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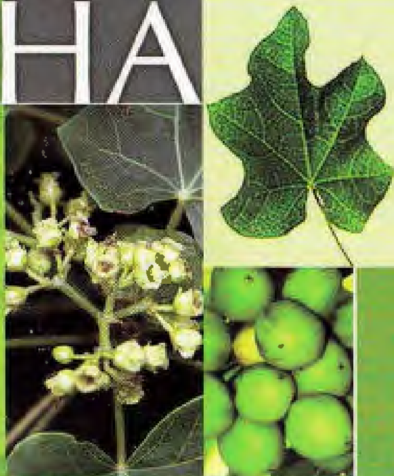
Getting Real with JATROPHA



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Proceedings of the NAST Roundtable Discussion and Workshop on Biofuels: Focus on Jatropha held in Manila on September 19, 2007

National Academy of Science and Technology, Philippines
Department of Science and Technology

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Foreword

The following proceedings were documented from the discussion of the NAST Roundtable Discussion (RTD) and Conference on *Jatropha*. Speakers and participants come from the government, non-governmental organizations (NGOs) and industry. It has been reported that the current state of development in evaluating *Jatropha* as a potential feedstock for biodiesel managed to identify key attributes essential for the success of the Program. The properties and characteristics of coconut biodiesel or coco methyl ester (CME) remain as the benchmark in assessing the viability of *Jatropha*. As a result, new areas have been opened for further investigation and scientific research.

It was also noted that initial physico-chemical analysis of some local *Jatropha* species has been undertaken. Results show that the composition and characteristic of the *Jatropha* crude oil is 84% unsaturated, in contrast to coconut oil's 91% saturated. The former indicates it has lower oxidation stability and is, therefore, more prone to oxidation than the latter. This requires more research towards improving its storage stability. In addition, there was also the need for developing a standard for fatty acid methyl ester (FAME) content. It has also been established that *Jatropha* has a yield of about 31% and that oil extraction ranges between 50 – 55 percent. Current research has also looked into the possible uses of *Jatropha* by-products such as the crude glycerol and the pressed cake. Unlike coconut, *Jatropha* is known to have toxic properties. Thus, this characteristic must be considered in investigating the utility of its pressed cake as fertilizer, biomass or as fuel for electricity production.

The other areas which require improvements include the standardization of the procedure of extraction and the yield reporting. Extraction procedure must include looking into the varying oil content across varieties while it was recommended that the yield should be based on the total oil content and not by weight. Taking into consideration factors such as weather condition, economic viability, plantation concerns and government support (particularly DOE) can further enhance research on this area. Furthermore, theoretical findings should be matched alongside actual scenarios by looking into the actual content and performance test results.

In moving forward, a futuristic view must be in place. Issues such as the projected mandated increase in biodiesel blend must be kept in mind. Looking at other sources for fuel can thus be considered. The viability of palm oil, *bagasse* or rice husk as the feedstock can be potential research areas, which must not be dismissed in order to achieve a successful Biodiesel Program.

Dr. F. A. Uriarte Jr.
Dr. A. B. Culaba

1

Introduction

The past two years have seen a considerable interest in liquid biofuels such as ethanol and biodiesel. This is a result of unprecedented oil price levels, which almost reached US$150 per barrel mid of this year coupled with increasing public awareness about the hazards of unmitigated climate change. Biofuels derived from agricultural crops offer the prospect of a measure of energy independence for oil-importing countries such as the Philippines; their basic fuel cycles are inherently carbon neutral, since combustion emissions of carbon dioxide (CO_2) are offset by photosynthesis during the growth of the feedstock. One of the weaknesses though of such biofuels is that they require agricultural resources, particularly land, to be diverted away from food production and reallocated to energy production. The effects are already being felt globally, as the prices of many agricultural staples and their derivatives have risen in conjunction with the increased biofuel market.

The cultivation of hardy, non-food crops such as *Jatropha curcas* is meant to circumvent these tensions between the food and energy markets. In particular, the crop is said to grow well on land of poor quality or which would otherwise have no alternative agricultural value. The crop itself can also be cultivated exclusively to provide oil that can then be processed into biodiesel. It is thus clear that commercial cultivation of this crop can be of value, especially considering the limited amount of surplus vegetable oil available for biodiesel production. Nevertheless, some uncertainties still remain:

- In the past two years, there has been a steady influx of investment in *Jatropha curcas* plantations. Some critics, however, have questioned the economic viability of such farms.
- Investment in seed crushing facilities seems to be lagging behind the growth of the plantations. This situation presents a potentially dangerous imbalance in the supply chain. If seed crushing develops into the

bottleneck of the biofuel supply chain, seed prices at the farm gate will fall and thus further weaken the viability of the farming sector.

- The exact mechanics of the supply chain have yet to be fully determined. *Jatropha curcas* tends to be grown in such a way that gives logistical problems during seed harvesting and collection. One school of thought favors small-scale seed crushing at or near the farm site. However, the absence of economies of scale in such a set-up may be detrimental to the fuel cycle energy balance.

- Problems in the conversion of the *Jatropha curcas* oil into biodiesel have not been fully appreciated. While transesterification itself should present no unique problems, the methanol requirement of the biodiesel production process favors large, centralized production facilities. At the same time, significant quantities of glycerol byproduct will be generated during the production process. It is still unclear how the byproduct should be purified further before being sold for use in the food and pharmaceutical industries, as oil feedstock is said to contain potentially toxic impurities.

The Biofuel Cluster, established through the joint initiative of the National Academy of Science and Technology (NAST) and the National Research Council of the Philippines (NRCP), followed up the highly successful "*Symposium on Biofuels: Way to Go Forward*" in 2006 with two major gathering of stakeholders in the biofuels sector this year -- a Roundtable Discussion (RTD) on "*Biofuels: Focus on Jatropha*" in July and a Conference on "*Getting Real with Jatropha*".

The RTD on Biofuels focused on the current Research and Development (R&D) activities on *Jatropha*, which were consolidated by the Agriculture and Process Technology (Industry) Sub-clusters. The former is headed by the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD) while the latter is chaired by the Philippine Council for Industry and Energy Research and Development (PCIERD) of the Department of Science and Technology (DOST), respectively. Policy initiatives have been reported by the Policy Sub-cluster headed by the Department of Energy (DOE).

2

Jatropha Curcas

Jatropha curcas is a shrub or small tree that belongs to the genus Euphorbiaceae. It is a native of tropical America but it now flourishes in different parts of the world, particularly the tropics and subtropics in Africa and Asia. It thrives in a wide range of climatic zones with rainfall regimes from 200 to over 1500 mm per year. The plant grows relatively quickly and can be easily propagated by cuttings. Jatropha can grow on moderately sodic and saline, degraded and eroded soil, and has low fertility and moisture demand (Mohibbe Azam et al., 2005).

Various researches show that *Jatropha curcas* is a plant of many uses. The whole plant itself may be used for erosion control, as rodent and snake repellant, and for fencing/hedging purposes. Its leaves and twigs have medicinal applications and may also be used as a substrate for the development of eri silkworm (Gübitz et al., 1999). Similarly, the aerial parts, stem and root of this plant may also be utilized for medicinal purposes. The aerial parts contain various organic acids as well as iridoids, saponins and tannins. The latex from J. curcas has been used to promote healing of wounds, refractory ulcers, and septic gums and as a styptic in cuts and bruises. Its bark is a source of tannins and may also be a source of dyes.

