Biofuel Plantations for Watersheds

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Introduction

Today energy crisis is worldwide because conventional forms of energy supply and consumption are causing serious economical as well as environmental problems. In our country consumption of petroleum products is increasing day-by-day resulting in huge gap of demand and supply. India rank 6th in the world in terms of energy demand accounting for 3.5 percent of world commercial energy demand in 2001.

India currently imports about 70 percent of its petroleum needs by paying Rs.1, 27,000 crores every year. The demand target may be 120.4 m t for 2006-07. Our domestic production of crude oil and natural gas will remain around 33.97 m t during 2006-07.The huge gap between demand and supply of 86.43 m t may be met only by import or by producing biofuels. The current consumption of diesel in India is approximately 40 m t forming about 40% of the total petroleum product consumption. This is expected to reach 52.32 m t by 2006-07 growing at approximately 5.6 % per annum.

Government of India has already introduced petrol blended with 5 percent ethanol for use in motor vehicles in 9 states. A committee constituted by Planning Commission for Development of Biofuels recommended replacing about 10 % of diesel with biodiesel by the end of year 2011-2012 (Singh, 2003). Biodiesel production was spread in 21 countries mainly in Europe, Malaysia and USA. The largest biodiesel plant currently in operation was in Rouen, France with a capacity of 120, 000 tonnes. France is currently the world largest producer of biodiesel using it in 50 percent blend with petrol and diesel.

During the last few decades, researchers tried all the edible and non-edible vegetable oils in compression ignition and spark ignition engines for different utilities. Since India cannot afford the usage of edible vegetable oils as power source because of short supply, planners suggested the use of non-edible vegetable oils as alternative fuels like Pongamia, Jatropha, and Neem etc. As Indian nation consists of 40 % of wasteland, it is better to develop all these lands by growing non edible oil plants which not only gives the oil but also enriches the environment by adding the green forest cover for ecological balance.

In India, rural areas, in general are facing steep power crisis during the last two decades. Farmers are unable to irrigate their lands because of interrupted and short-term power supply. Finally it is effecting the agriculture production very badly. In this context, it is better to use the available plants, which produce the non-edible oil seeds to cater the needs at rural level for self-sustainability. Though there are more than 300 different species of trees, which produce oil-bearing seeds, Pongamia and Jatropha are the drought

resistant plants, which grow with limited water. These two plants suit for the Andhra Pradesh ecological zone as it consists of 60 % of dryland, which has enough potential to meet the fossil fuel demand at rural level. Hence these plants can well be utilized to produce the biodiesel at rural and industrial level.

All over the world, the trials on biodiesel blending with diesel and other oils are still continued. In Andhra Pradesh, Integrated Tribal Development Agency (ITDA) of Adilabad district has started a pilot project at Utnoor with the effort of SuTRA (Sustainable Transformation of Rural Areas). Here, the villagers collect the Pongamia seed from the nearby forest and extract the oil using expellers. The filtered oil is then used to run the generator (50 W) to supply the electricity to the 100 houses in a village. This project created hopes in villages regarding self-sustainability in producing power.

Biodiesel: benefits and drawbacks

Benefits

- The higher cetane number of biodiesel compared to petro-diesel indicates potential for higher engine performance.
- Reduced vehicle emissions.
- Reduced engine wear because of the fuel's excellent lubricity (ability to lubricate the engine and fuel system).
- Increased safety in storage and transport because the fuel is nontoxic and biodegradable.
- Reduced dependence on foreign oil suppliers and associated price fluctuations.
- Biodiesel molecules are simple hydrocarbon chains, containing no sulphur or aromatic substances, associated with fossil fuels.
- Reduction of greenhouse gases at least 3.3 kg Co_2-equivalent per kg of biodiesel.

Drawbacks

- The need in older engines to replace rubber fuel hoses and gaskets with synthetics because of biodiesel's tendency to deteriorate rubber.
- Possible concerns with engine warranties.
- Special measures that must be taken to use biodiesel, particularly B100, in cold climates.
- Limited commercial availability of fuel if you are not going to process it yourself.

