Policy Options for Promotion of Alternate Feedstocks for Ethanol Production in India: Sweet Sorghum for Ethanol Production

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Introduction

To ensure the long-term sustainability of bioethanol production in the semi-arid tropics of India this brief explores the option for augmenting bioethanol production using alternative feedstock like sweet sorghum grown in the drylands in addition to use of existing feedstocks. Policy options for the promotion of alternative feedstocks to sustain the bioethanol supply chain for the benefit of all stakeholders involved in the chain are highlighted and discussed.

Background

Energy consumption is one of the major indicators of the country's economic progress and its use increases with economic growth and development. India ranks sixth in terms of energy demand accounting for 3.6% of the global energy demand (Prasad et al. 2007) and this is expected to increase by 4.8% per annum in the next few years (Gonsalves 2006). India's energy demand is primarily met through nonrenewable energy sources such as coal, natural gas and oil that will continue to play a dominant role in the country's energy scenario in the next few decades. However, being short in domestic production, India mainly depends on crude oil imports that account for about 81% of the oil consumption in the country (Ministry of Petroleum and Natural Gas, 2009) and the imports are slated to increase further with the growth in the economy. The highest demand for energy comes from industry, followed by the transportation sector, which consumed about 16.9% (36.5 m of oil equivalent) of the total energy (217 million t) in 2005-06 (TERI 2007). Within the transportation sector, the consumption of motor spirit (gasoline) grew by 6.64%, from 7.01 million t in 2001-02 to 11.26 million t in 2008-09 and that of high speed diesel (HSD) by 4.1%, from 36.55 million t to 51.67 million t, respectively (GOI 2009). Amid the growing demand for crude, the prices of crude too are increasing and fluctuating, putting a strain on the foreign exchange reserve of the country (import bill of $75.6 billion in 2009-10). Further, increased emissions from usage of fossil fuels are leading to environmental pollution, which is a major cause of concern. Hence, in lieu of the growing concerns of energy security (due to high dependency on fossil fuels) and environmental pollution, securing long-term supply of energy sources that are renewable and non-polluting has been the major thrust of many governments all over the globe, including the Government of India.

Among several alternative renewable energy sources (wind, solar, hydro), energy derived from plant biomass is found to be promising and a sustainable energy source that contributes to reduction in greenhouse gas emissions (Subramanian et al. 2005). Bioenergy derived from plant based biofuels are also found to provide a wide range of social and economic benefits (Gonsalves 2006, Rajgopal 2008). Hence, to promote biofuels as an alternative energy source, the Government of India in December 2009 announced a comprehensive National Policy on Biofuels formulated by the Ministry of New and Renewable Energy (MNRE), calling for blending atleast 20% of biofuels with diesel (biodiesel) and petrol (bioethanol) by 2017. The policies are designed to facilitate and bring about optimal development and utilization of indigenous biomass feedstocks for biofuel production.

However, experience has shown that the Government's initiatives have not translated into results on the production and commercialization fronts to meet the country's energy demand through biofuels due to ineffective policy implementation.

This paper highlights the challenges affecting biofuel production particularly for bioethanol and discusses how to bring about the long-term sustainability and commercialization of bioethanol production in the country. The paper then explores and discusses the viability of using alternative feedstock such as sweet sorghum grown on drylands for sustainable bioethanol production and policy options for its promotion.

Challenges towards sustainable bioethanol production

In January 2003, the Government of India launched the Ethanol Blended Petrol Program (EBPP) in nine States and four Union Territories promoting the use of ethanol for blending with gasoline and the use of biodiesel derived from non-edible oils for blending with diesel (5% blending). Due to ethanol shortage during 2004-05, the blending mandate was made optional in October 2004, and resumed in October 2006 in 20 States and 7 Union Territories in the second phase of EBPP. These ad-hoc policy changes continued until December 2009, when the Government of India came out with a comprehensive National Policy on Biofuels formulated by the Ministry of New and Renewable Energy (MNRE).

