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POTENTIAL OF TREE BORNE OILSEEDS (TBOs) FOR RURAL ENERGY NEEDS : EXPERIENCES AND IMPLICATIONS

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ABSTRACT

The Planning Commission, Government of India has set a target of 20 per cent blending of diesel with bio-diesel by the year 2012 to reduce the wide gap between demand and supply of petroleum products. This requires cultivating bio-diesel yielding crops on 11 M.ha to yield 13 M.t. of bio-diesel per year. In response to this, the Government of Andhra Pradesh (GoAP) launched a massive bio-fuel plantation programme in 2004-05. Since there was not enough research data to back a massive field plantation, GoAP sanctioned a R&D project on bio-fuels to CRIDA. The on-farm experiments were initiated in farmers' fields during kharif*, 2005 in 69 acres in three districts of Andhra Pradesh with three levels each of irrigation, nutrition, pruning and four levels of spacings. The wider spacing (3x2m or 4x2m) enabled inter-cropping, partial mechanisation, response to irrigation in Jatropha. Irrigation at 30 per cent of evapo transpiration level in combination with N and P at 45g and 100g per plant gave better results. The capsule bearing bunches were more, when the plants were pruned at 45 cm or 60 cm height. In order to provide immediate income to the farmer besides improving soil fertility, legume inter-cropping with pigeonpea, blackgram and horsegram was successfully taken up. Farmers were disappointed with the low levels of yields (0.5 – 0.8 t/ha) even after five years because of non-availability of promising variety/selection and no immediate buyers for the harvested seed in the vicinity. There is a need for quality seed collection, value addition and increased wages. 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 Scenario

India, the world's second largest populous nation is growing at around 8 per cent per annum. Like any growing economy, India's energy needs are enormous. It is one of the fastest growing petroleum oil consumers of the world. With limited domestic crude oil reserves, India's oil import bill has grown nearly three folds since 2004-05 due to high global oil prices and growth in domestic consumption of petroleum products is a serious national concern. For instance, India spent ₹2, 72,699 crore or USD 67.988 billion on its crude imports in 2007-08, up from ₹2, 19,029 crore or USD 48.389 billion in the previous year. India needs about 120 million tonnes (m t) of petroleum products every year,

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of which the domestic production of crude oil and natural gas is around 34 m t (2006-07). Given this scenario, the Government of India (GoI) is promoting production and use of bio-fuels to reduce its oil import bill. Besides, growing carbon emission rate (3.2 per cent) is a serious environmental concern, as India is one of the top five global contributors to carbon emissions.

Hence, the Planning Commission, India set a target of establishing bio-fuel plantations on 400,000 ha for the year 2006-07. It also set the year 2007 as deadline for 5 per cent blending of bio-diesel with diesel. In order to meet the projected diesel demand of 52.3 m.t. by 2006-07, bio-diesel yielding species needed to be cultivated over an area of 2 m.ha to produce around 2.62 m.t. of bio-diesel. The Planning Commission has also set an ambitious target of blending of diesel with 20 per cent bio-diesel by the year 2012. This calls for a systematic plan involving cultivation of bio-diesel yielding crops on an area spreading over 11 m ha to enable production of 13 m t of bio-diesel per year. Considering that nearly 55 m ha is classified as wastelands, it may well appear to be an achievable target. But on ground a significant part of the wastelands are under less intensive dryland farming owned by the marginalised sections of the rural society.

The Government of India policy of promoting tree-based bio-fuel plantations is focused on promoting use of wastelands and less productive lands. It also aims at completely avoiding competition of bio-fuel cultivation with food crops for scarce productive land and water in view of stagnating food production and rising domestic demand for food. Further, India's policy of not allowing/promoting use of food/feedstock for bio-fuel production (as is done in some bio-fuel producing countries) is based on the fact that food inflation in the past couple of years is continuously on the rise. Thus, the bio-fuel initiative of the country has to be carefully negotiated through sensitive domestic and global concerns. However, the current policy of allocating wastelands for bio-fuel production aims at bringing the wastelands into some productive use besides generating additional employment for vast rural populations.