The fruit of jatropha is the most useful part of the plant. The fruit hulls may be used as combustibles, green manure, and may be used for biogas production. The seeds may be used as insecticides and the nontoxic varieties may be used for food applications. Similar to the fruit hulls, seed shells may also be used as fuel resource (as combustibles). The seed cake may be utilized as organic fertilizer, as animal feeds (nontoxic varieties or after detoxification), as rodent repellant, as bio-pesticide, and for biogas production. The seed oil may serve as fuel, as bio-insecticide, as lubricant, as raw material for soap production and biodiesel production. Figure 1 illustrates the various parts of Jatropha curcas and their possible uses.

Several properties of the plant include hardness, rapid growth, easy propagation and wide ranging usefulness (Pramanik, 2003). The jatropha oil is a slow-drying oil, which is odorless and colorless when fresh but turns to yellow on standing. It is reported that the oil content of jatropha seed ranges from 30 to 50% by weight and the kernel itself ranges from 45 to 60%. Jatropha oil contains different fatty acids such as myristic acid, palmitic acid, stearic acid, arachidic acid, oleic acid and linoleic acid.

Its fatty acid composition classifies it as a linoleic or oleic acid type, which are unsaturated fatty acids. Table 1 shows the fatty acid composition of jatropha oil and other plant oils that may be used for biodiesel production.

Table 1 Fatty acid composition of different vegetable oils

Fatty acid	Jatropha oil	Soybean oil	Palm oil
Caprylic (C_8/0)	-	-	-
Capric (C_{10}/0)	-	-	-
Lauric (C_{12}/0)	-	-	-
Myristic (C_{14}/0)	-	0.1	-
Palmitic (C_{16}/0)	14.2	11.0	40.3
Palmitoleic (C_{16}-/1)	1.4	0.1	-
Stearic (C_{18}/0)	6.9	4.0	3.1
Oleic (C_{18}/1)	43.1	23.4	43.4
Linoleic (C_{18}/2)	34.4	53.2	13.2
Linolenic (C_{18}-/3)	-	7.8	-
Arachidic (C_{16}-/0)	-	0.3	-
Behenic (C_{22}/0)	-	0.1	-
Saturates	21.1	15.5	43.4
Unsaturates	78.9	84.5	56.6

Adapted from Sarin et al., 2007

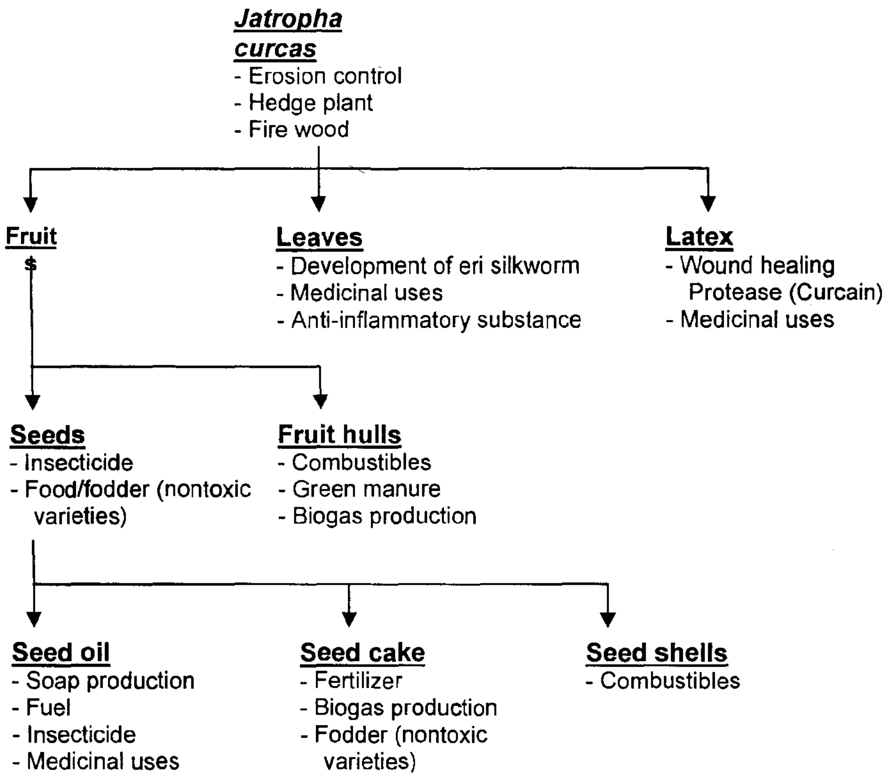


Figure 1 Exploitation of J. curcas (Adapted from Gübitz et al., 1999)

The seeds and the oil of *J. curcas* are, in general, toxic to humans and animals. Its main toxic principle is a hemaglutinin called curcin (Gübitz et al., 1999). Due to its toxicity, *J. curcas* oil is inedible and is traditionally used for the manufacture of soap and medicinal applications.

The fact that jatropha oil cannot be used for nutritional purposes without detoxification makes it a very attractive fuel source, although it does present some processing difficulties. Table 2 shows the various physical and chemical properties of jatropha oil blend compared with conventional diesel fuel.

Table 2 Physical and chemical properties of diesel and jatropha oil blend

Properties	Diesel	*Jatropha curcas* oil
Density (gm/cc), 30°C	0.836-0.850	0.93292
Kinematic viscosity (cSt), 30°C	4-8	52.76
Cetane No.	40-55	38.00
Flash point, °C	45-60	210.00
Calorific value, MJ/kg	42-46	38.20
Saponification value	-	198.00
Iodine No.	-	94.00

Source: Pramanic, 2003

Numerous researches have been done on the viability of *Jatropha curcas* as a raw material for biodiesel production. Various methods for oil recovery, including extraction with organic solvents and water, have been investigated. For jatropha oil to be utilized for fuel purposes, two strategies have been evaluated: (1) adaptation of the engine to the fuel; (2) adaptation of the fuel to the engine.

Because the main application for alternative fuels is for the transport sector, it would be more appropriate to adapt the fuel to the engines that are presently used in motor vehicles. This leads to the development of technologies that will enhance the fuel performance of jatropha oil, thus making it at par with petroleum-based diesel. One option is to blend neat jatropha oil with methanol (Senthil Kumar et al., 2003). Another option is transesterified jatropha oil or jatropha methyl ester (JME). Neat jatropha oil is transesterified with methanol, to lower its viscosity and increase its cetane number. According to studies, this alternative can give better performance and reduced smoke emissions than the blend.

3

Biofuels: Focus on Jatropha

Roundtable Discussion and Workshop

24 July 2007, Sofitel Philippine Plaza, Manila

The Roundtable Discussion (RTD) brought together the key stakeholders involved in the research & development efforts on Jatropha as an alternative feedstock for biodiesel in the country. The three (3) sub-clusters under the Biofuels Cluster of NAST-NRCP have presented their most recent developments with regards to the use of locally-grown Jatropha, commonly known as "tuba-tuba" in the country. The objectives of the RTD are as follows:

- To establish the status of Jatropha initiatives in the Philippines
- To develop an R&D road map for Jatropha utilization as an alternative feedstock for biodiesel

3.1

The Agricultural Issues

A Report of the Agriculture Sub-Cluster

Dr. Virgilio Villancio of Farming Systems and Soil Resources Institute (FSSRI) of UP Los Baños and Project Leader of the Integrated R&D on Jatropha Curcas for Biodiesel, made a presentation on agricultural sector.

In 2007, biodiesel demand is projected at 78 Million Liters, and by 2011, it is estimated to increase to 181 Million Liters. Various Jatropha nurseries and plantations have been established across the country and preliminary researches on the crop have been undertaken in SCUs and at UPLB in order to have a sufficient supply of biodiesel.

The fixed oil content of Jatropha seeds locally produced has been determined including the physical and chemical properties of oil extracted. Around 2,000 – 2,500 kg of seed/hectare/year can be harvested depending on the quality of seed and soil or approximately 0.3-0.9 kg per tree seed production. An oil yield of 30-40% crude non-edible oil can be extracted that can produce 0.75 – 2 tons biodiesel per hectare.