Table 1 Physical and Chemical Properties of Fuel Oils

Oil	Specific Gravity	Kinematics Velocity at 100ºF	Flash Point ºc	Net Calorific Value in Cal g
Diesel	0.85	3.90	105	10125
Pongamia	0.92	44	205	8705
Undi	0.92	54	198	8721
Castor	0.95	293	260	8875
Kapok	0.90	41	230	9392
Mahua	0.90	45	214	9464
Cotton seed	0.91	36	275	9599
Rape seed	0.91	49	221	9856

Source: Shrinivasa, U, 2003

Scope of Jatropha and Pongamia as source of biodiesel in India

Any vegetable oil can be converted into biodiesel, however in India, there is no surplus production of edible oil. Therefore, the oils that can be used, as biodiesel have to be non-edible, produced in abundance and withstand harsh climates, as they would be taken up in wastelands. The most suitable species in this regard are Jatropha and Pongamia, whose positive aspects for cultivation as source of biodiesel are mentioned below.

Jatropha

Short gestation, intercropping possible, improved germplasm available, some research information available, can be grown as boundary plants/live fence

Pongamia

Native, less prone to pests/diseases, Multiple uses, leguminous, deep rooted, longer life span, higher seed yield (9-90 kg/tree)

The bottlenecks in popularizing pongamia and jatropha among farmers

- Long gestation period - 5 to 7years for pongamia and 3years for Jatropha
- Low and uncertain yields. In Jatropha, actual yield under field conditions was only 1000 to 1200 kg/ha (Patil and Singh, 2003).
- No systematic attempts were made to develop pongamia and Jatropha based agroforestry models
- Pongamia has competing demands. It is lopped heavily for green manuring and thatching purposes thereby reducing its fruit bearing capacity
- No buy back facility and MSP extended by Govt.
- Regularized marketing facility to save the poor villagers from clutches of middlemen is not created.

CRIDA's On-Station experiences

CRIDA initiated on-station trials with Jatropha way back in 1992 and on Pongamia since 2003. Some of the important R&D work with respect to Biodiesel plants being carried out at CRIDA is given below.

- Identified 218 and 197 plus trees of Jatropha and Pongamia respectively in the states of Andhra Pradesh and Madhya Pradesh and collected the germplasm from them. Screened thus collected germplasm on the basis of oil content in the seed (Jatopha 21.0% to 38.96%; Pongamia 24.83 to 45.05) and nursery traits (Height & Collar dia.) and short-listed 42 and 23 Jatropha and Pongamia accessions for evaluation. The screened accessions of Jatropha and Pongamia are being evaluated in progeny trial. Germplasm of these two species exchanged with network partners (representing all states of India) for multi locational trials.
- Standardized mass multiplication and other agro technologies for raising elite accessions of Jatropha and Pongamia. Initiated trials on inter and intra specific breeding in Jatropha.
- The negative and positive interactions in biodiesel plants based agroforestry systems are being evaluated to develop sound agroforestry system suitable to dryland areas.
- Grafting in Pongamia standardized and performance of grafts vs. seedlings is being evaluated in the field.

CRIDA's On-farm experiences

On farm trials with biodiesel plantations in three districts of Andhra Pradesh (Ananthapur (22acres) , Mahaboobnagar (22acres) and Nalgonda (19acres) under rainfed and irrigated conditions involving various combinations of **nutrient levels, spacing and pruning regimes** are being carried out by CRIDA with the financial support from GoAP. The major activities are to standardize agro-techniques for jatropha and pongamia. The details of the experiments are given in Tables 1 and 2.

The experiments were initiated during *kharif*, 2005 and are in good progress. The sites have been selected mostly from degraded/wastelands belonging to small and marginal farmers with and without irrigation facilities. The soils are shallow, gravelly, and marginal in fertility and possess low water holding capacity. The average rainfall of most of these districts is around 650 mm while for Anantapur it is 510 mm. Added to this the topography is undulating with 3 to 6 percent slope. In some of the districts the programme is being implemented with the support from District Water Management Agency/NGOs. Good quality seedlings raised by the Forest Department in each district were used for planting. The pits of size 45x45x45 cm were prepared at desired distances (3 to 4 m between rows) and filled with a pit mixture before onset of monsoon. The experiences from Anantapur, Mahabubnagar and Nalgonda are highlighted here under:

In general, the survival of Jatropha was about 95% at 2yrs after planting. This shows good establishment of Jatropha even under deficit rainfall. The survival of Pongamia was around 98% at 1yr after planting.

