternative energy topics, and bioenergy grass biology with D.K. Lee. A field tour of the Energy Farm included viewing and discussion of the Feedstock Partnership *Miscanthus x giganteus* plots.



## Publications and Presentations (Switchgrass)

### Peer reviewed manuscripts

- E.G. Mbonimpa, C.O. Hong, V. Owens, R.M. Lehman, S.L. Osborne, T. Schumacher, D. Clay, And S. Kumar. 2014. Nitrogen fertilizer and landscape position impacts on CO<sub>2</sub> and CH<sub>4</sub> fluxes from a landscape seeded to switchgrass. GCB Bioenergy doi: 10.1111/gcbb.12187.
- C. O. Hong, V. N. Owens, D. Bransby, R. Farris, J. Fike, E. Heaton, S. Kim, H. Mayton, R. Mitchell, D. Viands. Switchgrass Response to Nitrogen Fertilizer across Diverse Environments in the USA: a Regional Feedstock Partnership Report. Bioenerg. Res. DOI 10.1007/s12155-014-9484-y.
- Anderson, E.K., A.S. Parrish, T.B. Voigt, V.N. Owens, C.H. Lee, and D.K. Lee. 2013. Nitrogen fertility and harvest management of switchgrass for sustainable bioenergy feedstock production in Illinois. Indust. Crops and Products 48:19-27.
- Owens, V.N., D.R. Viands, H.S. Mayton, J.H. Fike, R. Farris, E. Heaton, D.I. Bransby, C.O. Hong. 2013. Nitrogen Use in Switchgrass Grown for Bioenergy across the USA. Biomass and Bioenergy Res. 58:286-293. <http://dx.doi.org/10.1016/j.biombioe.2013.07.016>
- Watrud, L.S., J.R. Reichman, M.A. Bollman B.M. Smith, E.H. Lee, J.D. Jastrow, M.D. Casler, H.P. Collins, S. Fransen, R.B. Mitchell, V.N. Owens, B. Bean, W.L. Rooney, D.D. Tyler and G.A. King. 2012. Chemistry and Microbial Functional Diversity Differences in Biofuel Crop and Grassland Soils in Multiple Geographies. Bioenergy Res. DOI 10.1007/s12155-012-9279-y

### Proceedings/Abstracts

- Owens, V., B.S. Baldwin, D.K. Lee, and T. Voigt. 2013. Perennial Herbaceous Energy Crops and CRP Land for Biomass Production in the USA: A Five Year Regional Feedstock Partnership Report. The World Congress on Industrial Biotechnology and Bioprocessing, Montreal, Quebec, Canada, 16-19 June 2013.
- Owens, V., B.S. Baldwin, D.K. Lee, and T. Voigt. 2013. Perennial Herbaceous Energy Crops and CRP Land for Biomass Production in the USA: A Five Year Regional Feedstock Partnership Report. The World Congress on Industrial Biotechnology and Bioprocessing, Montreal, Quebec, Canada, 16-19 June 2013.
- Hong, C.O., V.N. Owens, T. Schumacher, D. Clay, S. Osborne, M. Lehman, and J. Schumacher. 2012. Nitrogen losses from switchgrass as affected by nitrogen fertilizer rate. 2012 National Sun Grant Conference, 2-5 Oct. 2012, New Orleans, LA.
- Owens, V., D. Bransby, R. Farris, J. Fike, E. Heaton, C.O. Hong, C. Hopkins, H. Mayton, R. Mitchell, and D. Viands. 2012. Switchgrass response to N fertilizer across diverse environments in the US. 2012 National Sun Grant Conference, 2-5 Oct. 2012, New Orleans, LA.
- Mitchell, R., V.N. Owens, N. Gutterson, E. Richard, and J. Barney. 2011. Herbaceous perennials: placement, benefits and incorporation challenges in diversified landscapes. In Proc. of the Sustainable Feedstocks for Advance Biofuels Workshop, R. Braun et al. (eds), Soil and Water Cons. Soc. 28-30 Sep. 2010, Atlanta, GA.

