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Sweet Sorghum: A Smart, Multipurpose Crop

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Sweet sorghum (*Sorghum bicolor* (L.) Moench) is similar to grain sorghum except for its juice-rich sweet stalk and it is often taller (up to 4 meters). It can be grown successfully in dry land growing areas. It is known as the sugarcane of the desert, a "smart" crop and "camel among crops". SS extracts only one seventh of the water that is used up by sugarcane. SS provides grain for human consumption and stover for fodder and it is also used for industrial biofuel production. It is not often that all three (Food, Fodder and Fuel) requirements can be provided by one crop. It has more total sugars in the juice than sugarcane. Also, SS-based ethanol is sulfur-free and cleaner than molasses-based ethanol, when mixed with gasoline.

SS is definitely profitable and comparison to competing crops like sole maize and sugarcane, the net returns are marginally better for SS in a few years. It can play a significant role in addressing the growing need for renewable energy to displace fossil fuel-based energy resources. Also it gives by-product like bagasse, spent wash etc. used as fodder, fuel, gives external income. SS can be used as a best alternative for sugarcane for syrup and ethanol making. Truly, sweet sorghum is a solution to the food-versus-fuel issue.

Introduction

The correct name for the cultivated sorghum is *Sorghum bicolor* (L.) Moench. Family: Poaceae, Chromosome no. $2n = 20$. Commercial cultivars of *Sorghum bicolor* (L.) Moench are categorized into the following agronomic variants: Grain sorghum, Forage (or fodder) sorghum, Fibre sorghum, Broom sorghum, Sweet sorghum, Biomass sorghum

Sweet sorghum is a C4 species plant having wide flat leaves and a round or elliptical head. Sweet sorghum, similar to grain sorghum except for its juice-rich sweet stalk and it is often taller (sometimes much taller, reaching up to 4 meters). Emerged in Northeast Africa Sweet sorghum can grow almost everywhere grain sorghum is grown. It can be grown successfully in semiarid tropics, where other crops fail to survive and are highly suitable for cultivation in tougher dry land growing areas. During very dry periods, sweet sorghum can go into dormancy, with growth resuming when sufficient moisture levels return (Gnansounou *et al.* 2005). It is known as the sugarcane of the desert.

In India sorghum area harvested 4.65 M ha, Yield 995 kg/ha and Production 4.63 M tonnes during 2019-2020.

Sweet sorghum has some interesting characteristics: Its growth cycle is short (about four months) facilitating double cropping. It can be easily grown from seeds. Its production can be completely mechanized. It produces sugar in the stalk and starch in the grain. It has a high water and nutrient use efficiency. The bagasse produced from sweet sorghum has high biological value when used as forage. It has a wide adaptability to different environments.

Why it is smart crop?

Sweet sorghum Known as a "smart" crop and also known as the "camel among crops" by many scientists and farmers because it is well adapted to the arid and semi-arid tropics. It is drought tolerant and very water-use efficient. As a dryland crop for biofuel production, it is highly favoured



for its effective conversion of atmospheric carbon dioxide into sugar, making it a viable alternative to sugarcane or maize for the production of ethanol.

"Sweet sorghum extracts only one seventh of the water that is used up by sugarcane," states Dr. Belum VS Reddy, Principal Sorghum Breeder at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).



Sweet sorghum under field condition

Why it is multipurpose crop?

Sweet sorghum (*Sorghum bicolor* (L.) Moench) not only provides grain for human consumption and stover (stalks and leaves) for fodder, but it is increasingly being used in India as feedstock for industrial biofuel production. It is not often that all three (Food, Fodder and Fuel) requirements can be provided by one crop.

<u>Crop part</u>	<u>Use option</u>
Grains	: Feed, food, first generation bioethanol
Juice	: Sugar, first generation bioethanol
Bagasse	: Feed, pulp, bioenergy, fertilizer, Second generation bioethanol
Leaves	: Feed, bioenergy, fertilizer, second generation bioethanol

Sweet sorghum is highly suitable for India:

Sweet sorghum is a specialty sorghum with sugar rich juice. It is 3-4 months crop can be grown in rainfed conditions and marginal land. More than 8 mha sorghum area in India and it is familiar crop to farmers. Higher on-farm productivity, fresh stalk yield 40t/ha. Brix% ranges from 15-20, influenced by genotype, season and growing area. Juice is rich in minerals like Ca, Mg, S, Zn, Fe, Mn, Cu, K and Na. Juice can go for ethanol (50lit/t) or syrup.