The initial studies on plant geometry in Jatropha showed more management problems and higher cost of cultivation due to manual weeding in closer planting (2x2m) unlike 3x2m or 4x2m spacing. The wider spacing also enables intercropping, partial mechanization, response to irrigation in Jatropha. The experiments on pruning of Jatropha plants in different districts have shown good response to the treatments at 45 & 60 cm height from ground level by reflecting in increased number of branches (10-15 per

plant) and also vigorous growth. The inflorescence as also the capsule bearing bunches was more, when the plants were pruned at 45 cm or 60 cm height. However, with a view to develop good plant growth the inflorescence should be removed during the first year. It was observed that the pruning had reflected in more pest problem as the pruned plants had more vigor and may also because of pruning injuries.

Experience on oil extraction:

During our surveys in rural areas, it was observed that the oil expellers with 100 to 200 kg seed crushing capacity are popularized for the extraction of jatropha and pongamia oils. These expellers consist of single chamber with 6 to 8 bolt arrangement and work with the electric motors with in the power range of 10 to 20 hp. These were initially designed for soft oil seeds, containing 20-55% oil. It was found in the survey and also at our workshop that their performance was not satisfactory. The data indicated more than 8% of oil in the cake of pongamia and jatropha seeds. This is because of excessive gums and waxes apart from the uneven moisture content and toughness of the seeds. The oil bonds were also stronger in these seeds over other seeds. The oil cake with excessive oil content is found dangerous when applied to the soil, which stopped infiltration of the water, reduced aeration in the soil and slowed down the microbial activity. The decomposition of the cake is delayed because of more oil content. Added to this, there was frequent choking of the cake. The reason was that the screw design was not suitable to carry out the meal uninterruptedly for the pongamia and jatropha seeds. The low recovery of oil from these expellers and other problems prompted CRIDA to work on the conventional oil expeller and attempt to design a separate mini oil expeller for testing purpose focusing the small scale industry needs.

As a result, CRIDA has designed the mini oil expeller by modifying the screw and oil chamber. A toggle mechanism is also incorporated for testing purpose to push out the cake if choked. The mini expeller increased the oil recovery in pongamia seed by 4% (from 25 to 29%) and 6% (from 27 to 33%) in jatropha. Presently, the oil expeller is under refinement process for commercial use. It was found that the oil in the cake was only 6 to 7%, which enabled the farmers to apply to their fields, and the decomposition period was reduced by 30%.

HRD

Since bio-fuel research in India is of recent origin, it would take some more time to develop package of practices and also curriculum for capacity building programmes. However, in order to bring awareness on bio-fuel plantations, CRIDA, Hyderabad have been undertaking programmes to train extension officers, trainers, secondary stakeholders and farmers in different districts. Exposure visits to the bio-fuel plantations also are being arranged to them for effective understanding / on-job training. Training manual/literature is also developed.

Road Map for bio-diesel plantations

- **Economics of Jatropha cultivation:** Which shows a modest estimate of production and economics from jatropha cultivation under good management in semi-arid conditions, a benefit cost ratio of 1.3 to 1.4 can be expected if the plantation is continued atleast for 10 year period. That is, the net returns from jatropha could be Rs.6000/ha/year while from pongamia, these could be around Rs.8500/ha/year. Alternate oil yielding tree crops for jatropha are pongamia, simarouba, neem,

salvadora, phalas. Jatropha can be encouraged along the field boundaries of existing orchards as bio-fence, on key lines and road side. The income from jatropha can be considered as bonus and **not as a substitute** for the main orchard. The response of jatropha to irrigation is not substantial since it is mainly a rainfed crop. However, one or two supplemental waterings or a light shower after pollination is likely to boost the yield and returns. Since the returns from jatropha are very marginal over other crops, it is suggested **not to replace the food / commercial crops** with jatropha.

