Strategies for the Sustainability of Bio Diesel Production from Feed Stock in India: A Review

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ABSTRACT

It is estimated that by 2011, 20 % of bio-energy needs of India should be met by biodiesel. To meet these expectations it would require 12 to 13 million hectares of biodiesel feed stock plantations. Currently biodiesel is produced using non-edible oil from trees like Jatropha curcas. This strategy of propagating Jatropha curcas as primary bio diesel feed stock has certain drawbacks. This paper addresses the shortcomings in the present strategy and suggests few alternatives, i.e. farmers can be encouraged to grow short duration annual crops like Ricinus Comunis (castor), which can be used to produce biodiesel. Alternate plantation in wasteland with trees like Calophyllum inophyllum (undi) with 50-73% oil, Diploknema (Aisandra) with 60% oil and Simarouba glauca (Lakshmi tharu) with 60-75% oil may be explored. In addition, Microalgae, which have much faster growth-rate than terrestrial crops and yield oil between 4.6 to 18.4 l/m^2 per year may be a prospective feed stock for bio diesel production. There is a need for developing alternate, multipurpose crop plantation strategies and methods for producing biofuels. Nevertheless, with out affecting the farmer's needs of food, fodder and fuel wood for cooking

Keywords: Bio Diesel**,** jatropha, babusa palm, algal biofuels, alternative strategies, India

1. INTRODUCTION

India is the sixth largest consumer of crude oil in the world with about 70% of its local requirement met through imports. It produced 70,000 barrel/day of crude oil in 2007, while the consumption of petroleum products was at 2.5 million barrel/day. The oil import bill surged to US$77 billion in 2007-08 from US$6 billion in 1990-91. Consequently, the share of crude oil imports in the total import bill increased to 32.7% in 2007 from 25% in 1990 [Rajeev Malik and Gunjan Gulati 2008].

In India 70% of the population live in 638,596 villages and to a large extent thrive on farming [http://www.indg.gov.in/rural-india/number-of-villages]. With growing population, farming community is under pressure to grow more food. This is possible by mechanising the farm operation. This mechanisation has led to increased usage of diesel fuel and electricity. Soaring fossil fuel prices, is drastically affecting farm mechanisation and in addition adds to cost of cultivation. One of the possible low cost alternatives for farm power (Both Engine and Electricity) requirement is usage of biofuels like biodiesel

The Government of India (GoI) has launched a National Mission on Biofuels with the aim of achieving a target of 20% blending of biodiesel by 2012 [http://planningcommission.nic.in/reports/genrep/cmtt_bio.pdf]. To meet these expectations it would require 12 to 13 million hectares of biodiesel feed stock plantations. Currently biodiesel is produced using non-edible oil from trees like Jatropha curcas. Studies reveal that Jatropha curcas yields better in fertile land than marginal land [Centre of excellence in biofuels, TNAU, 2008]. If fertile lands are used, it may create an imbalance in the food bowl. Hence there is a need to identify alternate local plant species, which can add to the biodiesel feedstock in addition to Jatropha curcas, with out affecting the needs of the rural poor and encroaching fertile lands used for food production [http://planningcommission.nic.in/reports/genrep/cmtt_bio.pdf]. This paper presents a re-look at the current strategy for biodiesel production and consequent modifications.

2. IMPORTANT FEATURES OF THE EXISTING STRATEGY

Government of India initially aims to bring around 400,000 hectares of marginal land under cultivation of Jatropha Curcas as biodiesel feed stock. These plantations are proposed to benefit small farmers and land less poor by providing employment and in turn improve their socio economic status. Government subsidies are provided to cover cost of cultivation during the initial years of growth of crop. Working in the direction of making India self reliant, private players have also started entering the market banking on Jatropha Curcas.

2.1 Short Comings of Current Strategy

- A majority of the waste land available around villages are known as “Gomala”(Grass land) “Gund thopu” (Community forest) are meant for providing land less, small and medium scale farmers with commodities like fodder, fuel wood, timber and thatching material for homes [N. H. Ravindranath and D. O. Hall 1995]. Therefore the mix of tree species planted in these areas is very important for the lively hood of poor rural community. If such properties are planted with Jatropha, it is likely to create more hardship to the rural poor depriving them of their daily needs of food, fodder and timber, because Jatropha leaves do not serve as fodder and it does not yield enough wood as well.

