

Twenty-years of Switchgrass Bioenergy Research & Stacked Multi- component Experiments

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Bioenergy crop productions systems will need to have the following:

- Adapted, high yield plant materials with high bioenergy conversion efficiency.
- Complete, fully validated, sustainable production and management systems.
- Economically viable for both producer and biorefinery.
- High net energy and energy yields per hectare or acre.
- Fully documented environmental impacts and credits.

USDA Native and Introduced Plant Research for Conservation and Grassland Agriculture

1930's to present

- Germplasm collection, assessment, breeding, and management research on switchgrass and other native grasses.
- Lincoln ARS program, 1935 to present. Work started by pioneer breeder, L.C. Newell.
- Use by livestock was emphasized.
- Currently 50% of research by ARS-Lincoln still on grasses for use in grazing systems.



USDA-ARS Grain, Forage, & Bioenergy Research Unit, Lincoln, NE

Grassland agriculture –
Unsubsidized agriculture



Switchgrass-Bioenergy Research, 1990's – 2007.

- Initial assessment studies.
- Management studies. Breeding and genetics.
- Large scale economics and net energy trials.

Current research 2008-2013.

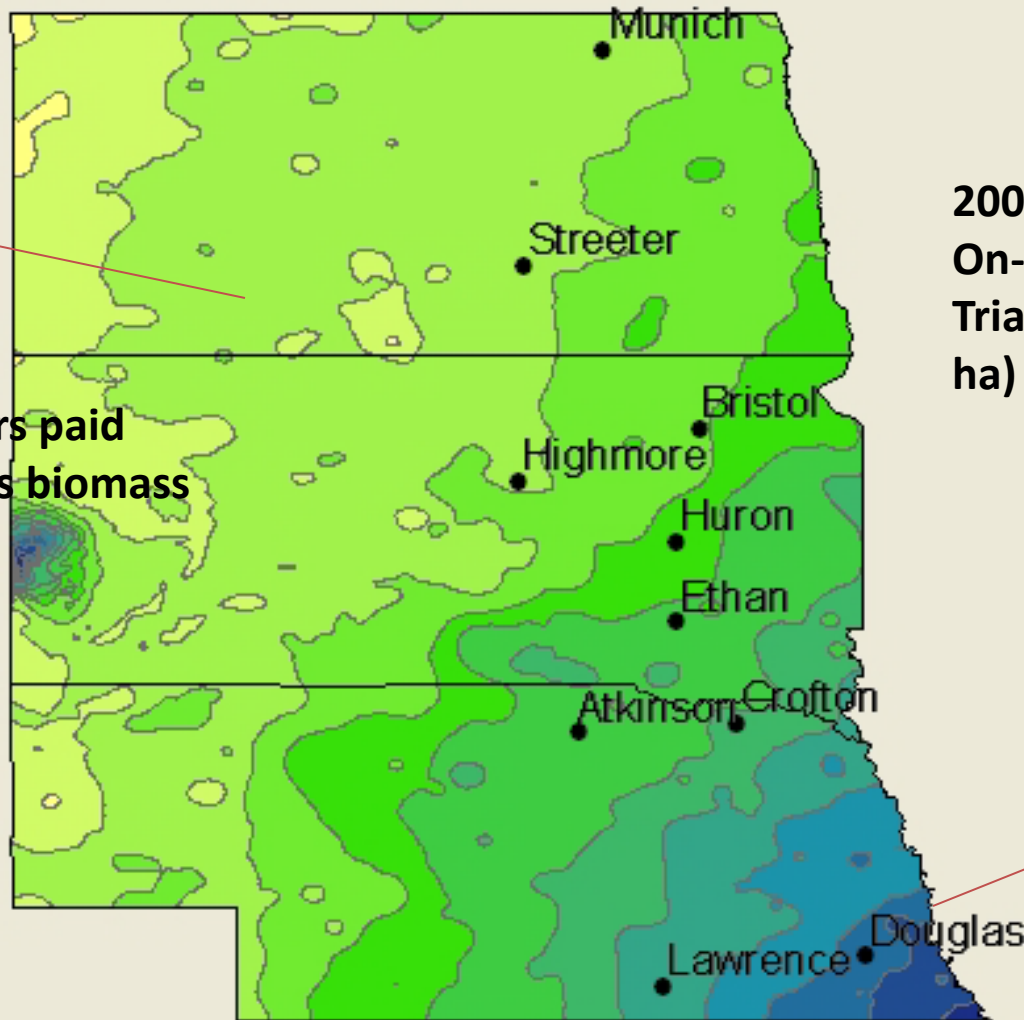
- Environmental factors: C
- Feedstock quality
- Feedstock harvest and storage.
- Genetics and management



Northern Plains Switchgrass Field Scale Production & Economic Trials 2000-2005

380-430 mm
Annual
Precipitation

Cooperating farmers paid
to manage fields as biomass
energy crops.