From the Research Front

Government of India in early 2003, launched National Mission of Bio-diesel. The Mission identified *Jatropha curcas* as the most suitable tree-borne oilseed and strongly recommended jatropha plantations on wastelands. Though jatropha is a widely growing species across the country under different agro-ecological zones, practically no research information was available on suitable plant types for different agro-ecological zones, yield attributes describing elite cultivars or agronomic practices as no systematic research was ever conducted on this species in the country. Thus, it was a typical case of policy driving the research than the other way round. After the Planning Commission's (GoI) emphasis on promoting bio-fuels, many premier research organisations like ICAR, DST, DBT, CSIR and NOVODB streamlined R&D efforts by forming network projects involving leading research institutes across the country. Besides, many States like Chhattisgarh, Uttaranchal and Andhra Pradesh started their own network programmes for encouraging R&D on bio-fuels. The main focus of these network programmes was germplasm collection and evaluation, standardisation of agro-techniques, crop improvement etc.

From the Development Front

In response to the recommendations of the Planning Commission, GoI, the Government of Andhra Pradesh (GoAP) launched a massive bio-fuel plantation programme across the State in 2004-05 with a target of 600,000 ha plantations on wastelands of the State (Table 1). A separate department called Rain Shadow Area Development Department (RSAD) was created by GoAP to implement this ambitious programme in 10 rain shadow districts of the State. Under this, GoAP announced a subsidy to the tune of 90 per cent for laying drip irrigation system to encourage farmers to take up bio-fuel (jatropha/pongamia) plantations on farmers' fields. The District Water Management Agencies (DWMA) which implement the watershed development programme in the districts were assigned with the additional responsibility of implementing the bio-fuel programme by collecting good seed material, raising nurseries, and identifying beneficiary farmers for raising plantations.

Table 1 : Wasteland Area in Andhra Pradesh

Districts	Lakh ha	% of geographical area	Districts	Lakh ha	% of geographical area
Khammam	2.07	12.89	Nellore	2.85	21.80
Kadapa	4.52	29.45	Anantapur	3.58	18.72
Chittoor	4.40	29.02	Nalgonda	1.55	10.86
Prakasam	3.19	18.11	Ranga Reddy	0.91	12.14
Kurnool	3.48	19.68	Medak	0.95	9.75
Mahabubnagar	2.39	12.99			
Total wasteland area in A.P.	45.27	16.46			

Source : NRSC, 2005.

Since there was not enough research data to back a massive field plantation, GoAP sanctioned a project for germplasm collection, evaluation and development of agro-techniques through on-station and on-farm trials both under irrigated (drip irrigation) and rainfed situations. Acharya NG Ranga Agricultural University, NBPGR, ICRISAT, DOR, IICT and CRIDA were involved in this multi-institute R&D initiative with the responsibility of coordination assigned to ANGRAU. Responsibility of conducting on-farm trial in the 10 RSAD districts was shared among CRIDA (3 districts), ICRISAT (3 districts) and ANGRAU (4 districts).

On-station-Experience on Cultivation of TBOs and Survey on Oil Extraction

Central Research Institute for Dryland Agriculture has been part of three important network projects viz., NOVODB, CSIR & RSAD (Govt. of AP) and is involved in research on TBOs (*Jatropha curcas*, *Pongamia pinnata* & *Simarouba glauca*) since 2003-04. In addition to this, CRIDA has also taken up processing studies on jatropha and pongamia bio-diesel production as well as mechanisation of sweet sorghum crop under NAIP-Sweet sorghum Bio-ethanol value chain project. The research experience at CRIDA so far shows that the average seed yield in six-year old jatropha, pongamia (grafts) and simarouba (grafts) were 2.7 , 3.0 and 5.0 tonnes per ha, respectively under rainfed situation.

A survey was conducted to study the kinds of oil expellers in use in the rural areas for expelling oil from pongamia and jatropha seeds. It was observed that the oil expellers with 50 to 100 kg/h seed crushing capacity were in use. These were not specially designed to expel oil from jatropha and pongamia. However, the traditional oil expellers used for expelling oil from groundnut, sesame and coconut etc. which contain oil ranging from 20-55 per cent, were used for the extraction of jatropha and pongamia oils. In a few cases such expellers were adapted to suit expelling oil from jatropha and pongamia with minor modifications. These expellers consist of single chamber with 6 to 8 bolt arrangement which work with the electric motors within the power range of 10 to 20 hp. It was found in the survey and also at the oil extraction unit of CRIDA that their performance was not efficient. The data indicated that more than 8 per cent of oil was found in the de-oiled cakes of pongamia and jatropha. This is because of excessive gums and waxes besides the uneven moisture content and toughness of the seeds. The oil bonds of pongamia and jatropha are stronger than that in the seeds of conventional edible oilseeds. This resulted in frequent choking of oil chamber which reduced expelling capacity. This is because of the conventional screw design which is not suitable to push forward the crushed seed meal uninterruptedly. Further, the oil cake with excessive oil content when applied to soil as an amendment is known to interfere with water absorption by soil and soil aeration resulting in sluggish microbial activity. The decomposition of the cake and subsequent nutrient from it is delayed because of higher oil content. The low recovery of oil from these expellers and the choking problems prompted CRIDA to work on the conventional oil expeller and attempt to design a separate mini oil expeller for trail runs focusing the small scale industry needs. This led CRIDA to develop a mini oil expeller by modifying the screw and other critical parameters. The mini expeller increased the oil recovery in pongamia seed by 4 per cent (from 25 to 29 per cent) and jatropha by 6 per cent (from 27 to 33 per cent). Further, the oil in the de-oiled cake was only 6 to 7 per cent, thus bringing down the decomposition period by 30 per cent and making it more suitable for soil application (Table 2).