- Government records claim 64 million hectares of waste land in India. However, only 10% is considered to be potential for Jatropha cultivation among three categories of waste land (degraded pastures and grazing land, underutilized degraded notified forest land and degraded land under plantation crop). The remaining waste land comprises of snow covered / glacial, barren rocky/ sheet rocky sand-inland/ costal, saline soil, alkaline soil, waterlogged soils etc, which can only be reclaimed either by adapted or specifically breed crops [http://www.indg.gov.in/rural-india/number-of-villages].

- A study conducted at Tamil Nadu Agricultural University, Coimbatore on the package of practices for jatropha plant, says plant density like 2500 plants per hectare is possible only under good soil and irrigated condition. Optimum plant density in rain fed marginal soil condition is about 1600 plant with oil content ranging from 21 to 48%. Such wide variation in key economic parameters and the lack of standardized seed material and cultivation practices call for intensive research and development prior to a large scale planting [Centre of excellence in biofuels, TNAU, 2008].

- Long gestation periods also do not motivate farmers to venture into plantation. The fact that Jatropha curcas (3 to 4 years), Pongamia pinnata (6 to 8 years) and other perennials have a long maturation phase and that various uncertainties exist especially in cultivation and marketing such crops present significant barriers to adoption especially for small farmers.

3. ALTERNATIVE STRATEGIES

3.1 Alternative Crops

India's net cropped area is approximately 150 million hectares, of which around 30% is irrigated and the rest is rain fed. Farmers in rain fed lands normally grow staple food crops to meet their family requirement at first instance and sell the remaining to make a living. Such farmers can also be encouraged to grow short duration crops like Ricinus Comunis [Castor], which can be used to produce biodiesel. Since these are annual crops it gives ample scope for crop rotation based on the market demand. Genetically modified or hybrid Jatropha curcas or Pongamia pinnata will be better candidates as well, if oil yield of rain fed crops grown on marginal lands is improved. Since hybridization and genetic engineering programmes are in their infancy stage, perennial oil yielding trees may become better candidates in near future.

3.2 Alternative Plantation Option for Wastelands

As mentioned earlier the common rural properties are meant to meet the biomass needs of the rural community. Hence tree species recommended for common properties and marginal lands must take into consideration the farmer needs, economics and local ecological impact.

Studies conducted by Professor Expedito Parente from Brazil on Babassu palm (Attalea speciosa) reveal the strategy of harnessing the native palm, which is grown wildly in Brazil. [Biopact Team 2007] He has launched a vast agro-industrial project in Brazil's Nordeste region based on cooperatives that will be serving as a model for reducing extreme rural poverty in tropical countries. This lesson can be repeated by a systematic research on alternative oil yielding Indian tree species like the following:

Table 1: List of oil yielding species [www.toenre.com/downloads/simarouba-joshi.pdf]

Sl No	Scientific Name	Common Name	Oil yield in %
1	Azadirachta indica	Neem	20-50
2	Simmondsia chinensis	jojoba	50
3	Vateria sp	dhupa	20-27
4	Calophyllum inophyllum	undi	50-73
5	Mesua ferrea	nahor	40
6	Aleurites sp	tung	50-60
7	Schleichera oleosa	kusum	34
8	Ceiba pentandra	kapok	20-25
9	Simarouba glauca	Lakshmi tharu	60-75
10	Madhuca longifolia	mahua; hippe	35
11	Garcinia indica	kokum	33-44
12	Shorea robusta	sal	12-13
13	Diploknema	Aisandra	60
14	Elaeis guineensi	Oil palm	56
15	Olea dioica; Olea europea	---	10-60

Research conducted by Dr Joshi proves to be one of the well justified strategies for adopting Simarouba glauca, as prospective oil yielding tree species. Simarouba glauca may be grown along with Jatropha curcas [www.toenre.com/downloads/simarouba-joshi.pdf]. Such research on other oil yielding tree species mentioned above, based on their habitat may help in recommending plantation strategies on common properties with little compromise on the local needs.