2000-2005
On-Farm Production
Trials: 15-20 acre (6-9
ha) fields

780-840 mm
Annual
Precipitation

Switchgrass for Bioenergy – On farm economic study in NE, SD, ND.

- Field shown at left had a five year cumulative average cost of \$33/T switchgrass biomass including land & money costs.
- Average costs for 10 farms was \$60/T; two experienced farmer's costs were \$39/T.
- Each big bale (left) represents a 50 gal barrel of ethanol at conversion rate of 0.38 L/kg with average farm gate cost of \$0.64/gal. Low cost producers = \$0.53/gal at the farm gate.

Switchgrass field in NE South Dakota in 2005. Yields averaged 4T/acre.

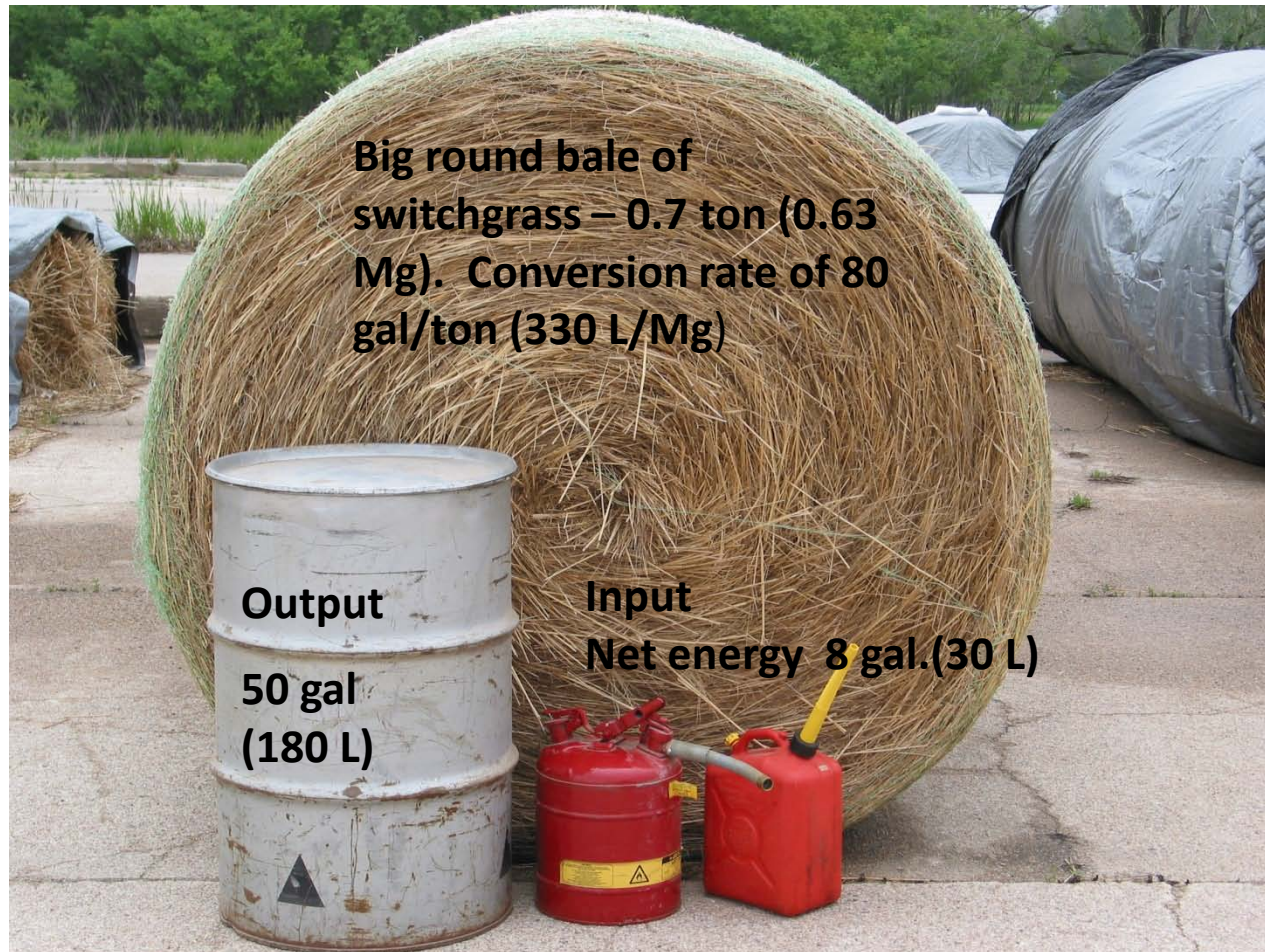


On-farm Switchgrass Production in the Great Plains – Net Energy

- Previous models over-estimated the energy inputs for switchgrass production by as much as 2X
- Switchgrass produced 13X more energy as ethanol than was required as energy from petroleum
- Switchgrass produced 540% more renewable than non-renewable energy consumed on marginal land when properly managed