Table 2 : Comparative Efficiency/Extraction Rate of Various Expellers

Type of oil expeller	Oil recover (%)	
	Jatropha seed	Pongamia seed
CRIDA mini oil expeller with 5 HP motor	33	29
Conventional oil expeller with 5 HP motor	25	33
Conventional oil expeller with 10 HP motor	27	25

CRIDA's On-farm Experiences

CRIDA initiated the on-farm experiments in Mahabubnagar, Anantapur and Nalgonda districts during *kharif*, 2005 in 69 acres (Jatropha-63 acres and pongamia 6 acres). Mostly degraded/wastelands belonging to small, medium and large farmers with and without irrigation facilities were selected for field trails. The major criterion for selection of the farmers was their willingness to stay with the project at least for five years (duration of the project). The study was conducted with three levels each of irrigation, nutrition, and pruning; and four levels of spacings.

Study Area : The soils of these sites are shallow, gravelly and marginal in fertility with low water holding capacity. The average annual rainfall of Nalgonda and Mahabubnagar is around 650 mm while that of Anantapur is 510 mm. Besides, the topography is undulating with 3 to 6 per cent slope. In all the three districts the programme was implemented with the support of District Water Management Agency/NGOs. The farmers having water source were provided with 90 per cent subsidy for laying drip irrigation system while cost of planting including sapling for those who did not have water was borne by DWMA.

Results

In general, the survival of jatropha was about 95 per cent in irrigated conditions while in rainfed conditions it was 80-85 per cent. This shows good establishment of jatropha even under deficit rainfall. Closely spaced (2x2m) jatropha encountered problems of high inter-cultivation costs; as such plots were not amenable for mechanisation. Thus, manual weeding pushed up the cost of cultivation in closely spaced jatropha. The widely (3x2 m, 3x3 m or 4x2 m) spaced jatropha enabled inter-cropping for the first two years, partial mechanisation and better response to irrigation. Pruning increased number of branches (10-15 per plant) and also resulted in vigorous plant growth. The inflorescence as also the capsule bearing bunches was more when the plants were pruned at 45 cm or 60 cm height from ground level when compared to pruning at 30 cm during the first year. However, it was observed that pruning resulted in higher pest infestation as the pruned plants had more number of succulent branches and of pruning injuries. In order to provide immediate income to the farmer besides improving soil fertility, legume, inter-cropping with pigeon pea, blackgram and horsegram was successfully taken up in jatropha. Chickpea, castor, pigeon pea, blackgram and green gram were found compatible inter-crops in pongamia. Contrary to the general belief that hardy species like jatropha and pongamia are less likely to have any major pests, several pests were recorded during the study. Moderate infestation of leaf & inflorescence webber (*Pempelia morosalis)* and red hairy caterpillar (*Amsacta albistriga*) was observed in jatropha whereas in pongamia leaf Galls (*Eriophyes cheriani)* were commonly observed. Details of experiments on farmers' fields in three districts of A.P. are given in Table 3.

Bio-fuel Development : The Road Ahead

CRIDA is engaged in developing roadmap for bio-fuel development in the country since the early 1990s though actual experimentations through a coordinated and concerted manner were initiated since 2003. During this period the institute has amassed quite valuable insights and learnings in this field. Following is the summary of CRIDA's experiences.