3.3 Algae as Another Alternate Biodiesel Feed Stock

Algae fuel, also called algal fuel, oilgae or third generation biofuel, is a biofuel from algae. Compared with second generation biofuels, algae are high-yield high-cost (30 times more energy per acre than terrestrial crops) feedstock to produce biofuels. Since the whole organism converts sunlight into oil, algae can produce more oil in an area the size of a two-car garage than an entire football field of soybeans [http://www.nrel.gov/docs/legosti/fy98/24190.pdf].

Currently most research into efficient algal-oil production is being done in the private sector, but predictions from small scale production experiments bear out that using algae to produce biodiesel may be the only viable method by which to produce enough automotive fuel to replace current world diesel usage. [http://www.nrel.gov/docs/legosti/fy98/24190.pdf] Micro algae have much faster growth-rates than terrestrial crops. The per unit area yield of oil from algae is estimated to be from between 5,000 to 20,000 gallons per acre, per year (4.6 to 18.4 l/m^2 per year); this is 7 to 30 times greater than the next best crop, Chinese tallow (699 gallons or 0.7 l/m^2).[Herro, Alana 2007]

The difficulties in efficient biodiesel production from algae lie in finding an algal strain with a high lipid content and fast growth rate that isn't too difficult to harvest, and a cost-effective cultivation system (i.e., type of photo bioreactor) that is best suited to that strain. Another obstacle preventing widespread mass production of algae for biofuel production has been the equipment and structures needed to begin growing algae in large quantities [http://www.nrel.gov/docs/legosti/fy98/24190.pdf]. Once these obstacles are overcome algae may be the most sought after biodiesel feed stock, which may help in eliminating food fuel conflict.

5. CONCLUSIONS

From the above arguments we can understand the current approach, which is encouraging Jatropha curcas alone to be cultivated on marginal lands, may not be the best strategy in meeting the India's biofuel goals. Realizing the mission to reduce India's dependency on petroleum imports would be successful if a holistic approach is adopted for biofuels feedstock cultivation. Such a strategy needs to address alternate multipurpose crop plantation and method of producing biofuels with out affecting the local ecology and farmer's needs.

A methodical research should therefore be carried out on variety of other oil yielding crops and other alternatives like algae as biodiesel feed stock that are suited to the diverse socioeconomic and environmental conditions in rural India. Simultaneously the efforts of scientists and extension agencies need to put forth policies like; directive renewable fuel standards, minimum support prices for biofuel crops. This may provide ample motivation for industrialist and agriculturists to start the necessary investments for exploitation of such technologies. Jatropha curcas and Pongamia pinnata might be promising crops in meeting the nation's need for biofuels in the future provided necessary research on their oil yield percentage is addressed. If algal biofuels technology is optimized, it may help in eliminating the food fuel conflict to large extent.

REFERENCES

Biopact Team 2007, *Father of bio-jet launches biofuel cooperatives in Brazil to reduce poverty*, http://news.mongabay.com/bioenergy/2007/05/father-of-bio-jetfuel-launches-biofuel.html. Retrieved on 27-04-09

Centre of excellence in biofuels, 2008, *Cultivation of jatropha and biodiesel production*, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore.

Department of Energy, Aquatic Species Program, *Biodiesel from Algae*, National Renewable Energy Laboratory. http://www.nrel.gov/docs/legosti/fy98/24190.pdf. Retrieved on 27-04-09

Herro, Alana 2007. *Better Than Corn? Algae Set to Beat Out Other Biofuel Feedstocks*. www.worldwatch.org/node/5391. Retrieved on 27-04-09

Number of Villages in India http://www.indg.gov.in/rural-india/number-of-villages. Retrieved on 27-04-09

N. H. Ravindranath and D. O. Hall (1995) *Biomass, Energy and Environment A Developing Country Perspective from India.* Oxford University Press, Oxford, New York, Tokyo, 391

Planning Commission, Government of India, New Delhi, *Report of the committee on development of biofuel,l* http://planningcommission.nic.in/reports/genrep/cmtt_bio.pdf. Retrieved on 27-04-09

Rajeev Malik and Gunjan Gulati, *Economic Research-India 1 May 28, 2008 focus*, JPMorgan Chase Bank, Singapore, (65) 6882-2375 and JPMorgan Chase Bank, Mumbai (9122) 6639-3125,

Syamasundar Joshi, *Simarouba Paradise Tree,* www.toenre.com/downloads/**simarouba-joshi**.**pdf** Retrieved on 27-04-09