The different local and foreign varieties of Jatropha are already present in the Philippines. A span of five years is needed to identify the full potential of each variety. Monocropping is not highly profitable and farmers have limited experience with Jatropha cultivation. To remedy such difficulties, processing plants should be capable of handling multiple feedstocks, thus benefitting the farmers.

Dr. Villancio mentioned the following concerns:

- A proposal of bioenergy system, an integration of coconut and jatropha plantation.
- The local jatropha germplasm must be characterized and evaluated.
- Availability of post-production requirements such as harvesting equipment, dehulling machine, transport facilities and storage
- Blending of CME and JME to produce a better fuel

Table 3.1 Agricultural Sub-Cluster

Current institutional concerns	Identified gaps	Action plan	Agencies/ Institutions involved
Areas planted with jatropha are not validated	*Identify areas planted with jatropha*	*Inventory and validation of sites*	*DA (lead agency), DENR, DAR, PAFC, PFC, SCUs, OPAG-LGUs*
Potential areas for jatropha	*Identify potential areas for jatropha plantations*	*Inventory and validation of potential sites*	*DA (lead agency), DENR, DAR, PAFC, PFC, SCUs, OPAG-LGUs*
Suitability assessment	*Identification of suitable areas for jatropha cultivation*	*Agri-system studies*	*DA (lead), DOST, SCUs*
Feasibility studies of village level and commercial production of feedstock	*Lack of feasibility studies conducted on jatropha production*	*Conduct feasibility studies*	*DA, DOST, SCUs*
No identified recommended variety	*Narrow germplasm collection*	*Germplasm and varietal improvement*	*DA, SCUs, UPLB*
IEC materials	*Information dissemination*	*Production and distribution of IEC materials, conduct of seminars*	*DA (lead agency), DENR, DAR, PAFC, PFC, SCUs, OPAG-LGUs*
Availability of technologies	*Additional studies on production systems and cultural management*	*Conduct researches on production systems and cultural management*	*DA (lead agency), DENR, DAR, PAFC, PFC, SCUs, OPAG-LGUs*
Value added products from jatropha	*Medicinal and toxicological studies*	*Conduct medicinal and toxicological studies*	*DOST, DOH, Academe*

3.2

The Technology and Processing Issues

A Report of the Industry Sub-Cluster

Engr. Raul Sabularse, Deputy-Director of PCIERD and head of the Industry (Technology and Processing) Sub-cluster focused mainly on the gaps of Jatropha processing in the country.

- The jatropha processing and utilization covers: dehulling, expelling, filtration, transesterification and by-products utilization. Dehulling of jatropha is done manually. The available technologies for dehulling are in prototypes or equipment intended for laboratory testing only. However, if the hull is not removed, there is a higher oil content, lower labor cost and higher economy. With these new findings, dehulling may not be necessary.

- The condition of jatropha seed is important. Storage and transportation may also contribute to the condition of the seed that will affect the quality or quantity of the oil extracted. It is important to consider the two factors.

- With all the processes involved in jatropha crude oil extraction, a study on process optimization must be conducted to maximize the yield including the type of oil extraction method.

- There is need to establish the following; processing technology of by-products, material testing, and engine performance that will be necessary to optimize the use of jatropha seed.

- A pilot processing plant facility is necessary.

Table 3.2a Technology and Processing (Industry) Sub-Cluster Issues

Current institutional concerns	Identified gaps	Action plan	Agencies/ Institutions involved
Drying	*Parameters/moisture specifications*	*Gathering data from past studies & from all sources as regards acceptable MC; Replicate/adopt the best dryer available from various sources*	*DOST*
De-hulling	*Best practices on harvesting design and fabrication of de-hulling machine, manually operated machine, pre-treatment conditions*	*Tests to be conducted if there is indeed a need to remove the hull to achieve higher oil content; Pilot operation of small/village level processing at Gen. Tinio; De-gum*	*ITDI, MIRDC & TUP to work together*
Expelling	*Pre-treatment conditions for seeds before expelling; Optimize expelling process: mechanical, chemical, or enzymatic; Optimize filtering process*	*Benchmark on efficiency of Jatropha expellers available; Visit at the PFC for expelling machine*	*DOST & Academe*
Crude jatropha oil	*Storage facility; Stability if with additives (Hybrid Fuel), microbial growth, oxidative stability*	*Testing on the best parameters*	*DOST & Academe*

Table 3.2b Technology and Processing (Industry) Sub-Cluster Issues

Transesterified	*best practice*	*Technology transfer*	*DOST, academe and private groups*
By-product utilization	*refining of glycerine developed by ITDI*	*Testing*	
Seed Cake	*other applications (wood pest; scavenger fro formaldehyde emission*		
Vehicle performance testing	*endurance on 2% and 5% Blend using existing car manufacturers*	*do*	*DOST, DOE*

3.3

The Policy Issues

A Report of the Policy Sub-Cluster

Ms. Elma Karunungan, chief of Alternative Fuel and Energy Technology Division of Department of Energy (DOE) presented an update on the Philippine Biofuels Program.

- A viability study for *Jatropha curcas* as a potential biodiesel is being conducted. The study will identify the maximum percentage of Jatropha oil content in biodiesel.

- There are twenty four (24) companies that are willing to invest on biofuel projects. Fifteen (15) companies for bioethanol and nine (9) companies for biodiesel.

- Companies that will invest on biofuels project will be given an incentive by the government. Pioneering firms and/or an investment of one billion or more will be given more incentives.

- DOE will further update the list of accredited producers, plantation areas and data on Jatropha.

Table 3.3 Policy Sub-Cluster

Current institutional concerns	Identified gaps	Action plan	Agencies/ Institutions involved
Sec 40 IRR	*Community Village Level* - *Benefits for the small farmers* - *Identify domestic household use/hazards of Jathropa*	*Technology development, testing and promotion for small scale application of Jathropa* *Continuous information and education campaign*	*DOST, DA and Academe for technology and economic R and D* *DSWD, DILG, TESDA, DOE Academe for dissemination and promotions*
Commercialization of Jathropa	*Performance, standards, sustainability, price, viability studies* *Mechanisms for "Social Amelioration" provision* *Incentives*	*R and D and validation studies* *Benchmark Social Amelioration mechanisms with RA 6982* *Continuous information and education campaign*	*DOST, DA and Academe for technology and economic R and D* *DOLE, DOE, DTI, DA for Social Amelioration Mechanisms*

4

A Symposium

Getting Real with Jatropha

19 September 2007, Sofitel Philippine Plaza, Manila

The symposium emphasized the important role of research in the implementation of the biofuels program of the country. Several areas of research have been presented including development of novel fuels, environmental and economic impact modeling, energy crops biotechnology studies, residue and byproducts utilization and process improvcment and optimization. The academe may be involved in the conduct of the actual research, research results and information dissemination and in providing an unbiased and critical look at the issues concerned.

Philippine Forest Corporation is a government owned corporation under the Department of Environment and Natural Resources (DENR). Its main mission is to create economic productivity out of idle lands in the country. It has been heavily involved in the development of Jatropha plantations and processing in the country. Its involvement includes establishment of demonstration projects, extension of support to related research efforts by the academe and DOST, development and distribution of processing equipments and acquisition of lands for Jatropha plantation.

The symposium provides an overview of the benefits and issues related to Jatropha as a Bio-fuel feedstock and plans and efforts to facilitate its commercial adoption. The major advantage of Jatropha over other biofuels feedstock is the absence of the "food versus fuel" issues. Its supply however would still have to ensure posing a major issue to its wide scale adoption. A roadmap have been established to produce 1 million tons of Jatropha based biodiesel from 2009-2011. The plan includes the implementation of an integrated research program on Jatropha funded by PNOC, DOST and CHED covering areas from germplasm management to processing technology and machinery development. The presentation provides details of this plan.