Life cycle and growth conditions:

Sweet sorghum is an annual plant with a short life cycle of about 4 months. It is a warm-season crop with the highest productivity in rainy and summer seasons. Sweet sorghum is mainly adapted to arid and semi-arid regions, with temperature range of 12–37°C, optimum range being 32–34°C. Yield of sweet sorghum is directly affected by the planting time. In the semi-arid tropical climate, ideal time for planting sweet sorghum is early June to early July.



The life cycle of sorghum has been divided into three distinct growth phases with ten morphologically distinguishable growth stages.

1. 1st phase involves germination to panicle initiation (GS1)
2. 2nd phase starts with panicle initiation and ends with the anthesis (GS2)
3. 3rd phase starts from anthesis until maturity (GS3)
4. Accumulation of soluble sugars in sweet sorghum stems is reported to surge after the internode elongation stops at the time of anthesis.
5. Therefore, sweet sorghum stems are usually harvested about 30 days after anthesis.

Sweet sorghum varieties:

- The important sweet sorghum varieties released at **International level** are Rio, Dale, Brandes, Theis, Roma, Vani, Ramada and Keller.
- BJ 248, RSSV 9, NSSV 208, NSSV 255 and RSSV 56 are the sweet sorghum cultures identified by the All India Coordinated sorghum improvement project at **National level**.
- **In Gujarat** CSV 13, CSV 24, E 173 (IC 568390) and E 158 (IC 568375) are sweet sorghum variety.

Products from sweet sorghum:

➤ **Fuel-grade ethanol:**

- Sweet sorghum with a potential of 30–50 t/ha of juicy biomass and 40-60% of juice recovery can serve as a potential alternative feedstock for fuel-grade ethanol.
- Because of seed propagation, short duration and lower cost of production, lower water requirement, and lower per liter cost of ethanol production, compared to sugarcane (molasses, the byproduct of sugarcane is the sole feedstock for ethanol production), policy makers and researchers are favoring the use of sweet sorghum as an alternative to molasses for ethanol production.

➤ **Natural syrup and jaggery:**

Sweet sorghum juice concentrated and sterilized to make natural syrup can be used in the dairy and confectionery industry as a sweetener.

- This syrup can be used in place of honey and can be served along with breakfast foods.
- This syrup called “**sorghum honey**” can be marketed immediately.
- The chemical composition of sweet sorghum syrup is similar to honey.

➤ **Jaggery:**

- Sweet sorghum juice can be concentrated and jaggery can be prepared using the same methodology used in sugarcane.
- Sugars in sweet sorghum stalk include sucrose, glucose and fructose.
- Depending on the sugar profile in juice, an average jaggery yield of about 30 to 35 q/ha.
- The cost will also be economical compared to sugarcane jaggery and may be about Rs. 5 per kg.

❖ **Biofuel:**

- Now a day's the world's present economy is highly dependent on various fossil energy sources such as oil, coal, gasoline, natural gas, etc. These are being used for the production of fuel, electricity and other goods.
- Due to excessive use of fossil fuels, mainly the level of greenhouse gasses in the earth's atmosphere has drastically increased.



- In the present demand for renewable, sustainable sources of energy is require to overcome the burden on world energy crisis, bioethanol have presented exciting options.
- Sweet sorghum is recognized as an alternate feedstock for bioethanol production by the Government of India.
- The sweet sorghum ethanol value chain shows a reduction of greenhouse gas emissions by 86%, compared to fossil fuels.

