Energycane Feedstock Development in Louisiana

Kaitlin Barrios[1], Collins Kimbeng[1], Anna Hale[2], Kun Jun Han[3], Niranjan Baisakh[3] and Daira Aragon[4]

[1]Sugar Research Station, LSU AgCenter, St. Gabriel, LA 70776; [2]USDA-ARS-SRRC, Sugarcane Research Unit, Houma, LA 70360;
[3]School of Plants, Environmental and Soil Sciences, LSU AgCenter, Baton Rouge, LA 70808; [4]Audubon Sugar Institute, LSU AgCenter, St. Gabriel, LA 70776;

Research Funded by AFRI Grant Number 2011-6900530515 from the USDA NIFA; *ckimbeng@agcenter.lsu.edu

Abstract

Global interest in developing renewable sources of energy and bioproducts has directed attention towards plant biomass as potential feedstocks. This paper reports on work currently underway to develop energycane varieties as feedstock for the emerging bioenergy and bioproducts industry. The term energycane loosely describes derivatives of sugarcane bred specifically as an energy crop. They include crosses between cultivated sugarcane and its wild relative *Saccharum spontaneum* or with the allied species, *Miscanthus*. The crosses maximize traits such as high biomass yield, tolerance to biotic (disease and insect pests) and abiotic (cold and drought) stresses, and ratooning ability. A strategy utilized in this project was to provide a challenging environment for selection, with a view of developing varieties for marginal lands that require minimal inputs. In 2012, approximately 1000 energycane clones planted at Houma (29° 35′ 15″ N), in southern Louisiana were replanted at Winnsboro, in northern Louisiana (32° 9′ 48″ N). The Winnsboro location is outside of the traditional sugarcane belt and experiences lower average temperatures and rainfall and atypical weather patterns than what is obtained in southern Louisiana. Whereas crops are traditionally grown under irrigation in Winnsboro, no irrigation, as well as minimal fertilizer and herbicide treatments, were applied to the energycane crop. The 1,000 clones were allowed to overwinter and about 200 clones were selected, based on visual appraisal for biomass yield, and replanted in 2013. These clones were also analyzed for biomass quality traits such as cellulose, hemicellulose and lignin. Following the severe winters in 2012 and 2013 the clones were rated in the ratoon crops for their cold tolerance and regrowth potential. The data collected so far are being used to select clones combining high biomass yield and quality for evaluation in multi-location trials across the southeastern United States.

Introduction

- Political, environmental and economic concerns have motivated several nations to become increasingly interested in renewable sources of energy and bioproducts such as those obtained from plant biomass.
- Sugarcane, a massive grass plant, is reputed as one of the most efficient plants in converting solar energy into chemical energy.
- Researchers in Louisiana are in the forefront of developing genetically improved varieties of sugarcane called energycane for this emerging bioenergy-bioproducts industry.
- The idea of using sugarcane to generate energy is not new. Bagasse, the residue remaining after milling sugarcane to extract sucrose, is burned to generate steam that powers the sugar mill and, in some instances, the excess electricity produced is sold to the electric grid.
- In Brazil, sugarcane juice has long been used to produce ethanol.
- What is new is the impetus to produce energy using dedicated energy crops rather than food crops and the desire to do so using the lignocellulosic biomass.
- Energycane is a term used loosely to describe derivatives of sugarcane bred specifically as a dedicated energy crop.
- In Louisiana energycane varieties are being developed by crossing sugarcane with its wild relatives such as *S. Spontaneum* and *Miscanthus*.
- Selection is focused on maximizing biomass rather than sucrose yield and takes advantage of traits such as biomass yield, stress tolerance (Fig. 1) and ratooning ability imparted by these allied species.

Table 1. Energy Cane Fiber Composition Analysis 2012 & 2013

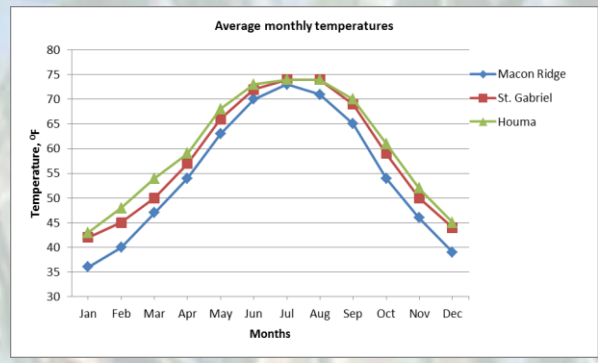
	Cellulose	Hemicellulose	EtOH	ASL	Fiber	Ash
	.....as a % of fiber					
Mean	39.95	25.06	3.16	4.02	17.20	3.11
Max	48.08	31.42	7.65	5.18	20.28	6.30
Min	23.99	17.05	0.27	3.53	11.87	1.36
N	146	146	146	146	146	146