The PNOC Jatropha Roadmap is presented which involves mega nursery programs, plantation development and setting up of biodiesel plants in various locations in the country. It is designed to produce 1 million tons of Jatropha based biodiesel from 2009 – 2011. Mega nursery sites being eyed include one area in Luzon and three other areas in Mindanao. Selected military reservations, penal colonies, private and ancestral lands and government lands have been identified to provide a total of 700,000 hectare of Jatropha plantations. Biodiesel processing is planned to be implemented in the PNOC-AFC Industrial Park, Phivision Industrial Estate, Nasipit Economic Zone and in General Santos.

4.1

Philforest Jatropha Plantation Development

Farm to Tank Experience

Abstract

Philippine Forest Corporation is a government owned corporation under the Department of Environment and Natural Resources (DENR). Its main mission is to create economic productivity out of idle lands in the country. It has been heavily involved in the development of Jatropha plantations and processing in the country. Its involvement includes establishment of demonstration projects, extension of support to related research efforts by the academe and the Department of Science and Technology (DOST), development and distribution of processing equipments and acquisition of lands for Jatropha plantation.

This paper was written based on the power point presentation of Mr. Celso P. Diaz of the Philippine Forest Corporation.

Philippine Forest Corporation (PhilForest) is a wholly government owned and controlled organization with the mandate to provide expert services and competent management to the government's country side development program. It is a subsidiary of the Department of Environment and Natural Resources (DENR). Its vision is "to restore life back to the forest". It intends to attain this by creating economic productivity out of idle lands. In September 2006, the DENR transferred to PhilForest an initial area of 375,091 ha (see Figure 4.1 for details) for agroforestry projects, including biofuel plantations, among others.

Breakdown of 375,091 hectares	
CAR	-
Region 1	3,210
Region 2	42,277
Region 3	7,540
Region 4a	268
Region 4b	2,304
Region 5	1,812
Region 6	50
Region 7	9,220
Region 8	1,922
Region 9	-
Region 10	2,477
Region 11	62,294
Region 12	74,515
CARAGA	167,203

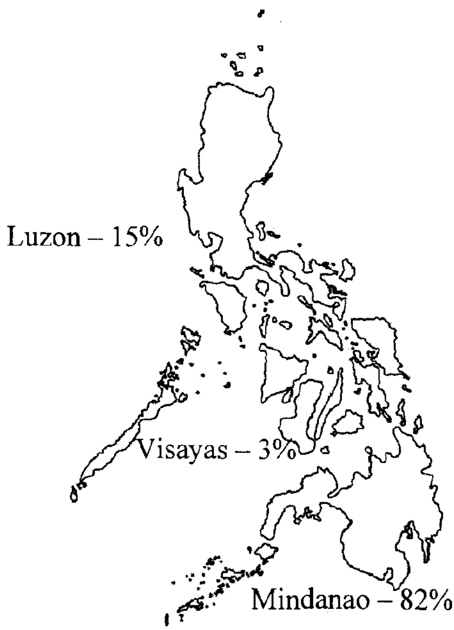


Figure 4.1 Distribution of idle lands granted to PhilForest

Since then, purchase and distribution of Jatropha seeds for plantation development was initiated by the corporation. As to this date, it has sold 9,500 kg of seeds to small owner plantations. A portion of seeds purchased are being used for own plantation development and the rest are supplied to various partners like local government units (LGUs), state universities and colleges (SUCs) and others.

A number of plans and programs have been lined up to facilitate the evelopment and use of Jatropha as a Biofuel feedstock including:

- Demo-plantation research for Jatropha production with the Philippine Army at Fort Magsaysay, Nueva Ecija where technical data were gathered and documented to support government advocacy to go into massive Jatropha plantation development;
- Commissioned the Ecosystem Research and Development Bureau (ERDB), DENR to do tissue culture protocol for Jatropha propagules;
- Research on Jatropha capability to sequester carbon dioxide from the atmosphere;
- Supply of free seeds to University of the Philippines – Los Baños (UPLB) study on oil extraction from Jatropha and production of Jatropha Methyl Ester (JME);
- Commissioned University of Santo Tomas (UST) Research Center to conduct study on the optimization of transesterification of JME;

Figure 4.2 Jatropha Oil Expeller purchased by PhilForest

- Joint Biofuel Research Project with the Commission on Higher Education (CHED) through its 17 SUCs with each establishing 10 hectares Jatropha plantation which will be the source of planting materials for the nearby communities;
- Acquired oil expeller from India (see Figure 2) with a processing capacity of 1 to 2.4 tons of seeds per day and oil recovery rate of 15 to 25 %;
- MOA with Japan-Phil NES Solutions;
- Laboratory research with DOST on the extraction of crude oil from Jatropha seeds and processed into biodiesel called Jatropha Methyl Ester through transesterification. Results show that the properties of JME meet the Biodiesel standards based on American and European Union (see Tables 4.1 and 4.2). Similar research was commissioned to the Department of Energy (DOE) and Petron with results similar to that of DOST;
- Crude oil from Jatropha seeds was tested by SGS and Wartsila of Finland and found out that its calorific value is comparable to bunker fuel (see Table 4.3).

Table 4.1 ITDI Test Results

Yield of Jatropha oil from seeds	31%
Yield of Jatropha methyl ester from seeds	23%
Yield of JME from oil	85%

Table 4.2 Jatropha Methyl Ester vs. EN14214 Characteristics

Test/Analysis	B100 EN 14214	Jatropha ME
Flash point (PM), °C	120	131
Sediments and water, % volume	0.05	<0.05
Kinematic Viscosity at 40°C, cst	3.3 – 5.0	4.59
Sulfated Ash, % mass	0.02	0.002
Sulfur, % mass	0.01	0.02
Copper Strip Corrosion, 3 hrs. at 50 °C	Class 1	Class 1a
Cetane Number	51	64

Table 4.3 Jatropha Crude Oil vs. Bunker Fuel

Properties	Bunker Fuel	Jatropha Crude Oil
Viscosity, cSt @ 50°C	< 220 (pref. 180)	19.33
Water, % vol	< 1.0	0.2
Sulfur, % mass	< 3 preferably	0.0154
Ash, % mass	<0.05	0.098
Conradson Carbon Residue, % mass	< 12	0.75
Asphaltenes, % mass	< 8	0.16
Flash point (PMCC), °C	> 60	100
Pour point, °C	< 30	20
Total Sediments Potential, % mass	< 0.1	0.02
Lower Heating Value, Btu/lb	**> 17,250**	**17,132**

At the center of the efforts of the corporation is the "Lupang Hinirang" program which intends to lease these lands to the highest bidder for 25 years and renewable for another 25 years for the purpose of an agreed development plan. Lessee will be granted a tenurial instrument called Economic Productivity out of Idle Lands (EPIL). Three packages were made available listed as follows:

- Family Farm

  Limited to 1 to 10 ha and is open to individuals. Reserve and minimum amount of development is PhP500.00 and PhP1,000.00 per hectare respectively.

- SME Farm

  Lands up to 500 ha and is open to corporations, partnerships, single proprietorships, cooperatives and non-government organizations. Reserve and minimum amount of development is PhP500.00 and PhP5,000.00 per hectare respectively. Bid bond required is computed at 10% of the bid price. Performance bond is required which is computed as 30% of the proposed cost of development.

- Industrial Farm

  Lands over 500 ha and is open to local and foreign corporations. Lands up to 500 ha and is open to corporations, partnerships, single proprietorships, cooperatives and non-government organizations.