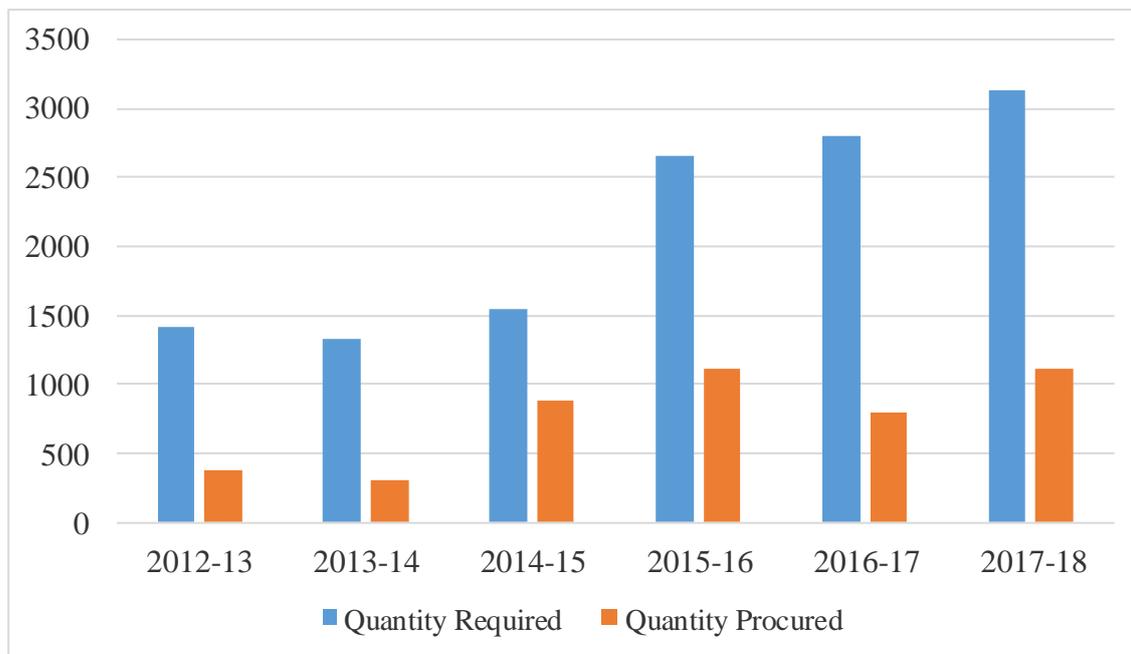


Fig. 2: Ethanol requirement and supply from sugar mills in India (M Liters)

Source : http://www.business-standard.com/article/economy-policy/govt-raises-ethanol-procurement-price-by-5-for-2017-18-117110101064_1.html

Requirement of ethanol was more compare with production. During 2017-18 requirement of ethanol was 3130 million liters while production was only 1110 million liters and that obtain from sugarcane mills. That’s while this sweet sorghum will become alternative crop for production of ethanol.

Sugar mills as entry point for sweet sorghum ethanol

- Ethanol price high now, close to Rs.40
- Large demand for ethanol for blending
- There are >600 sugar mills in India, of which >400 have distilleries attached.
- Sugarcane crushing: Nov-Mar

Proposed Sweet sorghum based Bioenergy Calendar

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Yellow	Yellow	Yellow	Light Blue	Yellow	Yellow						
Green	Light Blue	Light Blue	Brown	Green	Green	Light Blue	Light Blue	Brown	Brown	Light Blue	Light Blue



Sugarcane harvesting



Sweet sorghum planting



Sweet sorghum harvesting



This calendar was proposed by ICRISAT. In this stat that number of sugar mills present in India but they worked only November to March, Other months it not working. So during that time sweet sorghum was useful for working that sugar mills without any setup and that gave benefit to employers, farmers and sugar mill owner.

Uses of syrups

- Types of syrups include; glucose syrup, maltose syrup, fructose syrup, sugar cane syrup, maple syrup, honey, sweet sorghum syrup.
- SS syrups are used as natural sweeteners either in food or pharmaceutical industries where syrups are utilized as sweetening agents.
- Natural sweeteners have the ability to impart sweet taste hence masking the unpleasant taste of a material in which it has been added.
- Moreover, due to high sugar concentration, low water activity, anti-microbial and anti-oxidant properties sweeteners offer preservation effect by inhibiting growth of micro-organisms and increasing the shelf life of the food products.
- The presence of readily fermentable sugars in syrups makes them potential raw material for ethanol production, since with dilution and addition of yeasts these sugars could be converted to ethanol.