- **Jatropha based intercropping:** In highly risk prone and resource poor marginal lands jatropha / pongamia based intercropping system with annual crops matching the moisture availability period of the location may be built for economic stability.
- **Yield and price guarantee:** Since these are likely to be introduced on large scale in the country, the produce must have an assured buyer. Hence, a tie-up is a must with industry and the price must be guaranteed in advance of the season. It is desirable to make arrangements for collecting the material from plantations directly. There should be compensation for the jatropha cake or the de-oiled cake must be returned free of cost to the farmer for improving soil fertility. Agro-techniques, which will improve productivity from the plants, must be encouraged.
- **Areas to be proposed for plantations:** To start with, it is desirable to go in a small way in each of the rain shadow / rainfed districts on wastelands/degraded lands (say less than 10,000 acres/district every year). It can be promoted on private as well as public lands preferably with government support. Large scale demonstrations need to be initiated to convince the farmers on the utility of these plantations. This would also give us a feed back for improvement.
- **Procurement of seed or seedlings:** For the next year (based on the recent experiences on the procurement of seed), staff from agriculture / forest / horticulture departments should physically visit dependable sources of supply and personally procure quality material from different regions of the country. Seedlings can be procured only for demonstrations/on-farm research. It is worthwhile to encourage tissue culture at one or two institutions if elite material is available.
- **Focused programmes on TBOs:**
    - Detailed investigations, atleast for 3-5 years are suggested at research stations as also on farmers' fields for generation of valuable information on these species for their further expansion.
    - Crop diversification is always desirable. This will give us an idea as to in which district a particular oil yielding tree is performing better.
    - These are worth exploiting in any wastelands and also as boundary/avenue plantations.
    - Intensive training programmes and exposure visits have to be initiated for departmental staff/farmers/ market agencies/NGOs to enable proper dissemination of the technologies as also their wider adoption.

R & D issues

- Collection and evaluation of germplasm of jatropha, pongamia, simarouba and other species for high yield, oil content and quality.
- Nursery techniques for mass multiplication of healthy seedlings/*in-situ* grafting (for pongamia)..

- Standardization of agro-techniques for establishment, survival, growth and development of young plants in rainfed / irrigated situations.
- Water requirement during different stages of crop growth.
- Studies on life cycle and control measures for pests and diseases.
- Development of high yielding and high oil varieties of superior quality.
- Development of tissue-culture protocols for elite plants and their micro-propagation
- Post harvest processing of jatropha and pongamia seed for oil, cake and other bye-products for appropriate uses.
- Extensive on-farm experimentation with standard varieties and technologies in different rainfed areas / wastelands / farmers' fields.
- Development of location specific bio-fuel based agroforestry models.

Promotional Activities

- Promotion of tree oilseeds all along existing horticultural plantations, bunds, waterways, road- sides / rail lines and the like.
- Adoption of an integrated approach bringing closely the farmers – researchers - Extension specialists – NGOs – SHGs - industrialists for developing a good production system, while the Government should take care of storage and marketing.
- Government should encourage domestic production and reduce import burden at the earliest and give incentives, subsidies, good support price etc., to these commodities.
- Development of small processing units (at mandal/tehsil level) for bio-fuel extraction.
- Market interventions, buy back guarantee, minimum support price etc.
- Capacity building at various levels for understanding and promotion of bio-fuel programmes.
- Exposure visits of Scientists to see bio-fuel programmes in advanced countries / with in India.
- Exposure visits of farmers / extension agencies to the sites of success stories on bio-fuels.

Conclusion

There is great scope for undertaking plantations of tree borne oilseeds in wastelands under different agro-climatic conditions of A.P. and other states in India. Promotion of these can generate tremendous job opportunities among rural masses and augment the availability of vegetable oils for edible and non-edible uses to reduce foreign exchange burden.

Most of these non-edible oilseed trees do not compete with any arable crops for the resources as they are adaptable to wastelands and are good for their quick greening. Jatropha and pongamia oil is a potential non-conventional energy substitute for conventional fuels. The oil is almost odorless, non-smoky and non-pungent unlike kerosene. In view of several advantages as narrated above and minimal management after plantation, jatropha and pongamia can be considered for their extensive propagation in a mission mode approach.

There is a need for quality seed collection, value addition and increased wages. Development of storage and transportation facilities are essential. Seed collection centres must be nearer to the sites. The scientific know-how will have to be disseminated through

mass media, training of trainers and seed collectors; seminars, etc on various aspects of production technology and processing. The awareness programmes will have to be organized in the potential areas to motivate farmers. Such intensive efforts in wastelands will go a long way in increasing the availability of oilseeds and achieve self-sufficiency in vegetable oils apart from addressing poverty alleviation.

Value addition to this programme can be imparted by taking advantage of Carbon Trading or Clean Development Mechanism (CDM).

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