Agri. Residue availability in India and progress on energy crops

LCBF – All member meeting

07 Sep 2023

Ramakrishna Y B
Member Expert – Working group on Biofuels, Ministry of Petroleum & Natural Gas
BEST Associates - Partner
Chairperson – IFGE CBG Producers Form

Background

- The biofuel sector has a fundamental distinction from other sectors consuming agricultural commodities in terms of sustainability of supply chains.
- In the EU, United States and many countries governments created the biofuel sector that is broadly driven by policy instruments so has been case in India too.
- These policy decisions resulted in additional and growing demand for feedstock. Thus, for biofuels, the discussion is not about 'greening' the existing demand and supply chains, but about creating new adequate supply of sustainable feedstock that will not undermine, environmentally or socially, production and use of agricultural commodities in other sectors.
- To meet this goal, biofuel policies have to crosscut through a complex of issues related to energy, agriculture, regional development and environment protection.

Feedstocks for Ethanol production

- At present, about 60% of ethanol is produced from maize, 25% from sugarcane, 2% from molasses, 3% from wheat, and the remainder from other grains, cassava or sugar beets.
- More advanced technologies based on cellulosic feedstock (e.g., crop residues, dedicated energy crops, or wood) do not account for large shares of total biofuel production, 2G methods and lignocellulosic feedback producing less than 1-2 percent of the total share.
- In Brazil, ethanol is produced almost exclusively from sugarcane, accounting for 95 percent of the total
- In the US, ethanol production is mainly dependent on maize, and 40 percent of the country's total maize production is used for ethanol production

Ethanol capacity augmentation (1G)

in million liters

Year	Capacity requirement		
	Grain	Molasses	Total
2019-20	2580	4260	6840
2020-20	2600	4500	7100
2021-22	3000	5190	8190
2022-23	3500	6250	9750
2023-24	4500	7250	11750
2024-25	7000	7300	14300
2025-26	7400	7600	15000

Ligno cellulosic feedstocks

- 2G Ethanol essentially is produced from lignocellulosic material such as agriculture residues.
- The process is called Enzymatic conversion of Ligno-cellulosic material to Ethanol.
- The process involves different stages wherein the lignin cellulose bond is broken or loosened first. The cellulose both C5 and C6 is hydrolyzed by treating with Enzymes to get fermentable sugars. The fermentable sugars are then fermented yeast. The last stage would be distillation to recover Ethanol.
- Lignin will be a major by-product coming out of the process. Lignin could get separated in different stages depending on the process itself.
- Lignin can be used generating the process required or further valorized to get higher value products such as Bio Bitumen, Lignin sulfonate etc.
- This technology truly is not feedstock agnostic as enzymes are feedstock specific.

Technology commercialisation

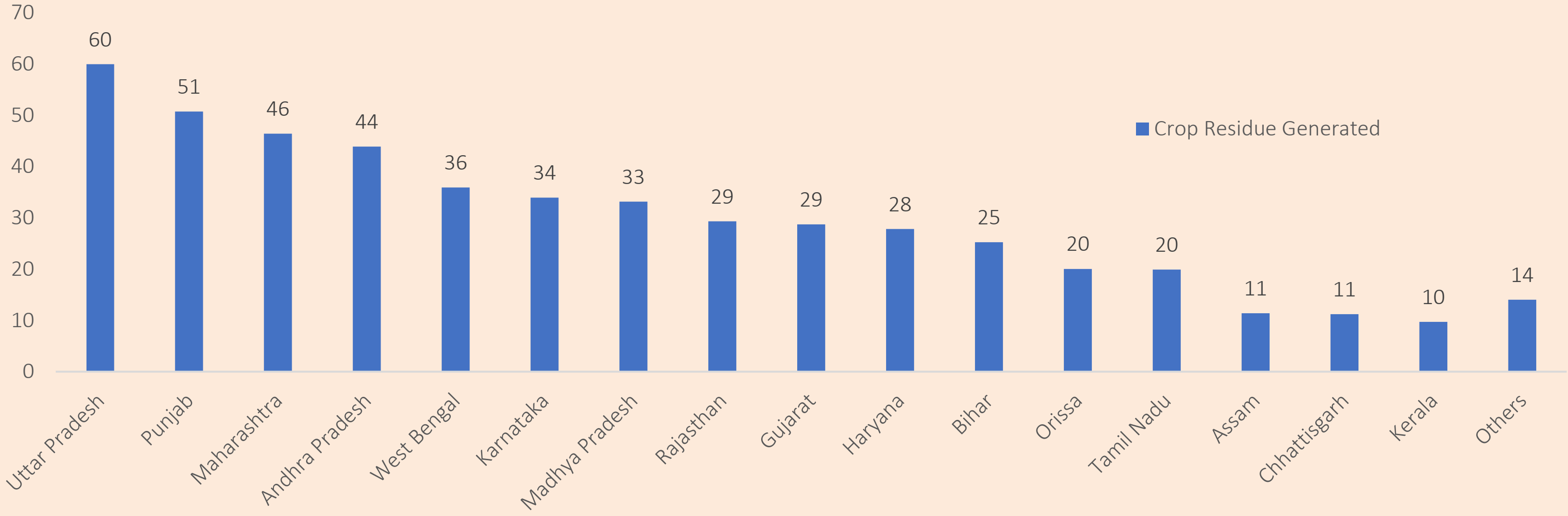
- These technologies are demonstrated at commercial scales in Brazil, Italy and Romania.
- India is also building 5 such commercial plants. Most of the plants under construction in India use agriculture residues.
- These agriculture residues are available over a short window of 4-6weeks during the harvest of grains.
- While part of these agricultural residues is used as fodder, for mulching, for manuring, thatched roof and heat generation, most of it is burnt on farmers field for want of a market. Harvesting the stubble, aggregation, bailing, densification, transport and storage are some of the challenges as no such established supply chain models exist.
- Absence of policy initiatives and programs to streamline the biomass/agricultural residue, lack of farmer awareness, inadequate funding support, non-existent Centre and State Coordination are some of the major challenges faced by the sector.