* *Economics of jatropha cultivation :* A modest estimate of production and economics from jatropha cultivation under good management practices (elite planting material, weed-free condition, and life saving irrigation with minimum nutrient supplementation during establishment phase) in semi-arid conditions, a benefit-cost ratio of 1.3 to 1.4 can be expected if the plantation is continued at least for 10-year period. That is, the net returns from jatropha could be ₹6000/ha/year, while from pongamia, these could be around ₹8500/ha/year. Alternate oil yielding tree crops for jatropha are pongamia, simarouba, neem, salvadora, phalas.

Table 3 : Status of On-farm Experiments in Three Districts of Andhra Pradesh

Title of the experiment	Village/ Mandal	Name of the farmer	Acre-age	Date of planting	Avg. seed yield (t/ha)
(1)	(2)	(3)	(4)	(5)	(6)
Mahabubnagar district (22 acres of jatropha)					
Effect of pruning on growth, development and yield	Chintagudem/ Farukhnagar	Krishnaiah			0.3 to 0.5
Effect of irrigation and nutrition on growth & yield					
Effect of soil & water conservation and irrigation on growth & yield		Venkataiah	Seven	July, 05	
Effect of nitrogen & phosphorus on growth and development		C.Vishnu			
Effect of soil & water conservation and irrigation on growth, development & yield	Veldanda	Venkat Reddy	Ten	July, 05	
Effect of irrigation & nutrition on growth, development & yield					
Optilmisation of plant density and pruning for higher productivity	Veldanda	Zilla Parishat High School	Five	October, 06	

(Contd.)

Table 3 : *(Contd.)*

(1)	(2)	(3)	(4)	(5)	(6)
Anantapur district (22 acres of jatropha)					
Estimation of minimum water and nutrient requirement for establishment	Amudalakunta/ C.K. Pally	K.Gunaranjan & Smt K. Manjula	Five	Sept.06	0.5to 0.7
Effect of spacing and pruning on the growth and yield	Amudalakunta			August, 06	Uprooted
	Kappalabanda	Chandra Varma Choudhary	Seven	July, 06	Uprooted
Effect of irrigation & pruning	Hampapuram	Eshwaraiah	Ten	July, 05	0.5 to 0.7
Nalgonda district (19 acres of jatropha)					
Estimation of minimum water and nutrient requirement for establishment	Dilawarpur/ Aleru	Amarlal Hariram	Nine	April, 06	0.45 to 0.67
Effect of spacing & pruning on the growth and yield				July, 06	
Optimisation of plant density and effect of pruning on growth, development and productivity	Mutthireddy-gudem/Athmakur	M. Sitaram	Four	August, 06	
Effect of spacing and pruning on the growth and yield	Chada	Amarender	six	July, 05	Uprooted
Mahabubnagar district (6 acres of pongamia)					
Optimisation of plant density for higher productivity	Telkapally	B.Narayana and brothers	Six	October, 06	Uprooted
Nitrogen and phosphorus requirement on growth & yield					0.3 to 0.5

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. CRIDA's trials show that jatropha responds to irriagation and the incremental benefits due to irrigation are in the range of 30-40 per cent, however, the bio-fuel policy of Government of India is to encourage bio-fuel plantations on wastelands where irrigation is a rare possibility.

* *Inter-cropping :* Though inter-cropping is a good option for any perennial plantation, the feasibility of raising inter-crops is limited owing to the harsh nature of the settings (wastelands) in which the bio-fuel species are required to be promoted. However, encouraging natural pastures in the interspaces of bio-fuel plantations and also introducing improved grasses and legumes into the natural pasture to improve fodder quality and carrying capacity could be a viable option. This will enable introduction of livestock component, especially small ruminants, into the system thereby making bio-fuel plantation economically more viable.

* *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. It is desirable to make arrangements for collecting the material from plantations directly. There should be compensation for the de-oiled cake or it 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 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/year). It can be promoted on wastelands either owned by individuals, community (CPR) or government. Though revenue records show availability of large tracts of lands under government/community ownership, in reality these lands are either under some kind of economic activity and/or some temporary ownership. Therefore, there is need for identifying the actual availability of such lands for bio-fuel plantations. Based on such data, the realistic production potential of bio-diesel of a region/nation should be arrived at.

* *Procurement of Seed or Seedlings:* Staff of agriculture / forest / horticulture departments should physically visit dependable sources of promising planting material and personally procure quality material from different regions of the country one year ahead of the planting season for the next year. It is worthwhile to encourage tissue culture at one or two institutions if elite material is available.

