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Sweet Sorghum Ideal for Biofuel

Research in India Finds Sorghum Well-Suited for Ethanol Production

By Nandini Nimbkar and Anil Rajvanshi

The potential for production of energy from crop plants has received much attention in recent years because of the great advantage of renewable energy sources over non-renewable ones. Ethanol from sweet-stem sorghum (Sorghum bicolor (L.) Moench) appears to be a viable alternative to fossil fuels, especially for petroleum products as a cooking, lighting and automotive fuel. Sweet-stem sorghum is a multi-purpose crop, yielding food in the form of grain, fuel in the form of ethanol from its stem juice, and fodder from its leaves and bagasse. Recognizing these benefits, the Nimbkar Agricultural Research Institute (NARI)—a non-profit, private organization based in Maharashtra, India—pioneered work on sweet-stem sorghum in India in the early 1970s.

Traditionally, ethanol has been produced mainly from sugarcane and molasses. Molasses, a byproduct of sugarcane processing, is available relatively cheaply, but sweet-stem sorghum can compete economically due to its high-value grain production. Also, it has several advantages over sugarcane, such as the ability to withstand dry conditions, require less fertilizer, rapid growth rate, ease of planting, and lower cost of total fermentable sugars.

Sweet-stem sorghum has been grown for more than a century in the southeastern United States in small plantings for making sweet syrup. It was introduced into India by NARI in late 1960s. As the American varieties produced very little grain of inferior quality, they were crossed at NARI with local grain types. This increased their adaptability to local geographic and climatic conditions. Due to economic considerations, emphasis was given to high grain and biomass as well as sugar yields in developing new sorghum varieties. Instead of pure lines, NARI opted for hybrid production in order to speedily combine high grain, biomass, and sugar production ability into one cultivar. This also made it possible to produce hybrid seed on short-statured females, thus reducing seed production problems. The hybrid seeds produced tall plants with high vigor. In addition, the use of hybrids simplified incorporation of disease and insect resistance.

The sweet-stem sorghum hybrid "Madhura" has been developed at NARI for ethanol, syrup and jaggery (unrefined sugar) production. Recently, the government of India started an initiative to make it mandatory to add 5% ethanol to gasoline, resulting in increased demand for Madhura seed. This year, a company in Pune manufacturing distillation plants has undertaken a large scale-planting program of Madhura to assess its ethanol production potential.

"Madhura" planted in a one hectare area was found to yield the following products in one year (two seasons): two to four tons of pearly white grain; five to seven tons of dry leaves; 15–20 tons dry bagasse; and three to six tons jaggery or five to nine tons syrup (750 brix) or 3,000 to 4,000 liters of ethanol (95% v/v).

Initially, studies were carried out at NARI to screen yeast from various sources for their potential to convert sweet-stem sorghum juice to ethanol. Out of the 16 strains screened, NCIM 3319 was found to be best suited for fermentation. It gave an average fermentation efficiency of 90%, which was completed between 48 and 72 hours. The juice contains an average of 10-11% (w/w) total fermentable sugars and the alcohol yields are about 6% (v/v).

A pilot solar distillation plant consisting of 38 m² of flat plate solar collectors linked to a hot water storage tank of 2,150-liter capacity was set up at the NARI campus. This plant logged about 4,000 hours of operation producing 30–40 liters day-1 of 95% (v/v) ethanol. About 70% of the total yearly distillation heat load came from solar energy. Techno-economic analysis for a 10,000 liter per day distillery producing 95% (v/v) ethanol showed the ethanol cost to be $0.30/liter for sweet-stem sorghum stripped stalk.

An improved, pressurized, multifuel (kerosene, ethanol or diesel) mantle lantern producing light output of 1,250–1,300 lumens (equivalent to that from a 100 W light bulb) called "Noorie" was developed at NARI. A pressurized alcohol stove with a heating capacity of three kilowatts for 85% (v/v) ethanol concentration with a thermal efficiency of 30–50% was also created.

Since ethanol is still under government control in India, there have to be basic policy changes before it can be used for cooking and lighting. Therefore, research efforts at NARI are also aimed at developing technologies to produce jaggery (unrefined sugar) and syrup from sweet-stem sorghum, using an efficient gasifier-powered furnace running on low-density biomass residues. Jaggery and syrup of excellent quality can be produced with this method.

Details on the sweet sorghum program are available online at http://nariphaltan.virtualave.net/sorghum.htm or by e-mailing Dr. Rajvanshi at nariphaltan@sancharnet.in.

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