India an agrarian society

- India being an agrarian society is one of the largest producers of food grains and as a consequence generate humongous volumes of agricultural residues.
- While significant part of these residues is consumed as fodder, for mulching, for manuring, as thatched roof, meeting domestic and Industrial heating needs, significant part is burnt on the farmers field or left wasted without recovering any value out of it.
- However, data on agricultural residues, surplus was missing.
- It is also a fact that there exists no value chain created for these residues.

Crop residue availability studies

- In 2004-05 study by IISC
- In 2009-10 study by CSIR - NIIST , Trivandrum
- MNRE 2004 Study estimating 500MT of crop residues



DST-TIFAC study 2018

TIFAC study involved four steps

- Compilation of area and production statistics of selected crops,
- Estimation of dry biomass generation,
- Development of surplus factors and quantification of surplus biomass generation, and
- Estimation of bioethanol production potential of surplus crop biomass.

- TIFAC collected the crop production data from Department of Agriculture Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, GOI, New Delhi and from different State Agricultural Departments of respective States for a period ranging from two to six years starting from 2010-11 onwards.
- The harvest index of crops and moisture content of crop biomass were managed from literatures, including Annual reports of IARI.

DST-TIFAC study 2018

- Crop ratios were determined from harvest index of crops. Residue to Crop Ratios were calculated from above indices. It finally enabled determination of crop biomass statistics in dry weight basis.
- Crop specific biomass surplus were determined through a survey conducted over 1400 farmers. Survey tried to determine the crop residues which after all domestic uses may be made available for generation of bioenergy etc. Crop specific biomass surplus factor (collectible coefficient) was determined using literature review where no survey can be conducted.
- Once the crop specific surplus biomass were determined, the bioethanol production potential was determined using literature review. The ingredients of cellulose and hemicellulose of various crops were tried to be estimated and were used to determine the bioethanol production potential of each using calorific values.

Findings of TIFAC Study

- According to the TIFAC 2018 report on estimation of surplus crop residues in India for Biofuel production, the total dry biomass generated in India was about 683 MT for the major eleven crops.
- Out of this, only 178 MT (26%) bio-mass was found to be surplus, and of this 72% was generated in Kharif season, 27% in rabi and 1% in summer season. The surplus biomass ranged from 0 to 31.59 MT among the states.
- The total annual surplus biomass was maximum in Uttar Pradesh (17.68%) followed by Punjab (17.31%), Maharashtra (14.22%), Gujarat (7.6%) and Haryana (5.6%).
- When you look at all other crops and the residues being burnt across the country it is a guesstimate that the total residues generated could be in excess of 1billion metric tonnes and surplus could be over 350 million metric tonnes an annum.
- Potential of Ethanol is estimated to be 51.35 billion liters per annum

