UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Sweet Sorghum for Biofuel

Introduction

Sweet sorghum (*Sorghum bicolor*) is primarily grown in Kentucky for its syrup. However, this crop may someday have another use in the Commonwealth — as a bioenergy crop. From 2007 to 2009, University of Kentucky researchers examined the feasibility of ethanol production from sweet sorghum. They concluded that "overall sweet sorghum would appear to be a very feasible crop for ethanol production in Kentucky." Additional states, along with several other countries, have also been actively conducting research on sweet sorghum for biofuel, and with promising results.

Similar to sugarcane, sweet sorghum juices extracted from stalks are high in sugars that are readily fermentable. It has been suggested that sweet sorghum has the potential of producing 530 to 700 gallons of ethanol per acre, compared to the maximum potential ethanol yield from corn of 420 gallons per acre. Additionally, because fewer inputs (e.g. nitrogen) and less water are required for sweet sorghum production compared to corn, sweet sorghum is considered a more efficient and cost-effective source of energy than corn.

The energy gain from sweet sorghum is substantially more than the energy used in production. The USDA reports that corn ethanol will produce 1.3 to 1.8 Btu of energy for every Btu of fossil energy used in production; whereas sweet sorghum ethanol could produce as much as 12 to 16 Btu for every Btu used.

Sweet sorghum may have multiple uses as an energy crop. The crushed stalks that remain after the juice is removed (bagasse) could be used for cellulosic ethanol production and the grain may be used for ethanol production from starch. According to UK researchers, if starch and cellulosic ethanol are considered, sweet sorghum would likely produce between 50 and 100 percent more ethanol per acre than corn grain and stover. Sweet sorghum bagasse could also be used as a combustible fuel to co-fire in power plants, similar to switchgrass and miscanthus. However, since sweet sorghum is an annual crop, it would not require the long-term field commitment of perennial grasses.

Sweet sorghum is not without shortcomings as a biofuel crop. One drawback is the short shelf-life of the raw juice, which prevents it from being stored. Processing plants would need to be located on-farm or at least within a few miles of production fields. UK researchers believe that fermenting the juice into ethanol on-farm appears feasible.

Marketing and Market Outlook

Commercially viable production of sweet sorghum for biofuel production in the U.S. will involve ethanol production facilities located near production areas, as well as nearby livestock feed markets for ethanol byproducts. Such facilities would provide a local market for sweet sorghum intended for biofuel production. Research results published in 2009 on the feasibility of sweet sorghum production for biofuel

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in the Mississippi Delta region confirmed that sweet sorghum biofuel processors should be located very near production fields. Other research has indicated that higher-yielding sweet sorghum varieties improve financial returns; and improvements in returns can help justify longer transportation costs.

In Kentucky, Commonwealth Agri-Energy LLC in Hopkinsville successfully produced ethanol from sweet sorghum sugars in 2012. This project, in partnership with Delta BioRenewables, is expected to continue in 2013. The project uses hybrid sweet sorghum varieties bred by Ceres, Inc.

The acceptance of sweet sorghum as an advanced biofuel feedstock under the Renewable Fuel Standard is a likely necessity for larger-scale commercialization of sweet sorghum for biofuel production. Grain sorghum received acceptance under the RFS in 2012, and sweet sorghum was said to be "on the pathway" to acceptance in late 2012, with USDA research necessary for the EPA approval continuing.

Production Considerations

Cultivars

Cultivars ideal for ethanol production will be those that produce medium- to large-sized, strong, erect stalks with high total sugars. Additionally, cultivars should be adapted to Kentucky conditions and resistant to prevalent diseases. Cultivars used in UK's sweet sorghum for ethanol research were Dale, Sugar Drip, and Simon. Later maturing cultivars such as Dale produce greater biomass, but earlier maturing types such as Sugar Drip lengthen the harvest period.

The first-ever sweet sorghum male-sterile hybrid was released by the University of Kentucky in 2007. Named KN Morris, this vigorous hybrid yields 25 percent more juice than other cultivars. Without seed formation, the crop stands better in windy locations and lodges less.

Site selection and planting

Production methods for growing sweet sorghum for ethanol are similar to those of sweet sorghum for syrup. The goal in both instances is the production of large amounts of juice high in sugars. In general, loam and sandy loam soils are best for the growth of sweet sorghum; however, most of the well-drained silt loams in Kentucky will produce excellent sweet sorghum when properly fertilized. Clayey soils usually produce poor stands and lower yields of juice. Soils high in organic matter are also thought to have a detrimental effect on yields. Sweet sorghum should not be grown on land following a tobacco crop; however, it can be successfully grown following corn or soybeans.

