Sweet sorghum and biomass energy improvement

India’s growing dependence on petroleum imports exposes its energy needs to external price shock. Therefore, production and use of domestic energy resources including renewable is the high priority to ensure India’s energy security (Planning comm., GOI, New Delhi 2006). The Government of India’s policy to blend ethanol (5-10%) with petrol has necessitated searching alternate feedstocks other than sugarcane molasses.

DSR released first commercial hybrid namely CSH22 SS

Sweet sorghum or more appropriately called sweet stalk sorghum is a biofuel crop that accumulates sugars (10-15%). It is similar to sugarcane, but it also produces grains like normal food or feed types of sorghum. Ethanol is produced from stalk juice as similar to molasses based ethanol production process. It is an important crop grown around the world for syrup, ethanol, power, food, forage, etc., (Blummel et al, 2009; Li Dajue, 1997 and Woods, 2001; Ratnavathi et al 2003; Shukla et al 2006; Rao 2005; Rao et al 2006a, and 2006b).

Delegates from India and abroad representing biofuel industry attended sweet sorghum commercialization media conference at DSR, Hyderabad in October 2007.
At DSR (Directorate of Sorghum Research), we are developing cultivars for high stalk yield, biomass, sugar content and bioethanol yields combining tolerance to shoot pests (shoot fly, stem borer, shoot bug etc) and improved crop production practices. Also, we provide pre-feasibility, consultancy studies on commercialization of sweet sorghum for bioethanol production in which we collaborated with sugar distilleries and biofuel industries. We are also focusing on medium to long term aspects such as conversion of sorghum lignocellulosic biomass to ethanol which includes compositional analyses for key bioprocessing traits, pretreatment of biomass, isolation of useful microbes, allele mining, and development of noval crops by inter-specific hybridization, etc.

The progress of work in this task-force is summarized below.

1. **Characterizing initial and advanced entries, pre and post harvest management:** Cultivars SPSSV 27, SPSSV 33 & SPSSV 34 gave high stalk yield (17-36%), ethanol yields (16-19%) than check. Mean ethanol yield recorded in sweet sorghum was three-fold higher (1399 L/ha) than grain sorghum (438L/ha). Stalk sugars can be retained up to 2 to 3-days after harvest in ambient field storage in mild winter (Nov.) & SPSSV 30 was found stable for stalk sugar retention even up to 7 days.

2. **Evaluation of experimental hybrids & inventorying existing parental lines for sugar & stalk yield:** 124 hybrids recorded high brix (16-21 %) than check. Another 62 were found to be sterile as they were based on A3 cytoplasm and equal number of hybrids was too fertile. 40 parental lines showed brix (17-19%) and promising. A total of 31 BxB crosses were effected to improve sweet sorghum and forage B lines.

3. **Lignocellulosic biomass/bagasse compositional analyses:** 150 entries evaluated for bagasse composition. The cellulose content varied from 26-40% and NSSV 13, and RSSV 138 were superior. Entries SPSSH 26 and SPSSV11 showed high cellulose to lignin ratio (C/L ratio).

4. **Developing improved agrotechniques and crop management:** Sweet sorghum stalk and ethanol yield did not differ between 1st and 3rd wks. of June. July middle and August planting decreased the same by >100%. Significant interaction observed between plantings and cultivars. CSH 22SS gave highest ethanol yields (820 L/ha) followed by SSV 74 (549 L/ha) across the plantings. Nitrogen and Potassium interaction on sugar accumulation in sweet sorghum indicated that N had significant influence on stalk and juice yield than levels of K application. The magnitude of increase was in the range of 29 to 42% for stalk yield, while it was 17 to 22% for juice yield.

5. **Evaluation of sweet sorghum against shoot pests:** Eight entries namely IS 18164, ICSV 93046, E 38, IS 5353, KARS 95, GGUB 50, ICSV 700 were found tolerant to stem borer as well as shoot bug.

6. **Pre-commercialization with biofuel entrepreneurs:** DSR supplied 6 tonnes of planting materials of sweet sorghum to M/S Tata chemicals and other six companies for large scale planting of >2000 ha of area. Advised crop devpt. & senior business managers of Tata chemicals, Nanded and other 10 biofuel companies on diagnosing the sweet sorghum production problems and suggested suitable remedial measures.

**Networking and services provided/received:**

1. Provide services to evaluate sweet sorghum stalk and juice samples for sugar compositional analyses to biofuel industry personnel and students of ANGRAU, IICT, etc.
2. ILRI facility on NIRS for bagasse and stover compositional analyses is being used.
On-going projects:

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<td>I.</td>
<td><strong>Institutional projects</strong></td>
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<tr>
<td>1.</td>
<td>Improving and utilizing sweet sorghum for high biofuel and biomass production</td>
<td>SS Rao</td>
<td>2009-12</td>
<td>ICAR</td>
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<td>2.</td>
<td>Sweet sorghum hybrid and R-line development</td>
<td>AV Umakanth</td>
<td>2009-12</td>
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<td>II.</td>
<td><strong>Externally funded projects</strong></td>
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<td>3.</td>
<td>Value chain model for bio-ethanol production from sweet sorghum in rainfed areas through collective action and partnership (In partnership with ICRISAT)</td>
<td>SS Rao</td>
<td>2007-2012</td>
<td>NAIP</td>
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Looking ahead:

- Developing cultivars tolerance to shoot fly, stem borer and shoot bug with high stalk yield and ethanol yields, & dedicated sterile hybrids
- Developing improved crop management techniques including pre-and post harvesting processing methods of sweet sorghum.
- Transgenic for borer resistance, high sugar accumulation and ethanol yield
- Rapid sugar accumulation immediately after flowering and retaining for a longer period for staggered feedstock supply.
- Pre-feasibility and commercialization and scaling up of sweet sorghum cultivation in collaboration with sugarcane distilleries, biofuel industry and farmers
- Diversified biobased products from bagasse i.e. cogeneration, bio-manure, and cattle feed etc.
- Compositional analyses of biomass/bagasse/stover for key bioprocessing traits, pretreatment, and bioconversion of bagasse to bioethanol (with TERI, New Delhi and NIIST (CSIR), Tiruvananthapuram).