TIFAC 2018 report – assessment of various feedstock potential

Crop	Season	Area (Mha)	Dry Biomass (MMT)	Surplus biomass (MMT)	Bioethanol Potential (BL)
Rice	Kharif	28.597	142.761	35.993	9.862
	Rabi	13.334	66.997	7.267	1.991
	Summer	2.429	15.728	0.596	0.163
	Sub-Total	44.360	225.487	43.856	12.017
Wheat	Rabi	30.838	145.449	25.070	6.919
Maize	Kharif	7.591	21.491	4.979	1.110
	Rabi	1.190	6.389	1.057	0.236
	Sub-Total	8.781	27.880	6.036	1.346
Sugarcane	Kharif	5.037	119.169	41.559	14.629
Gram	Rabi	8.484	26.515	8.724	2.172
Tur	Kharif	4.040	8.942	1.704	0.433
	Rabi	0.073	0.225	0.051	0.013
	Sub Total	4.113	9.167	1.755	0.446
Soyabean	Kharif	10.694	27.779	9.950	2.935
Rapeseed & Mustard	Rabi	5.869	17.085	5.157	1.495
Cotton	Kharif	12.039	66.086	29.555	7.359
	Rabi	0.116	0.480	0.178	0.044
	Summer	0.003	0.017	0.007	0.002
	Sub Total	12.158	66.583	29.740	7.405
Ground Nut	Kharif	4.399	9.449	2.648	0.580
	Rabi	0.593	2.145	0.961	0.211
	Summer	0.483	1.305	0.263	0.058
	Sub Total	5.474	12.900	3.873	0.848
Castor	Kharif	1.176	4.589	3.013	1.133
	Rabi	0.009	0.016	0.005	0.002
	Sub Total	1.185	4.604	3.017	1.134
All Crops across all seasons	Grand Total	136.994	682.618	178.738	51.348

Geo-Spatial mapping-NRSC Portal

- The portal offers spatial map of gross and surplus biomass of important crops, i.e., rice, wheat, cotton and sugarcane,
- It can generate 1 km X 1 km grid using district level crop statistics of TIFAC-DST and satellite based crop maps of MODIS Gross Primary Production (GPP) data.
- It gives spatial representation of biomass/bioenergy potential/and land use landcover maps over a fetch area Surplus biomass map at 1 km grid
- It offers district level crop map to surplus biomass map at 1km grid resolution.
- Gross and surplus biomass potentials are estimated at 80% accuracy using 5 years average data Biomass potential for a fetch area
- LULC and utility mapping: Land use and landcover maps over India along with administrative boundaries and road networks for an area. Delineation of district, state, town, railway station, petrol pump and other landmarks
- Other land use mapping: It also gives geospatial Information of wasteland, waterbodies, fallow land for industries etc;

Geo spatial report generation

Bio Urja report.pdf

Making the study dynamic

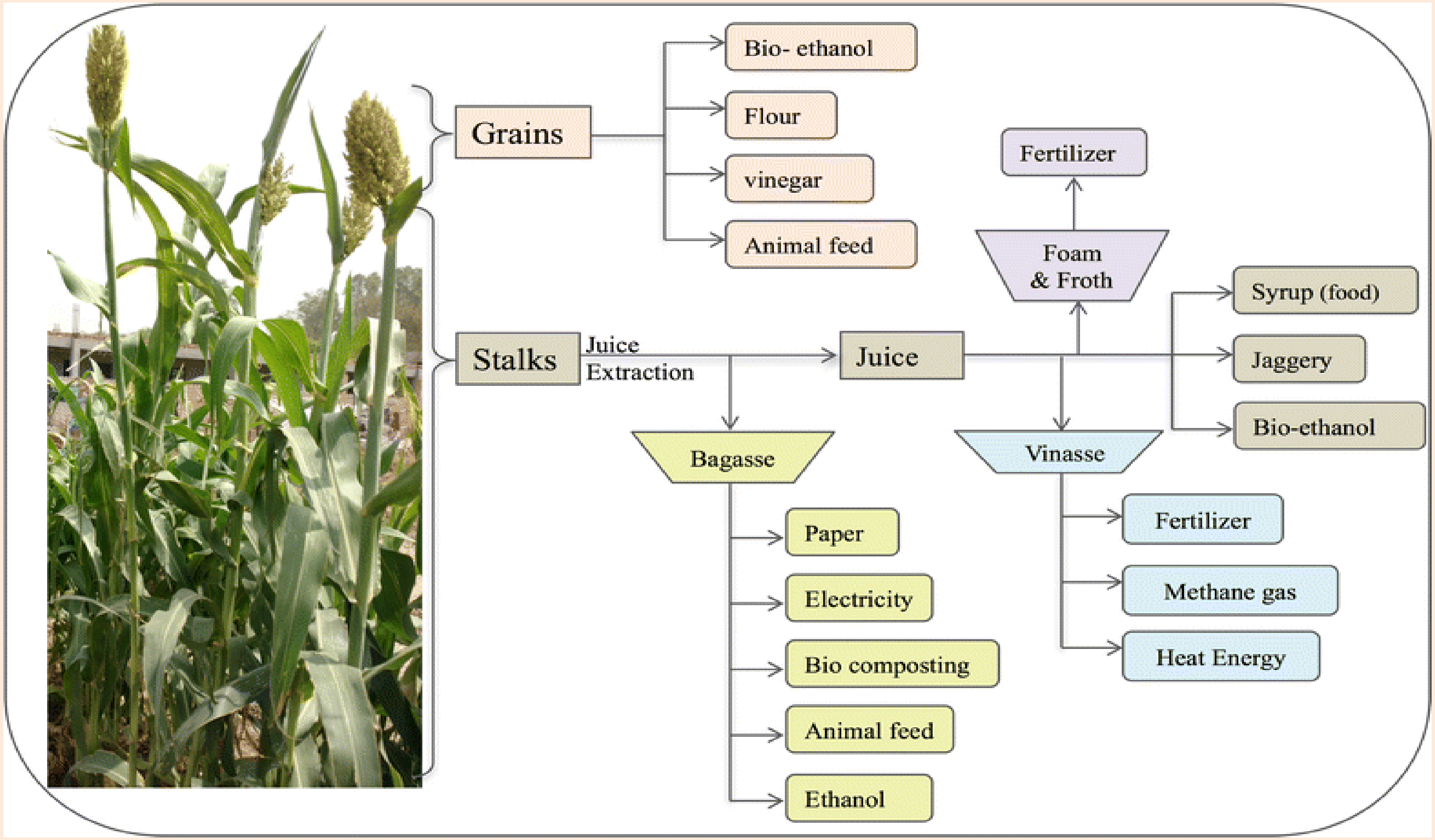
Important Goals Towards Dynamic Bioenergy Potential Mapping