Reserve and minimum amount of development is PhP500.00 and P10,000.00 per hectare respectively. Bid bond is required and computed as 10% of the bid price. Performance bond is required and computed as 30% of the proposed cost of development.

This program is expected to facilitate the establishment of Jatropha plantations in the country. The following land areas have been lined up for bidding in the near future:

Table 4.4 Jatropha Plantations in the Country

Negros Oriental	14,178 ha
Anitpolo, Rizal	1,424 ha
Albay	1,063 ha
Region 1	13,150 ha
Region 2	14,911 ha
Region 10	50,000 ha
Region 11	16,412 ha
Region 12	15,000 ha

Recently, the LGU province of Camarines Sur has offered to PHILForest 7,575 ha of idle land for Jatropha plantation. The corporation provided two (2) tons of seeds as project counterpart. In addition, 25 ha of land owned by the Manila Solid Group in Brgy. Sto. Toribio in Lipa City, Batangas was transformed as a research and demo site.

4.2

PNOC-Alternative Fuel Corporation (PAFC)

The Jatropha Roadmap

Abstract

The PNOC Jatropha Roadmap is presented which involves mega nursery programs, plantations development and setting up of biodiesel plants in various locations in the country. It is designed to produce 1 million tons of Jatropha based biodiesel from 2009-2011. Mega nursery sites being eyed include one area in Luzon and three other areas in Mindanao. Selected military reservations, penal colonies, private and ancestral lands and government lands have been identified to provide a total of 700,000 hectare of Jatropha plantations. Biodiesel processing is planned to be implemented in the PNOC-AFC Industrial Park, Phivision Industrial Estate, Nasipit Economic Zone and in General Santos.

This paper was written based on the power point presentation of Mr. Clovis T. Tupas of the Philippine National Oil Company – Alternative Fuel Corporation (PNOC-AFC) Philippine National Oil Company – Alternative Fuels Corporation (PNOC-AFC), formerly PNOC-Petrochemical Development Corporation was established in 1992. It is a government-owned and controlled corporation re-mandated through presidential directive and officially registered with the Securities and Exchange Commission on June

13, 2006. It is a wholly owned subsidiary of the state-owned Philippine National Oil Company with the mandate to:

- Explore, develop and accelerate the utilization and commercialization of and carry on the business of alternative fuels and other related activities; and
- Engage in and carry on the business of petrochemicals in any and/or all its activities.

It is one of the major proponents of the Jatropha Biodiesel Project consisting of setting-up of MEGA nurseries, plantations and biodiesel plants all over the country (see Figure 4.3).

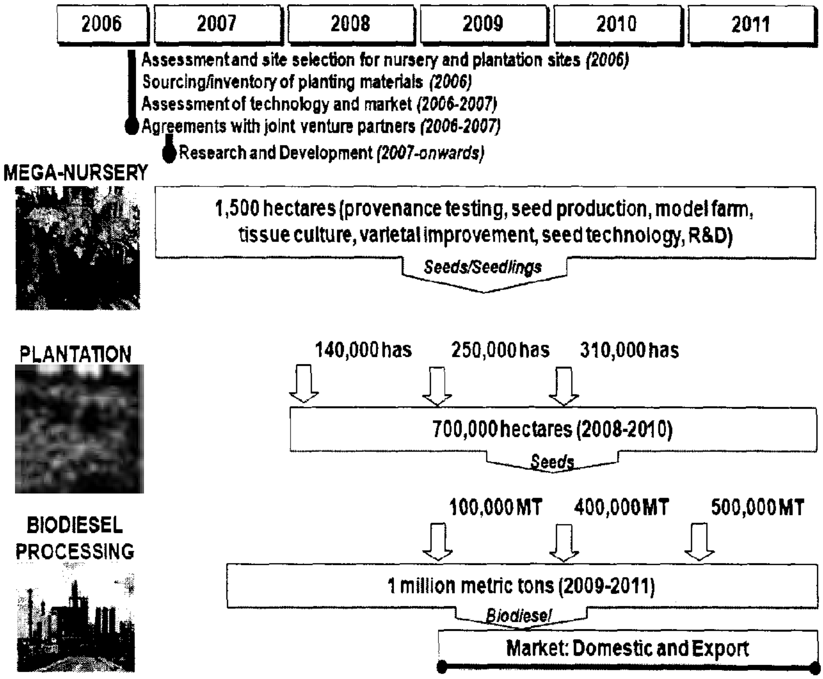


Figure 4.3 Jatropha Biodiesel Roadmap

The Philippines has sufficient arable lands and favorable climatic conditions for growing Jatropha providing an estimated 4 million hectares of land for captive plantation and 1 million hectares for hedge plantation. It also provides 15 million hectares of forest areas and more than 5 million of which have been denuded or logged. Distributed rainfall is also available throughout the year particularly in the Southern Philippines.

Currently, the project has already established and developed Jatropha mega nurseries and model plantations in Fort Magsaysay in Nueva Ecija with 300 ha and other military reservation areas. In addition, it has also established similar facilities in a 500-hectare ancestral land in Cagayan De Oro. A number of mega nurseries have been set-up in private lands churning up 6 million seedlings per hectare per year.

4.3

PCARRD

Progress on Jatropha R & D

Abstract

The presentation provides an overview of the benefits and issues related to Jatropha as a biofuel feedstock and plans and efforts to facilitate its commercial adoption. The major advantage of Jatropha over other biofuel feedstock is the absence of the "food versus fuel" issues. Its supply however would still have to ensure posing a major issue to its wide scale adoption. A roadmap have been established to produce 1 million tons of Jatropha based Bio-diesel from 2009-2011. The plan includes the implementation of an integrated research program on Jatropha funded by PNOC, DOST and CHED covering areas from germplasm management to processing technology and machinery development.

This paper was written based on the power point presentation of Dr. Patricion S. Faylon of the Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD), Department of Science and Technology.

The concept of Biofuels is not a new. One of its roots maybe traced from the father of automobile, Henry Ford in 1925. It has received significant attention in recent years due to global warming, energy security and other environmental fossil fuel issues. It is also expected to provide additional livelihood to farmers. However, it is also faced with a number of issues. If feedstock sources will compete with food production, there will be a shift in demand curve for food and income. It could also lead to food insecurity. Biofuel subsidies can increase demand for biofuel feedstock which may further increase food prices. The technical upside and downside of using Bio-diesels are provided in Table 4.4.

Table 4.4 Positive and negative impacts of Bio-diesel

Positive Impacts	Negative Impacts
• Biodiesel can also be used as a home heating oil. Because biodiesel is produced from natural sources, it generally releases as much carbon dioxide as it uses growing. • When blended with standard transportation diesel, biodiesel helps to extend the energy capacity of the diesel. • A blend of 20 percent biodiesel will reduce carbon dioxide (CO_2) emissions by 15 percent, and adding biodiesel also reduces the amount of particulates (PM), carbon monoxide (CO), and sulfur dioxide (SO_2) released as emissions. • If biodiesel spills, it is biodegradable and breaks down roughly four times faster than petroleum diesel.	• Use of biodiesel results in increased levels of harmful nitrogen oxide (NO_x) emissions when used in diesel engines, although not usually in residential heating equipment. • Also, in and of itself biodiesel releases the same amount of hydrocarbon (or soluble carbon) emissions when burned as regular diesel.

Efforts in other countries have mostly focused on food crop based feedstock. Germany, Francc and Italy strongly consider rapeseed as their major biofuel source. The United States have been using soybeans while palm oil

dominates the biofuel industry of Malaysia and Indonesia. Brazil and Argentina is strongly looking at soybeans as a biofuel feedstock for the future. In recognition of the possible food versus fuel implications, India has focused its attention on Jatropha.