## Publications and Presentations (Switchgrass-continued)

### Proceedings/Abstracts (continued)

- Kumar S., E. Mbonimpa, C.O Hong, V. Owens, S. Osborne Nitrogen Fertilization Rate and Landscape Positions Impacts on Root Growth Parameters of Switchgrass. ASA, CSSA and SSSA International Annual Meetings, Long Beach, CA, Nov 2014.
- Mbonimpa E. G., S. Gautam, L. Lai, S. Kumar, J. Bonta. Improved Calibration of Apex Model For a Small Watershed Managed with No-till System. ASA, CSSA and SSSA International Annual Meetings, Long Beach, CA, Nov 2014.
- Lai, L., S. Kumar, E. G. Mbonimpa, R. Chintala, V. Owens, J. Schumacher. Quantifying Current and Future CO<sub>2</sub> Fluxes Using Daycent and PEST Models from a Marginal Land Seeded to Switchgrass Production in South Dakota. ASA, CSSA and SSSA International Annual Meetings, Long Beach, CA, Nov 2014.
- Lai, L. E.G. Mbonimpa, C. Hong, S. Kumar, V. Owens, S. Osborne, M. Lehman. Daycent Application to Model Greenhouse Gas Fluxes from Switchgrass Land Managed with Nitrogen Fertilizer Levels Under Different Landscape Positions. ASA, CSSA and SSSA. International Annual Meetings, Long Beach, CA, Nov 2014
- Owens V., E.G. Mbonimpa, C.O. Hong, S. Kumar, S. Osborne, and M. Lehman. Soil surface greenhouse gas fluxes from switchgrass land managed with nitrogen fertilizer under different landscape positions in South Dakota. Poster Presentation on July 29–30, 2014: the U.S. Department of Energy's Bioenergy Technologies Office (BETO) is hosting its seventh annual conference—Biomass 2014: Growing the Future Bioeconomy in Washington D.C.
- Kumar S., C.O Hong, E. Mbonimpa, V. Owens. R. M. Lehman, S. Osborne, T. Schumacher, D. Clay. Soil carbon dioxide and methane fluxes influenced by nitrogen rates and landscape positions from switchgrass land of South Dakota, USA. Poster Presented at 20th World Congress of Soil Science from June 8-13, 2014 at Jeju, Korea.
- Mbonimpa E. G, S. Kumar, V. Owens, R. Chintala, J. Stone. Assessing Fertilization and Landscape Impacts on the Overall Life Cycle of Switchgrass Used to Produce Cellulosic Ethanol. ASA, CSSA and SSSA International Annual Meetings, Long Beach, CA, Nov 2014.
- Kumar S., E. Mbonimpa, C.O. Hong, V. Owens, and S. Osborne. 2014. Switchgrass root growth parameters impacted by nitrogen fertilization rate and landscape positions. New Philologist next generation scientists workshop held from 29–30 July 2014 at the John Innes Conference Centre in Norwich, UK.
- Kumar, S., C.O. Hong, V.N. Owens, D.E. Clay, M. Lehman, S.L. Osborne, T.E. Schumacher, and E.G. Mbonimpa. 2013. Soil carbon dioxide fluxes from switchgrass land under nitrogen fertility management in South Dakota. ASA-CSSA-SSSA Annual Meetings, 3-6 Nov., Tampa, FL.
- Owens, V., C.O. Hong, D. Bransby, R. Farris, J. Fike, E. Heaton, H. Mayton, R. Mitchell, and D. Viands. 2012. Switchgrass production across diverse environments in the USA: A Regional Feedstock Partnership Report. ASA-CSSA-SSSA Annual Meetings, 21-24 Oct. 2012, Cincinnati, OH

## **Publications and Presentations (Switchgrass-continued)**

### **Proceedings/Abstracts (continued)**

- C.O. Hong, V.N. Owens, T. Schumacher, D. Clay, E. Heaton, R. Farris, D. Viands, H. Mayton, J. Fike, D. Bransby, C. Hopkins. 2011. Field-scale Production of Switchgrass for Bioenergy Across the US. International Biomass Conference, 1-5 May 2011, St. Louis, MO.
- Owens, V., D. Bransby, R. Farris, J. Fike, E. Heaton, C. Hong, C. Hopkins, H. Mayton, R. Mitchell, D. Viands. 2011. Switchgrass Production across the USA: A Regional Feedstock Partnership Update. The World Congress on Industrial Biotechnology and Bioprocessing, 8-11 May 2011, Toronto, Ontario, Canada.
- Heaton and Viands. 2011. Field-Scale Yield of Switchgrass Under Varying Nitrogen Management Treatments In New York State. In ASA Abstracts

### **Presentations**

- Owens, V.N., D.I. Bransby, C. Daly, L. Eaton, R. Farris, J. Fike, E. Heaton, M. Halbleib, R. Mitchell, D. Viands. 2014. Estimating switchgrass yield potential across the USA: Results from the Doe-Sun Grant Regional Feedstock Partnership. 22nd European Biomass Conference and Exhibition, 23 – 26 June 2014, Hamburg, Germany
- Kumar S., C.O Hong, E. Mbonimpa, V. Owens. R. M. Lehman, S. Osborne, T. Schumacher, D. Clay. Soil carbon dioxide and methane fluxes influenced by nitrogen rates and landscape positions from switchgrass land of South Dakota, USA. Poster Presented at 20th World Congress of Soil Science from June 8-13, 2014 at Jeju, Korea.
- Owens, V. 2013. Multi-use grasses—The intersection between forage and bioenergy crops in a changing climate. Bioenergy Crops in Central Illinois, Argonne National Laboratory, 8 March 2013.
- Owens, V.N., Farris, R., J. Fike, E. Heaton, C. Hong., H. Mayton, R. Mitchell, D. Bransby, and D. Viands. 2013. Switchgrass for Biomass Production across Diverse Environments in the USA: A Five Year Regional Feedstock Partnership Report. 2013 European Biomass Conf. and Exhibit, Copenhagen, Denmark, 3-7 June 2013.
- Owens, V., D. Bransby, R. Farris, J. Fike, E. Heaton, C.O. Hong, C. Hopkins, H. Mayton, R. Mitchell, and D. Viands. 2012 Switchgrass response to N fertilizer across diverse environments in the US. 2013 Regional Feedstock Partnership Annual Meeting, 25-27 March 2013, Tunica, MS.