Currently, the entire bioethanol requirement for blending mandates has to come from molasses, a byproduct of sugarcane. The availability of molasses depends on cane and sugar production that are cyclical in nature. Lower molasses availability will put pressure on molasses prices, which in-turn affects ethanol production from molasses. Molasses prices in the last decade have fluctuated substantially and have ranged between Rs 1000 to 5000 per ton (Shinoj et al. 2011). Additionally, ethanol produced has many other alternative uses such as potable alcohol, and in chemical and pharmaceutical industries. During a normal year, cane converted into sugar generates enough molasses to produce alcohol that can meet the needs of both the potable and chemical sectors. The Government of India has assigned the responsibility of procurement, storage, distribution and marketing of biofuels to Oil Marketing Companies (OMC). Even during a normal year of cane production, OMCs are unable to procure the required quantity for blending as the current administered price of ethanol is ₹ 27 a liter while the market price for ethanol is on the higher side. There is assured demand from beverage and pharmaceutical industries under the current tendering system for ethanol. Further, blending of ethanol obtained at ₹ 27 a liter would prove uneconomical as the cost of petrol sans taxes during 2011 was around ₹ 23 a liter (Shinoj et al. 2011).

Import of ethanol for fuel usage is currently restricted through policy and even if made free, would cost the exchequer very dearly, as the international markets for ethanol are already very tight due to demand from other biofuel-consuming countries.

Given the scenario of the growing demand for alcohol from the potable and chemical sector (growing at 3-4% per annum) and the highest available alcohol from molasses pegged at 2.3 billion liters, there will be a shortage of alcohol for blending that will grow between now and 2020-21 even if we assume a moderate blending target of 10% (Table 1).

A study by Shinoj et al. (2011) finds that as per the 10% blending target set by the government, the demand for fuel ethanol is projected to be 2.16 million t and total demand (ethanol + alcohol) will be as high as 3.76 million t by 2016-17. If molasses alone has to meet the entire requirement of 3.76 million tons of ethanol, an area covering approximately 10.5 million ha with 736.5 million tons of sugarcane has to be cultivated (around 20-23% in excess of what is required to meet the corresponding sugar demand). This would be a doubling of both area and production to achieve 10% blending. Presently, the country lacks both technology and infrastructure required to implement this. Further, it is not possible to increase the area under sugarcane beyond a certain limit given that sugarcane is highly water intensive with a requirement of 20,000-30,000 m^3 per ha per crop. Also, increasing the area under sugarcane will be at the cost of diverting land from other staple food crops.

Table 1. Availability and utilization of ethanol in India.						
Year	Highest available alcohol from molasses (billion liters)	Ethanol utilization (billion liters)			Ethanol required for blending (billion liters)	Deficit/ Surplus
		Potable	Industry	Balance	@ 10%	
2010-11	2.3	0.86	0.82	0.62	1.53	-0.96
2011-12	2.3	0.89	0.84	0.57	1.64	-1.14
2012-13	2.3	0.91	0.87	0.52	1.70	-1.32
2013-14	2.3	0.94	0.90	0.46	2.02	-1.53
2014-15	2.3	0.97	0.94	0.39	2.13	-1.76
2015-16	2.3	1.00	0.97	0.33	2.23	-1.99
2016-17	2.3	1.03	1.00	0.27	2.34	-2.24
2017-18	2.3	1.06	1.04	0.2	2.46	-2.51
2018-19	2.3	1.09	1.07	0.14	2.58	-2.78
2019-20	2.3	1.12	1.11	0.07	2.71	-3.09
2020-21	2.3	1.16	1.15	-0.01	2.85	-3.42

Source: Planning Commission (2003) estimates on highest available alcohol from molasses.

Policy distortion affecting bioethanol production

The biofuel policy mentions that a level playing field is necessary for accelerated development and utilization of biofuels vis-a vis direct and indirect subsidies to fossil fuels and distortions in energy pricing (GOI, 2009). Policy also mentions that issue of fuel vs. food security is not relevant in the Indian context since bioethanol production from molasses, a by-product of sugarcane, and biodiesel from cultivation of shrubs and trees bearing non-edible oil seeds on waste, degraded forest land and non-forest lands do not compete with food crops. However, to augment the availability of ethanol and reduce the excess supply of sugar, the policy permits the sugar industry to directly produce ethanol from sugarcane juice. The policy implies further concessions to sugarcane growers and processors who are already benefiting from the huge input subsidy. Sugarcane industry has the advantage of existing infrastructure and favorable government policy support, that has led to the policymakers tailoring policies favoring ethanol production from sugarcane and molasses. Thus, the policy is sugarcane centric. This route, as is indicated, is not sustainable since molasses alone will not be able to meet the blending targets. Second, the diversion of sugarcane juice for direct ethanol production would be at the cost of reduction in sugar production and thus has implications on food security. Also, allowing direct conversion of sugarcane juice to ethanol is neither economically nor environmentally sustainable, given the fact that sugarcane is a water intensive crop. Thus, the policy emphasis on sugarcane is counterintuitive to the policy recommendation of using degraded, less fertile land and non-food feedstock for biofuel production. The sugarcane centric policy would thus have a detrimental effect on resource allocation in the agriculture sector. The vision and goals of the policy is to bring about accelerated development and promotion of the cultivation, production and use of biofuels while contributing to energy security, climate change mitigation, apart from creating new employment opportunities and leading to environmentally sustainable development. While the concerns of climate change have adverse impacts on agriculture crops, this would only exacerbate the situation if cultivation of water intensive crops are promoted.