- Switchgrass biofuel production systems are economically feasible, environmentally sustainable, and energetically positive on marginal cropland in the central USA east of the 100th Meridian



Ethanol from switchgrass: Input - output illustration.



Based on Schmer et al., 2008. PNAS105: 464-469.

On-farm trial soil carbon sequestration: soil sampling.



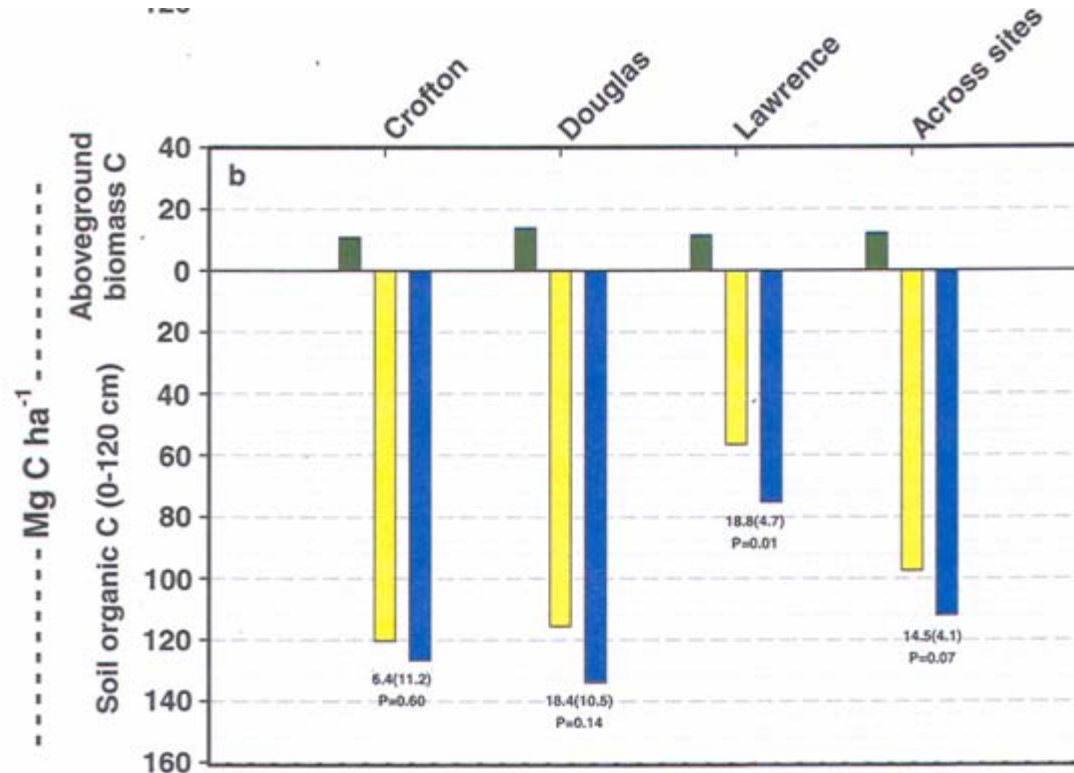
Switchgrass Soil Carbon Sequestration when grown and managed as a biomass energy crop

Douglas, Nebraska Field



- Field at left for period 2000 to 2005
 - 0 to 30 cm: 5 Mg C/ha increase in soil carbon (2.2 t/A)
 - 0 to 120 cm: 18.4 Mg C/ha increase in soil carbon (8.2 t/A)
- (Liebig et al., Agron. J. 2008).

Switchgrass grown for bioenergy: Soil carbon storage in 5 years: 0-120 cm Liebig et al. (2008)



Schmer, M.R., M.A. Liebig, K.P. Vogel, R.B. Mitchell. 201x. Field-scale soil property changes under switchgrass managed for bioenergy. Global Change Biology Bioenergy. Accepted 1/28/2011.

Developed stand threshold and biomass yield monitoring and prediction information that can be used by producers, biorefineries, and NASS.