In the country, biofuel efforts received a boost with the approval of the Biofuels Act of 2007 where Jatropha is expected to play a significant role. Large scale Jatropha plantations however would have to be limited only to idle lands so as not to affect food production. Possible land for such purpose is yet to be fully identified and an agronomic research is needed.

An Integrated Biodiesel Project has been launched which seeks to establish Jatropha mega nurseries, plantations and processing plants in various parts of the country specifics of which are provided in Figure 4.4.

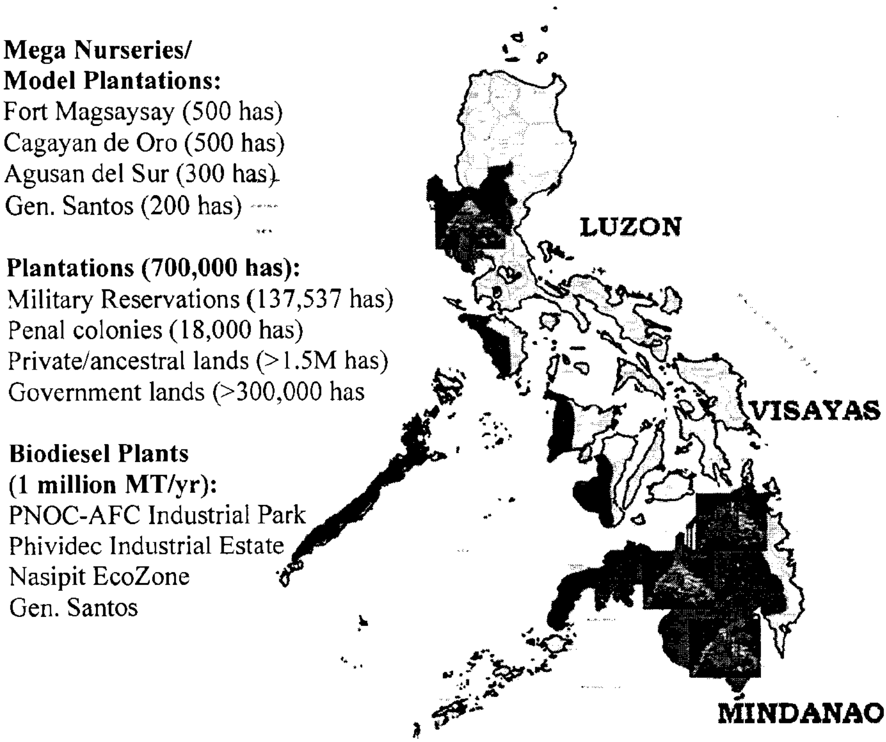


Figure 4.4 Jatropha Development Sites

The project is supported by a research and development component funded by PNOC-AFC. To this date, PhP15 M has been released to fund the first year of the 3-year R&D program on the following areas:

- Germplasm Management, Varietal Improvement and Seed Technology R&D for Physic Nut;
- Development of Component Technologies for Jatropha in Various Production Systems; and

- Process Development for enzymatic Biodiesel Production and By-product Utilization.

The Jatropha species geographic distribution map in the Philippines is provided in Figure 4.5 while the oil content of Jatropha sourced from the various regions and species in the country are provided in Tables 4.5 and 4.6.

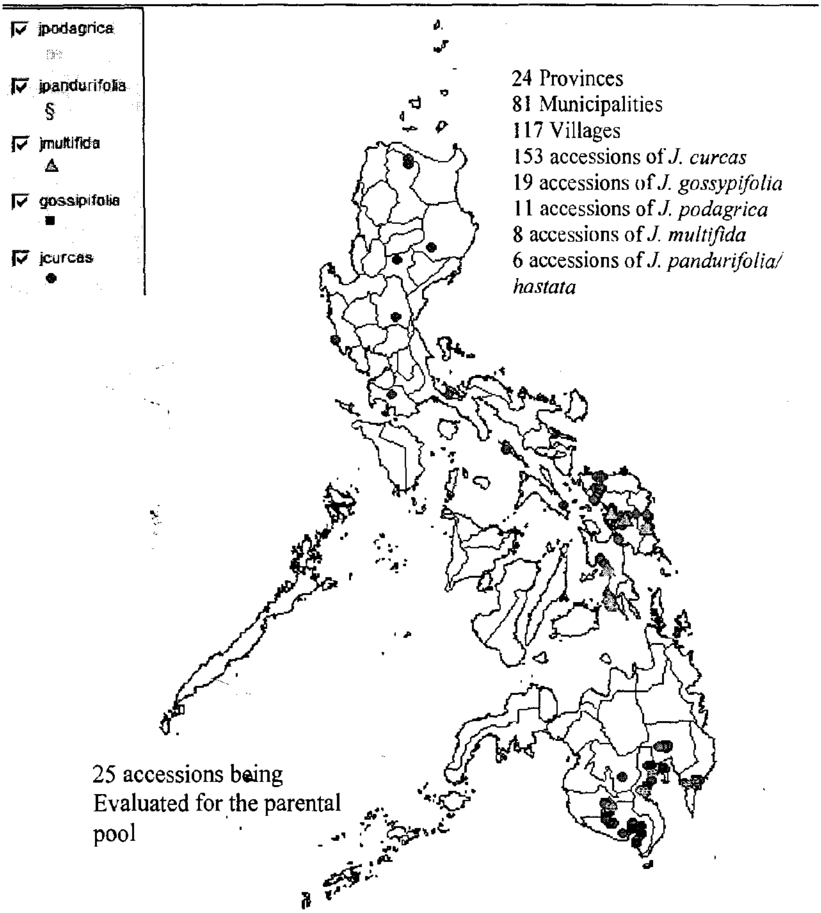


Figure 4.5 Philippine Jatropha Species Geographic Distribution Map

Table 4.5 Oil Content from Jatropha from Different Sources in the Philippines

	% Oil content	
	Hydraulic Press Extraction	**Soxhlet Extraction**
Region 1: Ilocos Norte	11.94	21.45
Region 2: Cagayan	8.32	28.02
Region 4: Oriental Mindoro Occidental Mindoro	11.30	33.03
Palawan	16.85	36.63
Marinduque	14.49	28.36
Region 7:	3.00	21.28
Region 9: Zamboanga City	-	19.26
Region 10: Cagayan de Oro	10.92	32.96
Region 11: Davao	11.70	31.66
Region 12: General Santos	19.00	34.27
Region CAR: Benguet	4.06	20.98
Region CARAGA: Agusan del Norte	-	35.31
Region CARAGA: Surigao del sur	9.39	30.87
Region CARAGA: Agusan del Sur	10.08	32.10

Source: ITDI-DOST Terminal Report: Determination of Fixed Oil Content Of *Jatropha Curcas* Seed Grown/Produced in Various Regions of the Country and the Physico-Chemical Properties of the Oil Extracted.

Extensive experimental study on tissue culture of Jatropha is ongoing and the response of Jatropha curcas nodes excised from germinated seedlings treated with different cytokinins on MS (Murashige and Skoog) basal medium.

Another R&D component of the integrated project is supported through the DOST-GIA program which has allotted PhP5.8 M to fund the first year of the two research projects. The total cost for the two year program is PhP14 M. Research components supported includes:

- Development of farming system models integrating *Jatropha curcas* in various production systems; and
- Development of post-production machinery for *Jatropha curcas* seeds.