The optimum time to plant sweet sorghum in Kentucky is from May 1 to May 20 for full-season varieties and before June 10 for earlier maturing varieties. Sorghum tolerates drought and high temperature stress better than many crops, but it does not grow well under low temperatures. Soil temperature should be above 65° F for the best seed emergence. Sorghum can be direct-seeded or transplanted. Transplants can be grown using the tobacco float system. Target plant populations for ethanol production are between 60,000 and 100,000 plants per acre. Populations that are too dense result in thin stalks, more lodging, and less sugar.

Pest management

Kentucky's major sweet sorghum diseases are leaf anthracnose, red stalk rot, and maize dwarf mosaic virus. Control of these diseases is mainly through the selection of resistant varieties and crop rotation. Insects do not usually cause a serious problem on sweet sorghum in Kentucky. There are limited herbicides currently registered for use on sweet sorghum, making cultivation the main method for controlling weeds. Fields heavily infested with Johnsongrass or bermudagrass should not be planted to sorghum.

Harvest and storage

Large-scale harvest of sweet sorghum for biofuel would need to be done mechanically. Because the sugars start degrading after harvest, juice must be extracted from the stalks within a few days if the stalks are harvested whole. The juice must be fermented quickly after extraction. This may require that some or all of this process be accomplished on-farm. Off-farm processing facilities would need to be located very close (a few miles) to production fields.

Labor requirements

Labor needs for sweet sorghum production are estimated at nearly 4½ hours per acre. Mechanical harvest for an acre of sweet sorghum using either a combine or forage chopper is estimated at less than 1 hour.

Economic Considerations

Initial investments include land preparation and purchase of seed, fertilizer, and other inputs typical in field crop production. Profitability is quite sensitive to transportation costs to market, with longer distances decreasing the likelihood of positive economic returns. Higher yielding varieties could help offset higher harvest and/or transportation costs.

According to the University of Missouri, sweet sorghum likely requires lower levels of nitrogen, and higher levels of potassium and phosphorus fertilizer than does grain sorghum. Sweet sorghum for biofuel will not require the drying costs of grain sorghum, but sweet sorghum seed and equipment costs will be higher than grain sorghum. Economic production costs for the production of sweet sorghum for biofuel may be estimated by modifying production budgets for grain sorghum, such as those available from the University of Missouri and University of Tennessee.

If viable commercial markets develop, sweet sorghum production for biofuel will likely be most economically feasible as a part of regular crop rotations or on lower-quality lands not as readily suited for corn or soybean production.

Selected Resources

- Production of Sweet Sorghum for Syrup in Kentucky, AGR-122 (University of Kentucky, 1994) http://www.ca.uky.edu/agc/pubs/agr/agr122/agr122.htm
- Feasibility of Ethanol Production from Sweet Sorghum in Kentucky (University of Kentucky, 2009) http://www.uky.edu/Ag/cdbrec/sorghumethanol.pdf
- Kentucky Foundation Seed Project: KN Morris Hybrid Sweet Sorghum (University of Kentucky) http://www.ca.uky.edu/pss/index.php?p=703
- Delta BioRenewables and Commonwealth Agri-Energy Produce Ethanol from Sweet Sorghum at Corn Ethanol Facility (Delta BioRenewables, 2012) http://www.biodimensions.net/DBR_SorghumBiofuelsTrial_Release_12.11.2012.pdf
- Economic Feasibility of Growing Sweet Sorghum for Ethanol on the Mineral Soils of Florida (University of Florida, 2012) http://sseassociation.org/Presentations/SlideShow.aspx?presentationID=1005&page=01
- Field Crop Budgets: Grain Sorghum (University of Tennessee, 2012) http://economics.ag.utk.edu/budgets.html
- Grain Sorghum Budget for 2013 (University of Missouri, 2012) http://extension.missouri.edu/seregion/Crop_Budgets_PDF&Excell/Grain_Sorghum.pdf
- Potential for Sweet Sorghum Biofuels (Memphis AgBioworks, 2012) http://www.agbioworks.org/regional.cfm
- Production of Biofuel Crops in Florida: Sweet Sorghum (University of Florida, 2011) http://edis.ifas.ufl.edu/ag298
- Sweet Sorghum Ethanol Association http://sseassociation.org/Default.aspx
- Sweet Sorghum for Biofuel Production (eXtension, 2012) http://www.extension.org/pages/26634/sweet-sorghum-for-biofuel-production

Commercial Web sites listed in the resources are provided for information purposes only and their inclusion does not represent an endorsement of the company or its products by the University of Kentucky.

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Photo by Steve Patton, University of Kentucky Ag Communications **Issued April 2013**