Powering Development for the Poor in India?

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ON-BOARD FOR BIOFUELS: CASE STUDIES

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In India, the energy sector is going to play an important role in the inclusive and holistic growth of the economy and society. Biofuels, apart from improving the energy scenario, will also have a positive effect on poor communities in rural sectors. India currently imports 70% of its oil, and this figure is estimated to touch 90% by 2030. Since India has only 0.4% of world crude oil, alternatives need to be found. Agriculture in India accounts for 43% of the total geographic area. The total estimated energy requirement of the unelectrified rural sector is about 102.6 million gigajoules(Gj). The current program of bringing 0.4 million ha of marginal land under biodiesel production would amount to producing about 42.1 million Gj from biodiesel, which can meet almost 50% of the energy requirement of this sector. In terms of achieving the target of cultivating 40 million ha of land (the best-case scenario), however, the energy production from biodiesel would be about 420.6 million Gj, which amounts to fulfilling most of the total electricity needs in rural sector. Towards this end, several states in the high- and medium-rainfall category and where wastelands are in the range of 0.1–5 million ha can be chosen for biodiesel production. Targeting marginal, fallow or wastelands would not only bring economic advantages but also open new avenues of employment and large-scale development, ensuring all-round inclusive growth.

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Introduction

Agriculture covers around 43% of the total area of India — that is, 142 million ha, of which 54 million ha is irrigated. India also has 60 million ha of uncultivated wasteland. These wastelands are the basic resources for biodiesel or biofuel. The Indian requirement for petroleum diesel is growing rapidly. In next two decades India will need a greatly increased quantity of this fuel — by 2030, about 200 million t annually. If we are able to use a blend containing a maximum of 20% of biodiesel, there will still be a requirement for about 40 million t of the latter — a huge quantity. India now imports 70% of its petroleum diesel, and it is expected that if the trend continues India will be importing 90% of its requirements (National Energy Map of India 2006).

Another aspect of India's energy needs is that in the rural sector there are around 138 million households that require electricity. If we aim for a basic minimum of 1 kilowatt hour per household per day, the annual total comes to around 182 million Gj. As about 78 million households are not electrified (and assuming that those already electrified receive the basic requirement), there is an additional requirement of around 103 million Gj to provide all rural communities with a basic minimum supply.

Biodiesel program: Phase one

The government is likely to launch a biodiesel program in two phases. The first phase envisages that 0.4 million ha of land will be used to grow feedstock for biodiesel. This area will be distributed across various states. In addition, there is increasing interest in feedstock production by the corporate sector — including one Australian company.

Fuel processing units with a capacity of about 300 t per day are being set up. Although the feedstock — palm oil or palm oil refuse — is presently obtained mainly from Malaysia, supplies are expected to be derived from the Indian region within the next few years.

Financial institutions are preparing credit arrangements for farmers, and the insurance sector will cater for risks involved such as natural calamities and so on.

Unfortunately there is no supply of quality planting material for biodiesel, and there is very little knowledge about variation within candidate crops. There are no cultivated varieties in plants like jatropha as far as we know. Thus a great deal of work is needed to develop cultivars and to match these to agro-climatic conditions and cultural practices, since India has a number of quite diverse climatic regions. Also, there are no successful case studies which can convincingly demonstrate the economics of various production scenarios (DPR 2005).

One study that has been undertaken in India encompassed over 5000 ha of land spread over 22 states. The results indicate that *Jatropha curcas* may have seed yields of 0.75–2 kg per plant on wasteland, equivalent to 0.5–2.5 t ha^{-1} of seed (TIFAC 2007). The procedure now used to extract oil from seed is quite primitive. Recovery of usable diesel, keeping glycerol aside, is generally around 27% of seed weight.

In the first phase of this biodiesel program in India, an annual yield of around 1 million t of seed is expected, which would give about 0.27 million t of biodiesel. In addition, the process yields two other very important energy sources — oil cake and fruit shell or husk (Fig. 1). These can be very useful in satisfying the energy requirements of rural households.

Phase two

The next phase — an ambitious plan — is to extend energy crops to 40 million ha of land. This will require an enormous amount of work, together with knowledge and vision that do not exist at the moment to any large extent. If we go for medium-yield scenarios — which are quite likely because of the diverse conditions and uncertainty about resource availability — the yield will be around 27 million t of biodiesel and of course the quite substantial 120 million t of the two other useful products.