Table 4.6 Oil Content in Different Crops

S. No.	CROP	Scientific name	Kg Oil/ha	Liters Oil/ha
1.	Corn (Maize)	*Zea mays L.*	145	172
2.	Cashew nut	*Anacardium occidentale L.*	148	176
3.	Oats	*Avena sativa L.*	183	217
4.	Lupine	*Lupinous L.*	195	232
5.	Cotton	*Gossypium sp. L*	272	325
6.	Soybean	*Glycine max L.*	375	446
7.	Linssed (Flax)	*Linum usitatissimum L.*	402	478
8.	Coriander	*Coriandrum*	450	536
9.	Mustard	*Brassica juncea L.*	481	572
10.	Sesame	*Sesamum indicum L.*	585	696
11.	Safflower	*Carthamus inctorius L.*	655	779
12.	Rice	*Oryza sativa L.*	696	828
13.	Sunflower	*Helianthus annuus L.*	800	952
14.	Peanuts	*Arachis hypogea L.*	890	1059
15.	Rapeseed	*Brassica campestris L.*	1000	1190
16.	Castor Beans	*Ricinus aommunis L.*	1188	1413
17.	Jojobs	*Simondsia chinensis L.*	1528	1818
18.	Jatropha	*Jatropha curcas L.*	1590	1892
19.	Coconut	*Coccus nucifera L.*	2260	2689
20.	Oil Palm	*Elaeis guineeis jacq.*	5000	5950

Another component of the program is supported by the Commission on Higher Education (CHED) through the different State Universities and Colleges (SUCs) amounting to PhP50 M. This involves the following:

- Central Nursery Operations
  Nurseries are established in 17 participating SUCs to consistently supply Jatropha plantations with seeds, seedlings and cuttings (see Figure 4.6);

- Plantation Development-cum-Germplasm Collection
  Involves at least 10 ha of land are planted with Jatropha per SUC or 153.3 ha in total. In addition, 746 hectares of land are available from private and corporate farms for plantation. As of June of 2007, the available seedlings are 571,074.

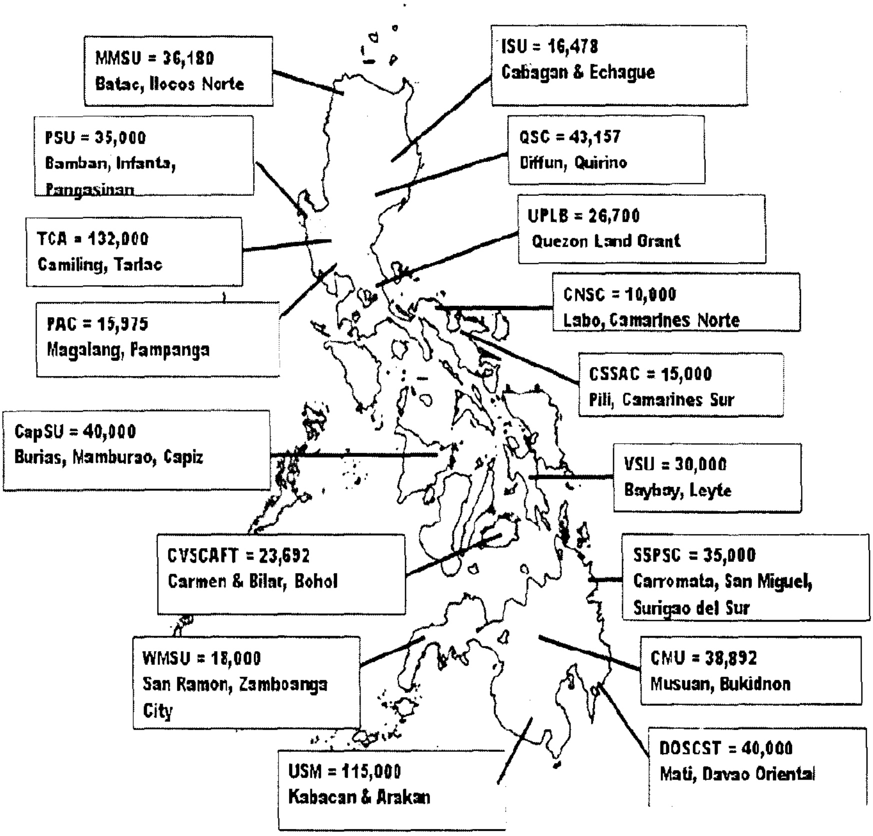


Figure 4.6 Geographic distribution of available seedling in the country

To this date, the best known variety of Jatropha is *Jatropha curcas* for biodiesel production. However, part of the component of the R&D Program is the selection and breeding of the ideal plant type of *Jatropha curcas*. The ideal breed should have the following properties:

- Short nodes
- More branching
- Continuous flowering
- Medium seed size
- High fertility capsule
- High oil content with resistance to biotic and abiotic stresses.

The program has already yielded a number of findings in the following areas:

- Pruning and Canopy Management
  The pinching of terminals is essential at six months age to induce laterals. Pruning at 30cm height is ideal. Likewise, the secondary and tertiary branches should be pruned at the end of first year to induce minimum of 25 branches and 35-40 branches at the end of second year. Periodical pruning can be carried out depending upon the vegetative growth of the plants.

- Mycorrhiza and Jatropha
  As Jatropha is itself a very hardy plant and with its known naturally existing association with mycorrhiza fungi, this combination of mycorrhiza and Jatropha will not only give higher yields of seed but will also give higher vegetative biomass. Since most of the Jatropha plantation is expected to come on marginal land, the use of mycorrhiza would be an essential component for production. The use of mychorrhiza would provide the following advantages: (1) make available nutrients from marginal soils, (2) increase water use efficiency, (3) disease protection, (4) reduced chemical fertilizer needs and (5) utilize organically bound minerals.

- Pests and Diseases
  Jatropha pests have been identified including white flies, mealy bugs, spider mites, leaf hoppers, black leaf hoppers, several species of tree hoppers, scale insects, scutellerid bugs, bug worms, leaf roller, measuring caterpillar and scarring beetle. The identified diseases of the Jatropha plant include leaf spot caused by *cercospora sp.*, leaf blight caused by *Melminthoporium sp.*, fruit rot caused by *Fusarium monilifrome.*

- Sex Switching and Drying of Flowers
  During summer days when temperature rises above 42 °C, the inflorescence which normally exhibits protandry turns to bit protogyny. This is due to the anticipation of strong signal transduction such that switching of sex occurs. The losses due to this phenomenon and adaptation measures are being taken up.

To summarize, biodiesel is produced from Jatropha planted in marginal lands. Results from SE Asian countries indicated that Jatropha is competitive as feedstock. We are still on the R&D phase of development, thus we cannot compare our viability. As a tropical country, we are confident that our yield/ha (under same level of management) will be higher than the countries from South Asia. The viability of existing commercial plantations linked with small-hold farms must be assessed and improved for viable feedstock production. We need to develop the supply/value chain providers based on indigenous technologies. Elite germplasm conservation and use must be pursued. To develop high yielding Jatropha clones is essential. Plantation management to achieve optimum yields including pests and diseases management schemes must be developed. The suitable intercrops to provide better returns to farmer must be identified. Developing decentralized oil extraction units at village level must be set up. Unbiased information on the life cycle performance and economics of Jatropha technologies, and their impact on food security and poverty must be conducted.