- Creating a platform for convenient collection of crop production data from Krishi Vigyan Kendras –KVKs of different districts of India and linking it with NRSC's database for dynamic mapping.
- Accurate and comprehensive determination of surplus Biomass factor for various crops of different places across India; and uploading of data to dynamic bioenergy portal.
- Biomass characterization of various crops across India for accurate bioenergy potential determination and its mapping.
- Enabling Dynamic bioenergy potential mapping for other crops too (along with Rice, Wheat, Sugarcane, and Cotton) by NRSC
- Determining optimum number and types of Biofuel plants that can be setup over an area.
- Determining the bioenergy generation potential of waste land or marginal land using the inputs of KVKs and NRSC's satellite images

New Feedstocks –Indian response to Energy Cane from Brazil

- Advanced research and field trials have been carried out on new crops such as Sweet sorghum, Pearl millet etc. by CSIR-IIMR and ICRISAT in Hyderabad.
- These crops can be grown with much less water and have short gestation period. They produce both grains as well as biomass useful for both 1G, 2G Ethanol and CBG programs
- Varieties have been developed and tested for different geo climatic conditions. Several cultivars released
- These crops which can be grown with farmer involvement can be harvested 3 times in 14 months bringing income thrice in a year as against one income in case of sugar cane. 15-20MT of dry biomass per harvest.
- Results in better biomass supply chain and inventory management from the perspective of the processing units

Multiple use of sweet sorghum Crop



Major advantages with Sweet Sorghum

- It can be grown across the length and breadth of the country in kharif and summer seasons – means more farmers can be benefitted
- In Rabi, it can be grown in south India, western India and in coastal areas where winters are mild
- Well-developed genetics, agronomy perfected and it can fit in to a number of farming systems (better utilization of land, moisture)
- Can be grown rainfed (in the rainy season), responds well to irrigation, and applied nutrients. Higher productivity is feasible with good management
- Farmers can harvest grains for food or feed use and supply stalks for distilleries/sugar mills for ethanol production (multiple income opportunities)
- Supply chain can be tweaked by making use of varieties with different maturities and by changing agronomic practices
- The bagasse (left over stalks after crushing of stems) is an excellent animal feed and can be composted
- No capex required when used in a sugar mill system as same machinery can be used for crushing and fermentation
- Existing distilleries can make use of sweet sorghum by establishing their own crushing system or tie up with sugar mills for crushing of stalks
- Sweet sorghum stalks *per se* are excellent animal feed and in case of exigencies, the stalks can be diverted for feed use.

Actions needed to promote New feedstocks

- **Popularization of energy crops such as Sweet Sorghum and Napier Grass by MOA by taking up trials and large-scale cultivation**
- **Biomass sorghum could be cultivated and supplied during the lean period of primary crop as currently the land remains mostly barren in cases where farmers cultivate only one major crop in a year.**
- **Commercialization of Biomass sorghum cultivation is possible if the required policy support in the form of incentives from Government for both producer and processor are extended.**
- **Greater investment in research on sweet stalk and high biomass sorghums from Govt. of India is needed to achieve the goal of enhancing biofuel production to support the government policy of reducing the oil imports.**
- **Mechanization is need of the hour because of labor scarcity, higher labor costs, increase in cost of cultivation and drudgery involved in all farm operations. Future research should focus on fine tuning tools for mechanical harvesting of both grain and fresh stalks in a single pass**
- **The large-scale crop cultivation is recommended under contract farming with buy-back arrangement between growers and agro-industry or entrepreneurs' as similar to existing sugarcane industry.**

Thank You