A supply gap will remain, but…

The 27 million t of oil will provide only 12% of our blending requirement in 2030.

The program might also contribute to India's energy supply via the generation of bio-gas from the oil cake. Indian bio-gas generation programs have not been very successful in the past, so new technologies are required to satisfy increasing needs. The slurry that comes out the digester could be used as manure, and used for energy conversion later. Gasifiers are now being used on a larger scale for decentralised electricity generation in places that are not connected to the grid. The fruit shell can also generate power via gasification. Together these resources could satisfy much of the present significant rural energy deficit.

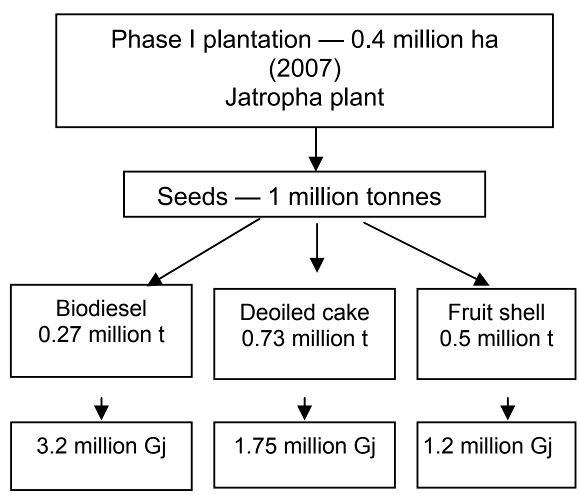

Figure 1. The scale and products of Phase 1 of the expected Indian national biodiesel program

Other energy crops, and employment

Another possibility is that a tree legume, *Pongamia pinnata*, might be grown by the forestry sector on wastelands. Farmers will not grow this plant on their own land because it requires a long gestation, although it can give significant yields and contribute to Indian biodiesel production. In addition — and particularly in the north-eastern region of the country — there may be other species that can eventually produce some diesel.

Employment is another important aspect of this initiative: if the program proceeds as it is envisaged now, it will generate around 7000 million man-days of employment in a calendar year, which will afford very useful socio-economic benefits.

Beneficial micro-organisms

In India, we have been very concerned about taking biodiesel plants to marginal land and expecting high yields. Recognising that soil amendments may be necessary to permit and sustain production, we have explored the potential of a specific group of micro-organisms known as mycorrhizae to assist in this challenge. Although successful examples of this approach have been known for more than a hundred years, applications have been limited because the technology for mass production has been a constraint.

Encouraging examples of the application of mycorrhizae emerged in the early 1970s in a variety of plant species. They are of potential benefit to 85% of plants — they increase nutrient availability in marginal soils, improve water use efficiency and afford protection against some soil-borne diseases. In forests and perennial crops the need for chemical fertiliser may be eliminated, while in agricultural crops their use can be substantially reduced (up to 50–75%).

Thread-like hyphae from germinating mycorrhizal spores enter the roots of plants and form a symbiotic relationship. The structures within the plant cells provide nutrients and in exchange take synthesised carbon from the plant in the symbiotic partnership. A very large network of hyphae develops around the roots and may extend for several metres beyond the roots. This network is able to efficiently pick up minerals in solution and transfer them to the plant. Several different nutrients may be mobilised for plants in this way.

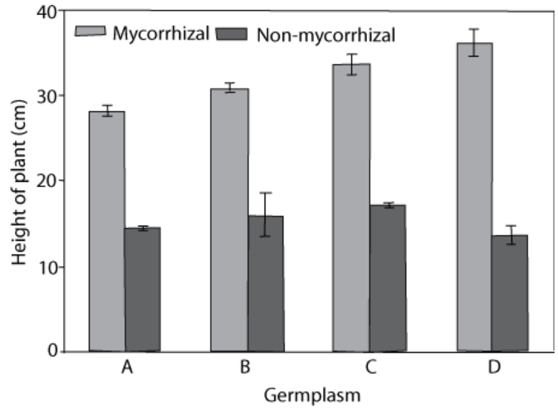

Figure 2. The growth response of seedlings of *Jatropha curcas* from four provenances when gown with and without the addition of mycorrhizae

The technology for using mycorrhizae that TERI has developed since 2000 is globally unique. We isolated and selected organisms that are useful for production, and multiplied them in a culture system. A carrier-based product was developed that on application can transfer the mycorrhizae back to nature (Adholeya and Pant 2007).