Hence, to meet the targeted blending requirements, alternative feedstocks will have to play a more important role to fill the current and future gap between demand and supply of bioethanol. Sweet sorghum is one such alternative feedstock that has been pilot tested in recent years for cultivation under rain-fed conditions for ethanol production. Though the policy document mentions feedstocks such as sweet sorghum, sugar beet, etc, for ethanol production, these crops have neither been given due prominence in the policy nor has a clear roadmap been specified for their commercialization and utilization.

Sweet sorghum as a biofuel feedstock-Opportunities for cultivation under rainfed conditions of SAT regions

As per land use statistics of 2007-08, the net irrigated area in the country was reported to be about 62.28 million hectare against the net sown area of 141 million hectare. Thus, about 78.5 million hectare (56%) of net sown area was reported to be under rain fed agriculture (Table 2). The SAT (semi-arid tropics) regions of Maharashtra, Rajasthan, Madhya Pradesh, Karnataka, Gujarat and Andhra Pradesh account for nearly 67% under rain-fed agriculture. The average annual rainfall in the semi-arid tropic regions varies from less than 150 mm to 1600 mm and hence the cropping pattern is largely influenced by the magnitude and distribution of rainfall. The state-wise sorghum area presented in Table 3 shows that sorghum is predominantly a rain-fed crop cultivated in semi-arid tropical (SAT) regions of these states. Geographically, the Deccan Plateau and the Eastern Ghats are found suitable for sorghum cultivation and have a large area under rain-fed conditions. Specifically, the agro-ecological sub-regions 6.1, 6.2, 6.3 and 7.2 mainly semi-arid (moist or dry) are found to be potential zones for cultivation of sorghum. Here, sorghum – a dual purpose crop (food and fodder) – provides both food and feed security and economic security to farmers in these regions.

Like grain sorghum, sweet sorghum, a warm season crop requiring about 600-800 mm rainfall distributed across the growing period can be cultivated by farmers under rainfed conditions in these states. Cultivation practices of sweet sorghum are similar to that of grain sorghum. The only dissimilarity between grain sorghum and sweet sorghum is seen in the accumulation of sugars in the stalks of sweet sorghum that can be crushed to extract juice, which can then be processed into bioethanol. Besides the juice extracted for bioethanol, additional benefits are the grain harvested for food and bagasse left after extraction of juice from the stalk that can be used as livestock feed. While sweet sorghum can be a promising alternative feedstock for sustainable ethanol production, it can also provide a wide range of environmental, economic and employment benefits under rainfed conditions.

Table 2. Rainfed area across states of India, 2007 (000 ha).

State	Net Cropped Area (NCA)	Net Irrigated Area (NIA)	Rainfed Area	Share of rainfed area to NCA (%)	Total sorghum area	Rainfed sorghum area to total sorghum area (%)
Maharashtra	17473	3181	14292	82	4148	91
Karnataka	10419	3132	7287	70	1382	89
Gujarat	9747	3528	6219	64	128	88
Rajasthan	17096	6444	10652	62	625	100
Andhra Pradesh	10756	4644	6112	57	331	92
Madhya Pradesh	14687	6418	8269	56	531	100
Tamil Nadu	5062	2864	2198	43	283	93
Uttar Pradesh	16417	13085	3332	20	212	100
All-India	140861	62286	78575	56	7764	91

Source: Compiled from publications of Directorate of Economics and Statistics, Ministry of Agriculture, Government of India

Competitiveness of sweet sorghum

The economic competitiveness of sweet sorghum was worked out from on-farm data collected from a pilot project carried out by ICRISAT funded under the National Agriculture Innovation Project (NAIP), Indian Council of Agricultural Research (ICAR), Government of India (GOI). The analysis conducted by the authors from the cultivation data collected over the past three years (2008-09 to 2010-11) across locations of Andhra Pradesh has shown that sweet sorghum is competitive with dryland crops such as sorghum and maize. The benefit cost ratio (BCR) for sweet sorghum was 1.55 while it was 1.30 and 1.37, respectively, for maize-pigeonpea intercrop and sorghum-pigeonpea intercrop in 2008 (Table 3). Though BCR obtained were less than one for sweet sorghum during 2009 and 2010 due to poor rainfall years, sweet sorghum performed better than the competing crops.

