Sweet Energy Crop

Sweet Sorghum Biomass and Stem Juice to Produce Ethanol

by Lynn Grooms

With yields of approximately 12 tons of biomass per acre, sweet sorghum could be a "sweet" cellulosic ethanol feedstock.

At 112 gallons per ton, that would mean sweet sorghum could produce 1,344 gallons of cellulosic ethanol per acre.

In addition to its biomass producing cellulosic ethanol, the crop's stem juice can be fermented into starch-based ethanol.

Also rich in micronutrients and minerals, stillage from sweet sorghum after the extraction of juice has a high value when used as fodder for animals.

These are just a few of the advantages that sweet sorghum offers, Ismail Dweikat, associate professor, Sorghum & Pearl Millet Genetics, University of Nebraska-Lincoln (UNL), said at the National Ethanol Conference, Feb. 25-27, Orlando, FL.

Not only is sweet sorghum a high yielder, it can be produced for about $150 per acre, about $200 per acre less than what it costs to produce corn.

Moreover, it tolerates drought and high temperature stress and can be grown on marginal land in at least 35 states.

It can be grown on soils ranging from heavy clay to light sand.

Although grown from Alabama to Minnesota, it is grown most extensively in the Southeast, Dweikat said.

Sweet sorghum is a warm-season crop that matures earlier under high temperatures and short days.

University Research

The University of Nebraska's sorghum breeding program features an extensive collection of sweet sorghum germplasm ranging in maturity period, photoperiod sensitivity, height, total biomass production, and brix readings (measurement of the mass ratio of dissolved sugar to water in a liquid) from 12% to 23%.

Sweet sorghum stalks range in diameter from 4.5 to 1.5 inches.

According to Dweikat, UNL has several objectives for its sweet sorghum program.

Lifecycle analysis. First, the university is performing a lifecycle analysis of the sweet sorghum ethanol system to determine net energy yield, efficiency and potential to mitigate greenhouse gases as compared to other biofuels as well as petroleum-derived gasoline.

Fermentation. Second, the university is conducting chemical and fermentation analyses of sweet sorghum sap for maximum conversion to ethanol and sorghum stover for cellulosic ethanol production.

Lower Lignin. Sweet sorghum stover is as an excellent feedstock for ethanol production, Dweikat said.

The brown midrib (*bmr*) mutants of sorghum have significantly lower levels of lignin content (51% less in their stems and 25% less in their leaves).

Nebraska research has shown 50% higher yield of the fermentable sugars from the stover of certain *bmr* lines after enzymatic hydrolysis.

Therefore, these cultivars could reduce the cost of biomass-based ethanol production. Nebraska breeders have moved two *bmr* genes to sweet sorghum lines and hybrids.

UNL researchers also are selecting for non-flowering high sugar types to extend the crop's growing season and total biomass, and are developing sterile F1 hybrids.

Management Practices

Another goal is to develop management practices that achieve high water and nitrogen use efficiency while maintaining high sugar yields.

Because sorghum harvested for biomass can be harvested before maturity, it can be grown in a double-crop sequence with a winter annual, Dweikat said.

Hairy Vetch (*Vicia villosa* Roth), for example, can be seeded in fall and will reach maturity by early summer.

It can produce 3-5 tons per acre and leave up to 100 pounds of nitrogen in the soil which is sufficient to grow a crop of sweet sorghum.

In addition to the University of Nebraska, sweet sorghum breeding is being conducted at the University of Kentucky and Texas A&M University.

Since both grain and forage sorghum have long been grown in the United States, changing to sweet sorghum should not present problems, Dweikat said.

Challenges. The main issue deals with processing, he says, explaining that the directly fermentable sugars in the stalk present a challenge in that they are unstable compared with starch.

"Whether sweet sorghum can become a viable energy crop will depend on solving this serious seasonality problem. Processing facilities must be large enough to handle the entire crop in a matter of weeks, and the conversion to ethanol or other energy products must be spread out over a sufficient time period to keep unit capital investment low," Dweikat said.

"Studies on fermentation and distillation methods indicate the technical and economic feasibility for on-farm fermentation of sweet sorghum forage sugar to ethanol. They also indicate the feasibility of distillation of the ethanol to an ethanol-water solution that could be transported to a central facility for making fuel-grade ethanol."