An example from the Jatropha Nursery (Fig. 2) shows the tremendous difference that mycorrhizae may make to plant growth. In general these products can benefit farmers by bringing down input costs, and at the same time increasing yield and the biological health of the soil. They also improve water use efficiency. These important products are likely to be of immense value in marginal areas.

TERI has a project with British Petroleum (BP) that entails growing 20 million jatropha plants over 8000 ha. The project is comprehensive, involving community mobilisation and studying environmental and social impacts of the enterprise throughout its whole life cycle. It is expected that the project will fill some of the knowledge gaps that have been mentioned earlier.

In this project mycorrhizae has been used to replace chemical fertilizer, which would have been a large energy investment as well as costing about 21 million rupees.

National action

The Indian government is going to launch a demonstration program. In addition, Maharashtra state government in western India has a new policy linking an employment guarantee scheme to a subsidy to promote jatropha plantations on marginal lands. Several other initiatives from different state governments are in the offing.

There are, however, no large-scale financial incentives from the national government at the moment. Only public companies are allowed to provide blended petroleum diesel. The national government adopted a purchasing policy for biodiesel two years ago: to buy at 26.50 rupees or US$0.66 per litre. Although no significant quantity of feedstock is available yet, it is expected that in 4–5 years commercial quantities of jatropha and pongamia will be produced. In this period we will learn a lot about the technical and economic prospects of the initiative. An association from the petroleum industry is involved in setting-up a biodiesel credit bank in order to coordinate and use carbon credits generated in this program.

Although the corporate sector is aggressively becoming involved in the Indian biodiesel program, farmers' responses have been mixed. This is understandable in view of the absence of creditable data on productivity. For this, a sound case study is greatly needed.

Yet another aspect which merits attention is that of biotechnology. Biotechnology can play a major role in the area of stress biology. Genetically modified plant varieties with higher levels of stress tolerance need to be developed. Cloning of tissue-cultured plants and manipulation of genes is also going to play a very important role.

Concerns

The potential concerns are several, including pests and diseases. We have already observed some pests on species related to those proposed for the plantation program. They include various bugs, inflorescence webbers, leaf miners and flower beetles. Once the larger-scale plantings are established, we expect to have to work on pest and disease management.

Another challenge is to develop cultivars that exhibit improved yield, oil content and agronomic properties — efficient and effective strategies for such domestication are available.

The feasibility of agro-forestry or inter-cropping should be explored — these practices are accepted and successful in forestry.

Combinations of coconut and jatropha (Fig. 3), and sweet sorghum and jatropha, are interesting.

Unresolved policy issues relating to cultivation, processing, marketing, sales and regulations need to be addressed on an urgent basis.

Because the production of feedstock will be geographically dispersed over small blocks of land and minimum transport expenditure is desirable, optimum processing infrastructure will require an efficient continuous process of esterification, much smaller in scale than is available now.

Conclusion

To conclude, the Indian story is that we have a long way to go. We have made substantial progress in recent years, but we need to do a lot more — including investing substantially in research in order to bring this story to a successful operational stage.

References

Adholeya, A. and Pant, D. (2007) Biofertilizers: are they here to stay? *Biotech News* **II**(1)**,** February 2007, http://www.biotechnews.in/archive.html.

Detailed Project Report (DPR) (2005) Prepared for Ministry of Rural Development (MoRd), Government of India. TERI, New Delhi.

National Energy Map of India (2006) Technology Vision 2030. Office of the Principal Scientific Adviser, Government of India. TERI Project Report PSA/2006/3.

TIFAC (Technology Information, Forecasting and Assessment Council) (2007) http://www.tifac.org.in/news/Bioenergy_1.htm (last accessed on 25 July 2007).

Figure 3. An example of *Jatropha curcas* being grown as an intercrop among coconuts