Table 3. Benefit cost ratio of sweet sorghum cultivation with competing crops in Ibrahimbad, Andhra Pradesh.

	Benefit-Cost Ratio		
Crop Name	2008	2009	2010
Sweet Sorghum	1.55	0.96	0.81
Maize - Pigeonpea	1.30	NA	0.97
Sorghum - Pigeonpea	1.37	0.97	0.59

Economic viability assessment without accounting for capital costs of investment was carried out to understand the relative economics of ethanol production from 4 different feedstocks (sugarcane molasses, sugarcane juice, sweet sorghum and grains) in India. The assessment shows that sweet sorghum is economically the next best alternative to molasses for ethanol production (Table 4), when the feedstock is priced at ₹ 800 per ton of stalk with an average recovery rate of 4.5% alcohol per ton of stalk at the prevailing ethanol price.

As can be seen from the table, feedstock and ethanol pricing have a bearing on the viability of ethanol production from all available feedstocks. Economic viability assessment was also carried out by the authors taking into consideration the various economic and financial costs in establishment of the distillery. The results of the assessment show that the profitability of ethanol production is highly sensitive to ethanol price, feedstock price and recovery rate. Sensitivity analysis performed to derive the values of the key parameters of profitability shows that for sweet sorghum, when the feedstock is priced at ₹ 1500 per ton of stalk with the recovery rate at 4.9% alcohol, the price of ethanol has to be increased to ₹ 36 per liter from the existing administered price of ₹ 27 per liter to make the distillery viable.

Table 4. Relative economics of ethanol production from different feedstocks in India.

Parameter	Sweet sorghum	Sugarcane molasses	Sugarcane juice	Grains (Pearl millet & broken rice)
Cost of raw material (₹/t)	700[1]	3000-5000[2]	1200[3]	8000[3]
Cost of processing (₹/t)	384	1890	490	2800
Total cost of ethanol production (₹/t)	1084	4890-6890	1690	10800
Output of ethanol (l)	45	270	70	400
Value of ethanol (₹/t)	1215	7290	1890	10800
Net Returns (₹/t)	131	2400 - 400	200	0
Cost of feedstock (₹/l)	15.56	11.11-18.51	17.14	20.0
Cost of ethanol (₹/l)	24.08	18.11-25.51	24.14	27
Profit from ethanol (₹/l)	2.91	8.88 - 1.48	2.85	0

Note: The information on the parameters is collected from Rusni Distilleries for sweet sorghum, Nizam Deccan Sugars Pvt. Ltd. for molasses and AGRO Bio-tech, Ajitgarh, Rajasthan for grains. The value of by-products is not considered in the analysis; 1. Even when the feedstock is priced at ₹ 800, it becomes profitable to produce ethanol from sweet sorghum without accounting for capital costs; 2. The molasses prices have ranged between ₹ 3000 and 5000 /t during the last few years and hence the profitability of molasses ethanol production is highly sensitive to fluctuating molasses prices; 3. The data on all the other feedstocks cost is for the year 2009. The prices of feedstock (sugarcane and grains) have increased in the recent years.
Source: Authors' own estimates

Based on the recovery rate an analysis was performed by the authors to assess the land requirement for sweet sorghum cultivation by 2020 if it is commercially exploited as an alternate source of ethanol production. It is expected that a crop like sweet sorghum would only bridge a small gap in ethanol requirement supply from the existing feedstock, ie, molasses. The estimates show that to meet 30% of the ethanol requirement at 10% blending by 2020 (3.47 billion liters[1]), the area required under sweet sorghum would be about 1.16 million hectare (mh). This is calculated under the assumption of sweet sorghum stalk yields of 20 t/ ha and 4.5% recovery rate. This would be a small proportion of the total area under sorghum cultivation in the growing regions in the country.