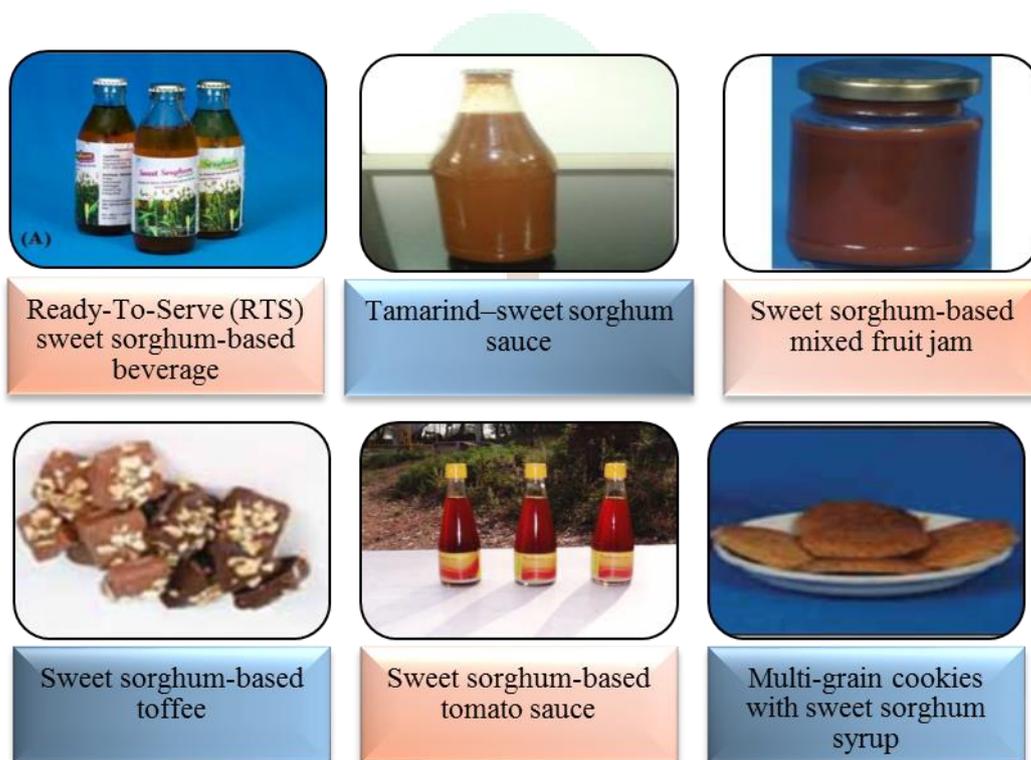


Fig.3: Various products prepared from sweet sorghum Syrup



Table.1: Comparison of SS with sugarcane

Crop	Sugarcane	Sweet sorghum
Duration (days)	Seasonal - 360	110-150
	Pre-seasonal - 420	
	Adsali - 480	
Fertilizer N:P:K (kg/ha)	Seasonal – 250:115:115	100:50:50
	Pre-seasonal – 340:170:170	
	Adsali - 360:170:170	
Amount of water required (mm)	Seasonal – 2000 - 2200	400-500
	Pre-seasonal - 2500	
	Adsali - 3000 - 3500	
Commercial cane sugar produced (t/ha- season)	9.4	2.4
Cost of cultivation of stalks (Rs./ha – season)	46,355	23,245

Ingle *et al.* (2018) at Dharwad found short duration, low fertilizer and water requirement, low cost cultivation of sweet sorghum compare to sugarcane.

Future Prospective

- Demand for renewable energy sources and biofuel which would minimize pollution are expected to rise rapidly in coming years.
- It is need to provide consultancy services on commercialization of sweet sorghum for bio-ethanol production.
- Efforts are on for development of sweet sorghums hybrids and varieties with high juice yield with high sugar content.
- Need to aware the farmers about commercial cultivation and valuable uses of sweet sorghum.
- Sweet sorghum will be most important alternative crop for sugarcane in dry land area.
- Sweet sorghum can overcome against the climate change issue and pollution, hence need to increases area under sweet sorghum and establish bio refineries at village level.
- Make a biofuel policy for sweet sorghum based bioethanol production.

**Table.2: A comparison of sweet sorghum and other bio-ethanol feedstocks rich in raw sugars**

Characteristics	Sweet sorghum	Sugarcane	Sugar beet
Crop duration	3–4 months	12–18 months	5–6 months
Growing season	All seasons	One season	One season
Soil requirement	Grows in all types of drained soil	Grows well in drained soil	Grows well in sandy loam; also tolerates alkalinity
Water management	Needs less water; can be grown as a rainfed crop (10,000 m ³ /ha)	Requires water throughout the year (36,000 m ³ /ha)	Requires 40-60% water compared to sugarcane (18,500 m ³ /ha)
Crop management	Easy management; low fertilizer, 90 N, 40 P and 40 K	Requires good management, 250–400N 125P and 125K	Requires moderate management, 120N, 60 P and 60 K
Yield (t/ha)	45–65	60–85	85–100
Sugar content on weight basis (%)	7–12	10–12	15–18
Sugar yield (t/ha)	3–7	5–12	11.25–18
Ethanol yield from juice (l/ha)	2,000–5,500	4,350–7,000	7,100–10,500
Harvesting	Predominantly manual and mechanical	Mechanical	Mechanical

Rao *et al.* (2009) at Hyderabad conduct a comparison of sweet sorghum and other bio-ethanol feed stocks rich in raw sugars and found characteristic of sweet sorghum is superior as compare to sugarcane and sugar beet.

Conclusion

In comparison to grain sorghum, sweet sorghum is definitely profitable and comparison to competing crops like sole maize and sugarcane under rainfed conditions, the net returns are marginally better for sweet sorghum in a few years. With the improvement in agronomic practices (farmers are still not fully familiar with the practices for a relatively new crop of sweet sorghum), sweet sorghum becomes viable option with assured incomes for cultivation under dryland conditions for smallholder farmers. It can play a significant role in addressing the growing need for renewable energy to displace fossil fuel-based energy resources. Also it gives by-product like bagasse, spent wash etc. used as fodder, fuel, gives additive income. Sweet sorghum can be used as a best alternative for sugarcane for syrup and ethanol making.



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