ASL = Acid Soluble Lignin; National Renewable Laboratory Method used in analyses

Strategy

- About 1000 clones taken from the USDA Sugarcane Research Station at Houma in southern LA (29°35'15" N) were evaluated in 3-m plots at the Macon Ridge Station, Winnsboro in northern LA (32°09'48" N) well outside of the traditional sugarcane belt (Figs. 3 and 4).
- No irrigation was used in these experiments although, crops (corn, soybeans) grown in northern LA are traditionally irrigated. Fertilizer and herbicide treatments were applied at sub-optimal rates.
- About 200 clones were selected, based on visual appraisal for biomass yield, cold tolerance (Fig. 1) and ratooning ability and re-evaluated in bigger (5m) plots.
- Estimated yields, based on stalk number and whole plot dry matter, cold tolerance ratings (see Fig. 1) following the uncharacteristically cold winters of 2012 and 2013, spring regrowth ratings, and disease ratings were used to preselect good performing clones in the plant and first ratoon crops at both locations (Fig. 4).
- A number of cold-responsive genes have been isolated and characterized from an energycane clone. Genetic markers derived from these genes were used to distinguish among cold-sensitive commercial sugarcane hybrids, cold-tolerant *Saccharum spontaneum* and energycane clones (Khan et al., 2013; Plant Science, 211: 122-131).
- Feedstock quality of biomass destined for biorefineries will affect its value in much the same way as the quality of other agricultural products affect their use for food, animal feed, fiber and industrial products. Near infrared spectroscopy calibration curves are being developed to assist in energycane biomass compositional analysis. This will provide a tool in the future to rapidly analyze biomass to assess feedstock market value as well as a toll to assist the feedstock development program in selecting new varieties.

Fig 1. Progeny from energycane crosses between sugarcane and *Miscanthus* (top) and sugarcane *Saccharum spontaneum* (bottom). Note that compared with the other plants in the background, the energycane plants in the foreground in both pictures remained green after exposure to subzero temperatures.



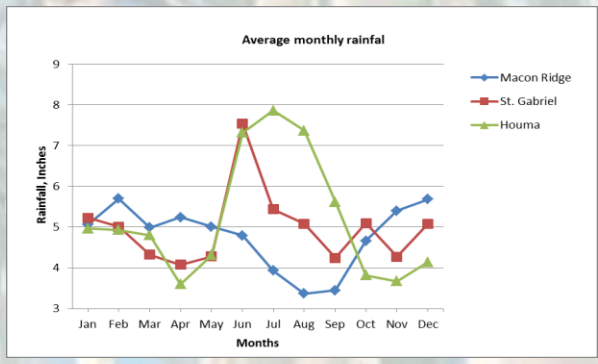


Fig. 3. Ten year average monthly temperatures (°F) and rainfall (inches) in Winnsboro, St. Gabriel and Houma, LA. Note differences in temperature and rainfall pattern between Winnsboro and the other two locations found within the sugarcane belt. Source: Weather Channel, LLC.

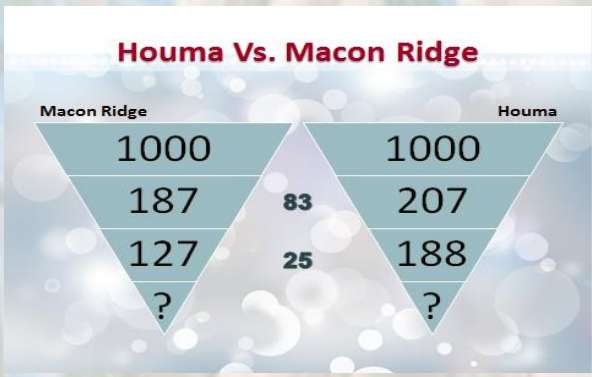


Fig. 4. Clones selected at northern (Macon Ridge) and southern (Houma) LA and that were common to both locations (middle) after evaluation in the plant and first ratoon crops