Why sweet sorghum requires policy promotion

Industries processing alternative feedstock for ethanol production are discouraged at the existing level of ethanol price fixed at ₹ 27 per liter as the cost of production is on the higher side. Sweet sorghum is relatively a new feedstock for ethanol production and technological innovations are ongoing for cost reduction for processing. However, though cost of production of ethanol is on the higher side compared to sugarcane molasses, it is the second best alternative to augment ethanol production and meet the blending mandates.

Further,

- Sweet sorghum has the ability to adapt to drought; to saline and alkaline conditions; water logging conditions; tolerant to biotic and abiotic stresses (Reddy et al. 2005);
- Sweet sorghum does not compromise on food, feed or fodder production when used for energy production[2];
- Sweet sorghum is cultivated under rainfed conditions and utilizes resources judiciously;
- Sweet sorghum has the highest percent carbon emission reduction compared to other feedstocks. The net energy ratio (output energy/input energy) for sweet sorghum with 7.06 is the highest compared to other feedstocks in production of ethanol due to high conversion efficiency of sweet juice to ethanol (DBT-CII report, 2010);
- Less sulphur and high octane rating for ethanol produced from sweet sorghum (Reddy et al. 2008);
- The pollution levels in sweet sorghum based ethanol production has 25% of the biological oxygen dissolved (BOD), ie, 19,500 mg/liter and lower chemical oxygen dissolved (COD), ie, 38,640 mg/liter compared to molasses-based ethanol production (as per pilot study conducted by Vasantdada Sugar Institute (VSI), Pune, India).

In view of the above mentioned benefits, the existing National Policy on Biofuels requires a re-look to specify a clear road map on policies favoring ethanol production from alternate feedstocks like sweet sorghum. This will aid in sustainable ethanol production to meet the blending mandates.

Policies for promotion of alternate feedstocks

In the current market context, policy support for the production of a biofuel crop primarily depends on mutual co-existence of producers and processors to promote alternate feedstocks. For growers, it's the relative profitability of bioethanol crops vis-a-vis competing crops and assured buy-back at pre-determined prices that are the important factors determining allocation of land for these crops. For industry, the raw material's conversion efficiency, its continuous supply for at least 5-6 months in a year, the economics of establishing multi-feedstock production units and the purchase price of ethanol by oil companies are critical factors. For growers and industries producing ethanol from alternative feedstock, policy support should be in the form of:

- Provision of assistance to farmers cultivating sweet sorghum justifying the support on the arguments of augmenting bioethanol production under rainfed conditions, which meets both the food and fodder requirements of farmers;
- A one-time capital assistance for industries crushing alternate feedstocks for ethanol production or assistance in the form of "infant industry sops" for bioethanol industry for setting up of machinery for bioethanol production;

[1] Authors' calculation

[2] The grain can be harvested for food, and bagasse left after extraction of juice from the stalk is a good feed for livestock

- Compensating industry for the difference in economic cost of ethanol production from alternate feedstocks and the minimum purchase price until industry achieves technological and efficiency breakthrough;
- Permission to crush sweet sorghum by integrating with sugar industry during lean periods of sugarcane crushing;
- Licensing and permissions to be made easy for establishment and operationalization of multi-feedstock units that can operate for longer periods in a year to augment the ethanol production using different feedstocks;
- Increasing the administered price of bioethanol produced from alternate feedstocks;
- Exploring viability gap funding options as undertaken for infrastructure projects in Public Private Partnership (PPP) mode for the private sector to produce ethanol from alternate feedstocks like sweet sorghum;
- Exemption of duties and taxes on production of bioethanol produced from indigenous feedstocks like sweet sorghum.

Conclusions

The concerns of economic viability and sustainability of ethanol production indirectly from molasses and directly from sugarcane juice necessitates the need for promotion of alternate feedstocks like sweet sorghum. The apprehension of diversion of land for cultivation of biofuel crops does not exist in case of sweet sorghum, which can be cultivated under rainfed conditions and does not compromise on food security.

About 57% of the cultivable area in SAT India is under rainfed conditions. Crop choices are limited for resource poor farmers under harsh environments of semi-arid regions. Dryland crops like sorghum and millet thrive under such harsh conditions. Hence, cultivation of sweet sorghum in marginal and rainfed areas of SAT regions provides opportunity for smallholder farmers to enhance their incomes through cultivation of biofuel crops. Promotion of sweet sorghum through favorable polices related to production, processing and marketing, and more importantly pricing will pave the way for a bioenergy revolution in India through agriculture intensification in dryland areas.

Key words: Sweet sorghum; National Biofuel Policy; Bioethanol; Alternate feedstocks.

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