Continued Adoption : Issues

The project generated a lot of hope among farmers who owned marginal lands, as bio-fuel species like jatropha and pongamia were believed to be drought-hardy and would yield substantially even when grown on poor soils. This however could not come true. Though the plants survived, their yields were not economical, as the yields were in the range of 0.5 to 0.8 t/ha in jatropha and 0.6 to 1.1 t/ha in pongamia. Farmers were disappointed with the low levels of yields even after five years since the planting material supplied was not of proven variety/selection. This was due to non-availability of a promising variety/ selection at the time of the launch of the project. Further, there were no immediate buyers in the vicinity which made it difficult for farmers to sell their produce for a remunerative price. Besides, farmers did not have the required skills or infrastructure to add value to their produce (seed) which forced them to settle for lower profits. All this led most of the small and medium farmers (holding < 1 – 3 ha) to realise that the opportunity cost of bio-fuel cultivation (say, other crops like groundnut or sweet lime cultivation) was not attractive enough. As a result, most of the farmers uprooted bio-fuel plants in the second/third year of establishment even though planting material and inputs were provided free of cost. Subsequently, they either went for groundnut which they used to cultivate earlier or other profitable horticulture species. Drip system supplied under the bio-fuel programme came in very handy for this switch over for the farmers. Some of the large farmers (holding > 3ha) who are still persisting with bio-fuels, as they are able to afford it, even they also have reported that they are actively considering replacing bio-fuel plants with fruit orchards (See Table 2).

Future R & D Issues

* In the climate change scenario, raising bio-fuel plantations is a win-win proposition. Bio-fuel production can claim carbon credit both on account of reduced emissions (by reduced burning of fossil fuels) and for sequestering atmospheric carbon by TBOs. Presently there is lack of information on many critical factors that determine the carbon sequestering ability of different bio-fuel yielding species as prescribed by UNFCCC. Generation of information on carbon sequestration potential of different TBOs under different agro-ecological regions and age gradations will facilitate the process of claiming carbon credit. Once this is done, it would be easy to bundle small groups of farmers to meet UNFCCC standards for claiming carbon credits.

* Presently the financial institutions are not in favour of lending for bio-fuel plantation ventures due to long gestation period and lack of credible information on the economic viability of such projects. Financial institutions must consider lending to new ventures of small scale oil extraction units in rural areas, as these have the potential for proving the much needed forward linkage to bio-fuel plantation ventures. If the country needs to alleviate its current situation of paying huge oil import bills, there is a need for a long term commitment by investing in bio-fuels. It will also help the country to go a step closer to meeting the Kyoto protocol requirement of reducing emissions. It is time the Government thought of building a corpus fund to implement a nation-wide bio-fuel plantation programme as envisaged in bio-fuel policy of the country. Such a programme should be dovetailed with a flagship poverty alleviation programme like MG NREGS and others like JFM, etc.

Conclusion

If a SWOT analysis of the TBOs for bio-fuel programme is carried out, we can say that there are wide ranging options available in the form of several TBO species which can be cultivated in the varied agro-climatic conditions of our country. Availability of candidate plus trees (CPTs) of these TBOs in the wild is a valuable resource. Their careful collection, evaluation and multiplication on a large scale is the need of the hour. 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 odourless, 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.

However, the current bio-fuel policy of the Government of India is to promote TBOs on wastelands, their yields are obviously low. The country cannot afford to promote TBOs on arable lands, as this would trigger competition between food and fuel. Among the opportunities we can enlist the benefits of raising TBOs and claim carbon credits both for carbon sequestration and by providing alternative to fossil fuels which are more polluting. If other renewable energy sources like solar power, hydro or wind power become more affordable, the TBOs may lose their competitive edge.

Abbreviations

ANGRAU	Acharya NG Ranga Agricultural University
CDM	Clean Development Mechanism
CRIDA	Central Research Institute for Dryland Agriculture
CSIR	Council for Scientific and Industrial Research
DBT	Department of Biotechnology
DOR	Directorate of Oilseeds
DST	Department of Science and Technology
DWMA	District Water Management Agency
GoAP	Government of Andhra Pradesh
GoI	Government of India
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IICT	Indian Institute of Chemical Technology
JFM	Joint Forest Management
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
NAIP	National Agricultural Innovation Project
NBPGR	National Bureau of Plant Genetic Resources
NGO	Non-Government Organisation
NOVODB	National Oilseeds and Vegetable Oil Development Board
NRSC	National Remote Sensing Centre
R&D	Research and Development
RSAD	Rain Shadow Areas Development Department
TBOs	Tree Borne Oilseeds
UNFCCC	United Nation's Framework Convention on Climate Change