

# SWEET HARVEST

Many years have passed since sweet sorghum made its debut in the 1800s as a potential substitute for sugarcane. The crop is now back by popular demand, this time as a potential ethanol feedstock.

By Timothy Charles Holmseth



## SORGHUM

One hundred and fifty years ago sweet sorghum plants could be found swaying in the winds across parts of southeastern United States. A U.S. patent officer brought the plant to the United States in 1853, according to the National Sweet Sorghum Producers and Processors Association. The plant was of interest as a substitute for sugarcane, but it proved too hard to extract dry sugar from the syrup. Sorghum production peaked in the 1880s and declined as it faced competition from sugarcane and sugar beets.

Today, sweet sorghum is making its second debut as a versatile feedstock that can be used for food, fuel and animal feed. “It is the only crop that can save the United States,” says Ismail Dweikat, an associate professor at the University of Nebraska-Lincoln. An agronomy and horticulture expert, Dweikat says the speed bumps, headaches, economical and political challenges the nation presently faces as it attempts to wean itself from foreign oil could be avoided if we would focus on using the sugar from this 18-foot-tall energy crop to produce ethanol. “Despite controversy, support for nonpetroleum fuels remains strong,” he says.

Dweikat spoke to attendees at the 13th annual National Ethanol Conference in February in Orlando using this quote from George Washington Carver to kick off his presentation: “I believe that the great Creator has put ores and oils on this earth to give us a breathing spell. As we exhaust them, we must be prepared to fall back on our farms, which is God’s true storehouse and can never be exhausted. We can learn to synthesize material for every human need from things that grow.”

Dweikat believes that sweet sorghum can do the job of producing ethanol for the nation, and he’s giving it a personal letter of recommendation. Sweet sorghum is appealing on several fronts, he explains. “It doesn’t need additional irrigation so you can save money on irrigation,” he says. “It doesn’t need as much nitrogen as corn—50 to 60 pounds of nitrogen will give you a full crop of sweet sorghum,” he said, noting that one pound of nitrogen is required for each bushel of corn produced.

Dweikat explains that the total biomass stover from corn is 4 to 5 tons per acre plus 150 to 180 bushels of grain per acre. Sweet sorghum trumps corn when produced and sold to cellulosic ethanol plants. Sweet sorghum typically yields 14 tons of biomass per acre. “If you are selling it for \$40 a ton, that’s about \$560 per acre. That would out-produce corn, with less output,” he says, noting they both go for about \$40 per ton.

“Sweet sorghum requires half the amount of water that sugarcane needs. It has more sugar on a plant than sugarcane,”



DWEIKAT



A mature rainfed field of sweet sorghum variety M81E grown at Havelock, NE in 2007. The crop was planted in rotation with soybean and no additional nitrogen was applied. Total biomass yield is 35.5 tons/ha.

Dweikat says. “On a one crop basis, sweet sorghum out-produces sugarcane because sweet sorghum matures within 100 to 120 days, while it takes the first sugarcane crop one year to mature. Also on a volume basis, sweet sorghum has higher sugar content compared with sugarcane. As sweet sorghum requires less water (one-third less than sugarcane) and has a higher fermentable sugar content than sugarcane (which contains more crystallizable sugars), it is better suited for ethanol production than sugarcane. Also, sweet sorghum-based ethanol is sulfur-free and cleaner than molasses-based ethanol, when mixed with gasoline,” he explains.

Sizing it all up Dweikat says quite plainly, “The more sugar, the more ethanol.” The net energy ratios of sugarcane and sweet sorghum are similar, with 1 input rendering 8 outputs, he says. “In corn ... [the ratio] is 1:1.25,” he adds.

David Cukierman, president and chief executive officer of Ethano Peru LLC in Houston, compares sweet sorghum with corn. “The average corn yield in the U.S. is about 150 bushels per acre. The average ethanol yield per bushel is 2.8 gallons per bushel,” he explains. “That equates to an average production rate of 420 gallons per acre.”

The average sweet sorghum yield in the United States corresponds with two cuttings per year, in comparison to the four cuttings it renders in Peru, Cukierman explains. They are planning to test their hybrids in the South Texas Valley near the Rio

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	U.S. #2 Yellow Corn	Sweet Sorghum		
		2 harvests per year	3 harvests per year	4 harvests per year
Gal/acre production	420	1,424	2,136	2,837

Grande, he says, adding that cuttings are determined by global longitude and latitude and three annual cutting are expected in that region. “[Ethano Peru] strongly believes that sweet sorghum is the future and the answer to the food-versus-fuel controversy based on tests with our own hybrids in Peru,” Cukierman says.

Sweet sorghum also wouldn’t interfere with food production because it can be grown on marginal land, Dweikat explains. “You don’t have to use your best land,” he says. It’s also drought tolerant, he says describing how the plant behaves much like a camel. “It is more drought-tolerant than corn,” Dweikat says.

### Testing and Investing

Most commonly grown in Texas, Louisiana, Oklahoma, Nebraska, Florida, Kansas and Iowa, sweet sorghum has garnered some attention, and significant money has been invested to advance its growth. “In Florida, they have just approved a \$54 million ethanol plant based on sweet sorghum ethanol,” Dweikat says. “In Louisiana, they are going to plant 750 acres this year to replace sugarcane because it requires less irrigation.” Testing is also underway in Nebraska and Texas, he notes.