The image shows a screenshot of the USDA National Agricultural Statistics Service (NASS) website. The header includes the USDA logo and the text "United States Department of Agriculture National Agricultural Statistics Service". Navigation tabs include Home, About NASS, Newsroom, Publications, Data and Statistics, Census, Surveys, and Help. A search bar is labeled "Search NASS" with a "Go" button. A sidebar on the left offers "Browse NASS by Subject" with categories like Crops and Plants, Demographics, Economics, Environmental, Livestock and Animals, Charts and Maps, Research and Science, and Education and Outreach. It also has a "Statistics by State" section. The main content area features a "Headlines" section with several news items, including "On-Farm Renewable Energy Production Shows Tremendous Growth" and "Row Crop County Estimates Now Available". A "Research" tab is visible in the top navigation bar. Overlaid on the right side of the website is a research paper titled "Research to monitor production and supply (essential information for NASS)".

Research to monitor production and supply (essential information for NASS)

- Schmer, M.R., K.P. Vogel, R.B. Mitchell, L.E. Moser, K.M. Eskridge, and R.K. Perrin. 2006. Establishment Stand Thresholds for Switchgrass Grown as a Bioenergy Crop. *Crop Sci.* 46:157-161.
- Kiniry, J.R., M.R. Schmer, K.P. Vogel, and R.B. Mitchell. 2008. Switchgrass simulation at diverse sites in the northern Great Plains of the U.S. *Bioenergy Research* 1:259-264.
- Schmer, M.R., R. Mitchell, K.P. Vogel, W.R. Schacht, D.A. Marx. 2010. Spatial and temporal effects on switchgrass stands and yields in the Great Plains. *Bioenergy Research* 3: 159-171.
- Schmer, M.R., R.B. Mitchell, K.P. Vogel, W.H. Schacht, and D.B. Marx. 2010. Efficient methods of estimating switchgrass biomass supplies. *BioEnergy Research* 3:243-250.

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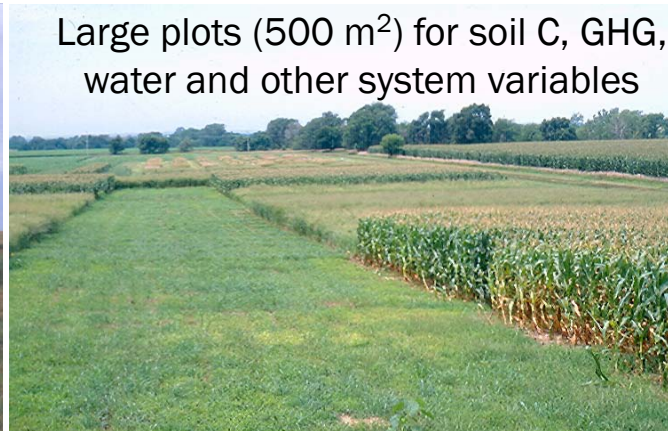
Regional Scaling

- Research conducted at multiple scales on breeding & genetics, production practices, environmental sustainability, ecosystem services, and economics.

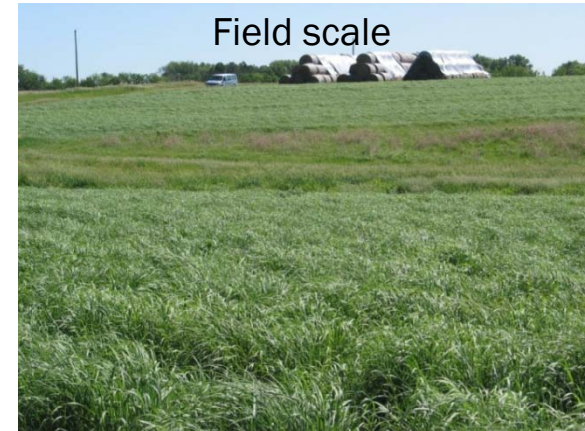
Small plot (5m²) production variable trials at multiple sites



Large plots (500 m²) for soil C, GHG, water and other system variables



Field scale



Protocols, Data and Sample Collection, and Management

- Develop a comprehensive strategy and plan.
- Bring the necessary scientists on board as partners.
- Develop major research thrusts to address gaps in knowledge.
- Have research planning meetings to develop experiment plans to address gaps. All basic protocols are worked out and agreed upon.
- Major tasks and responsibilities designated as per agreement by cooperating SY's.
- Follow-up, Follow-up, Follow-up.
- Get 'er done.

Lincoln ARS Switchgrass Bioenergy Cooperative Research