4.4

Jatropha R & D
The Role of Academia

Abstract

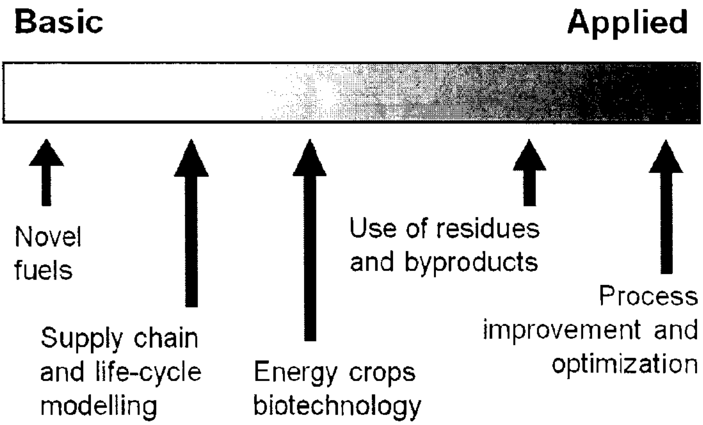
It is essential to maintain continued research on bioenergy to sustain a healthy diversity of scientific developments on biofuels and bioenergy. Such R&D can continue alongside the growing commercial production of biofuels. Continuous R&D provides a foundation for future innovation and long-term competitiveness and sustainability.

This was abstracted from the reactor, Dr. Raymond R. Tan of the Center for Engineering and Sustainable Development Research (CESDR) of De La Salle University-Manila.

Future research as illustrated in Figure 4.6 can investigate on the robustness of the biofuel supply chain; develop technology on reaching the ultimate production ceiling; utilization of residues and byproducts; use of genetically modified (GM) crops; use of novel biofuels such as dimethyl furan (DMF) or biobutanol; process improvement and optimization such as exploration of thermochemical conversion.

To achieve these advancements, the research community and academe must continue to explore interesting R&D questions even as commercial biofuel use grows and must stay abreast with relevant global and local issues. It is the position of the academe to be the interface with industry, government and the public and to provide a critical, unbiased and long-term view.

Figure 4.6 Bioenergy research spectrum



5

Summary

By Alvin B. Culaba, PhD

The event's objective was to get an accurate picture of the real state of jatropha development and its use as a biofuel and its place in the country's value chain. Academician Emil Javier pointed early on that the case of Jatropha is a challenge for scientists and engineers as the policy preceded the technology. Undersecretary Mariano Salazar of the Department of Energy (DOE) emphasized the key towards achieving our goals is to support each other in this endeavor. It is about matching our resources with our needs and being passionate with our goals in order to move forward.

The first presentation "From Farm to Tank Experiences" was done by Mr. Celso Diaz from the Philippine Forest Corporation. It discussed the programs of PFC on the development of jatropha for biofuel. PFC has the mission to create economic productivity out of idle lands and DENR allocated 375,000 hectares for agroforestry projects. Aside from utilizing their own plantation development, the *Lupang Hinirang* Program will be auctioning the land to interested investors. Other programs include a demo jatropha plantation with the Philippine Army at Fort Magsaysay, joint Biofuel Research Project with CHED through its 17 State Universities and Colleges (SUCs), who already established at least 10 hectares of Jatropha plantation which will be the source of planting materials for the nearby communities. To date, PFC continues to purchase jatropha seeds for plantation and research efforts. A laboratory research with DOST showed that JME properties were able to meet the biodiesel standards based on the American and European Union.

Dr. Faylon of PCARRD – DOST highlighted the focus on R&D on this phase of the Jatropha Biodiesel Road Map. PNOC-AFC funded an integrated R&D program intends to develop the following systems: (1)

Germplasm Management, Varietal Improvement and Seed Technology R&D; (2) GIS-Aided Suitability Assessment for Commercial Production; (3) Component Technologies for Jatropha in Various Production Systems; (4) Production Systems Models in Agricultural and Agroforestry Systems; (5) Environmental Impact Assessment of the integration of Jatropha curcas in Various Production Systems; (6) Post-Production Management Systems; (7) Process and Equipment Development for the Production of Esterified Jatropha curcas oil; and (8) Developing Mechanism for Community-based production. Preliminary research outputs suggest that the potential yield per hectare of jatropha plantation in the Philippines could be much higher than those found in South Asia. In addition to this Dr. Faylon remarked that further research must focus on (1) looking into the viability of existing commercial farms which are linked to smallholds, (2) developing the supply/value chain providers based on indigenous technologies, (3) improving plantation management in order to optimize yield, (4) identifying suitable intercropping which would benefit farmers and (5) generating and providing unbiased information on the life cycle performance and economics of jatropha technologies and their impact on food security and poverty.

Ms. Merle Villanueva of ITDI-DOST, provided the information on their experience with CME and its related concerns with JME. These include concerns on pricing, toxicity of by-products, fatty acid composition and stability. Future research should consider the viability of blending CME and JME in order to obtain the ideal characteristics and minimize limitations.

The success of this program not only rests on the government and private investors - the academia also plays a major role. Engr. Philip Argamoza of Technological University of the Philippines (TUP) shared their involvement and contribution to the program. Their projects include the manufacturing and fabrication of manually operated equipment for extraction of jatropha oil, production of JME, looking into other applications of Jathropha oil and engine performance testing once JME passes the PNS standards.

Dr. Raymond Tan of CESDR-DLSU emphasizes the role of the academia in this endeavor. Again research and development is the key element. There must be a continuous effort in R&D to provide a foundation for future innovation and long-term competitiveness and sustainability in the area of bioenergy. Future research could look into things such as the robustness of biofuel supply chains, utilization of residues and by-products, and the use of novel biofuels such as dimethyl furan or biobutanol. To achieve this, we must continuously be interested in research and development, be abreast of relevant global and local issues, interface with industry, government and the public and provide critical, unbiased and a long term view.

Given this, it is obvious that various sectors of the economy are interested in the Biodiesel program and are doing their part towards its eventual realization. Jatropha plantation has been going on for 2 years now and seedlings are available for cultivation, testing on the properties of jatropha has been conducted and preliminary results are promising. In this forum we have also identified the current state of all our efforts and have provided direction towards future research and development as well as identified our roles in this program. What we really need to do now is to organize our efforts and create a centralized repository of information. It was suggested that a website may be created containing relevant material in order to disseminate information, promote awareness and answer some frequently asked questions. Usec. Dela Peña suggests that a matrix containing all institutions and groups alongside with their responsibilities and current developments be prepared.

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Administrative Assistant

Ms. Jhona S. Camba

ANNEX

PROGRAMME

8:30 a.m.	Registration	
9:00 a.m.	National Anthem	
	Welcome Remarks	**Acd. Ceferino L. Follosco** *Adviser, Biofuels Cluster and Chair, NAST-ESTD*
	Opening Remarks	**Usec. Mariano S. Salazar** *Undersecretary, Department of Energy*
	Rationale and Mechanics	**Usec. Fortunato T. Dela Peña** *Undersecretary* *Department of Science and Technology*
	Paper Presentation	
9:40 a.m.	Farm to Tank Experiences	**Engr. Rodolfo Noel Lozada** *President, Philippine Forest Corporation*
10:10 a.m.	Reaction from Panelists	**Dr. Patricio S. Faylon** *Executive Director, PCARRD-DOST*
		Ms. Merle A. Villanueva *Chief, Minerals and Chemicals Division, ITDI-DOST*
10:30 a.m.	Open Forum	
11:00 a.m.	Jatropha Biodiesel Roadmap	**Mr. Clovis T. Tupas** *General Manager, PNOC-AFC*
11:30 a.m.	Reaction from Panelist	**Engr. Felipe Ronald A. Argamoza** *Professor and Research Director – TUP*
		Dr. Raymond R. Tan *Senior Research Scientist, CESDR-DLSU*
11:50 a.m.	Open Forum	
12:00 p.m.	Lunch	
1:30 p.m.	Synthesis	**Dr. Alvin B. Culaba** *Co-Chair, Biofuels Cluster and Chair, NRCP Engineering Division*
2:00 pm.	Closing Remarks	**Usec. Fortunato T. Dela Peña** *Undersecretary* *Department of Science and Technology*

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