The crop has proven to be durable under the relentless heat of the Texas plains, where corn doesn’t thrive as well. “The Southeast grows pretty crappy corn,” says Juerg Blumenthal, associate professor and state sorghum cropping specialist at Texas A&M University. “One-hundred-bushel corn is common.” Biomass sorghum can endure periods of stress much better than grain sorghum or corn, he says.

Although sweet sorghum can be grown a little further north, it has some issues with the cold winters, Dweikat explains. “The problem in the Midwest is that it gets killed by the freeze so you have to re-plant it every year, like corn” he says. “That’s one of the limitations here in the United States.” However, continuous testing and hybrids are being pursued to address the plants’ tolerance for cold. “We are trying to make sweet sorghum a cold-tolerant plant by introducing a rhizome to it,” Dweikat notes.

He says indicators of sweet sorghum’s viability can be found across the globe where much testing is taking place. “In terms of acreage, the premier country that is using [sweet sorghum] now for ethanol is India,” Dweikat says.

Belum Reddy, the principal sorghum breeder for the International Crops Research Institute for the Semi-Arid Tropics in Andhra Pradesh, India, says a future exists for this plant. “In the past 35 years, the ICRISAT has been doing continuous research

### Potential Yield per acre in the U.S.

Latitudes	up to 32n	25n54 to 26n12
Average yield biomass tons/acre	36	36
Ethanol production gallons/ton	20	20
Harvests/year	2	3
Total biomass in tons per year	73	109
Gallons/acre yeild	1,424	2,136

to develop improved sorghum hybrid parents, varieties and hybrids,” he says. The crop is especially of interest because it can be used for food, animal feed and ethanol. “Farmers can harvest the grain for their food and then sell the surplus in the market,” he says. “The stalks of the sweet sorghum plants have sugar-rich juice in them. They can be crushed and used by a distillery to produce ethanol. The crushed stalk, after the juice is extracted [and the stripped leaves], can also be used as animal feed.”

At a distillery not far from ICRISAT, sweet sorghum juice is being converted into ethanol at a rate of 10,000 gallons per day, Reddy says. “Ethanol can also be produced from grain sorghum,” he says, although ICRISAT encourages farmers to sell sorghum grain for ethanol only after all their food needs are met.

With testing underway on several continents, sweet sorghum production is being observed in a variety of climactic conditions. With 750 acres of testing grounds on the coast of Peru, Cukierman says his company is rapidly discovering methods that will lead to sweet sorghum’s production as an ethanol feedstock on a worldwide basis.

One issue producer’s face is finding seed, but research into corn hybrids is being used to remedy that situation. “In their native countries, seed is saved from sorghum plants by farmers to plant the next generation crop,” Cukierman says. Over time plant breeders discovered and applied hybrid vigor to corn that rendered a higher yield than either parent, and the concept eventually reached sorghum. “It involves producing and maintaining a male and a female line,” he says.

Ethano Peru’s experimentation with hybrid seeds for sweet sorghum has shown promising results. “Hybrids of sweet sorghum for Peru are very fast growers,” Cukierman explained. The cycle for one crop is 90 days to harvest. With that short of a growing cycle, four crops per year could be produced.

Although the cost involved in breeding, producing, storing and marketing hybrid seed makes the cost of production relatively high, that cost is not prohibitive because the performance of the seeds is so high and more gallons of ethanol are produced with sweet sorghum, Cukierman says.

Dweikat points to Brazil and its research advances over the past 30 years using sugarcane to prove that energy independence can be obtained. “[Brazil] announced last year that they soon expect to be oil free,” he says.

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Sweet sorghum plants reaches 17 feet in Sep. 2007 at Lincoln, NE. The plants were rainfed and were grown in rotation with soybean.



A sweet sorghum harvester and crusher (designed and built by Mr. Harold Wituski, Beatrice, NE). The plants were harvested and directed via belts to the crusher. The squeezed juice is then deposited into a mounted tank that contains yeast for fermentation.

### A Viable Biomass Alternative

How does sweet sorghum fare in the viability arena? Dweikat says the plant meets or exceeds expectations. The criteria for determining the viability of biomass use for biofuels centers on the four general areas: energy balance, materiality, sustainability and economics, he observes. “Does it yield more energy than is required to produce it?” he asks rhetorically, pointing out that sweet sorghum does. “Can it be produced at a large enough scale to be meaningful in terms of fuel supply?” he continues, stating that sweet sorghum certainly can. “The U.S. is capable of producing 1 billion dry tons of biomass annually—enough for 60 billion gallons of ethanol per year, [which is] 30 percent of today’s transportation fuel usage,” Dweikat explains, noting the numbers include agricultural and forestry wastes, grains

and perennial bioenergy crops. He says the country can produce at that level “and continue to meet food, feed, and export demands.”

Is sweet sorghum a solution to the food-versus-fuel issue? Dweikat, Cukierman, Reddy, and Blumenthal believe it is because it’s not raised for human consumption. Sweet sorghum experiences a short vegetative period at a very high photosynthesis rate, which is why it can produce more sugar than any other crop. It has low water requirements, grows on marginal land, experiences little disease or pest attacks, and produces good cash flow at a low investment per acre. “[It has a] high conversion to alcohol, and therefore to ethanol,” Cukierman says. **EP**

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