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JATROPHA IN SOUTH EAST ASIA

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ABSTRACT

Due to the demands of differing soil conditions, Jatropha is found to survive in different locations that bio-fuel forumers in South East Asia prefer to differentiate the location by referring to it as the Jatropha belt or Oil Palm belt areas. Jatropha oil is favoured to palm oil for its cold filter plugging point (CFPP) value, making it a better option for use in cold climates. As economies of scale of Jatropha development will alter the environmental impacts in a given area, there is more likelihood of small-scale projects on marginal lands being more sustainable. Benefits of Jatropha have been debated informally within the agricultural fraternity and plantation forums in recent years.

1.0 Introduction

Large-scale energy crop production requires large land areas that could lead to changes in agricultural land use patterns. Energy crop production competes for land uses that are meant for food production, forestry or environmental protection and nature conservation and with this in mind, this paper provides an overview on the possibilities and consequences of using agricultural land in a country or region for commercializing Jatropha planting. Jatropha belongs to a large family, Euphorbiaceous, and the Jatropha genus includes about 175 different plants (Lakoh & Peterson, 2008). Jatropha-Curcas is a perennial sub-tropical shrub that produces oil-rich seeds. Jatropha is unique in that it thrives on semi-arid regions (La Koh & Peterson, 2008), is highly adaptable and requires limited nutrient (Jones and Csurhes, 2008). The oil from the Jatropha plant can be used to run a diesel engine (De Oliviera *et al*, 2009) and fuel a lamp (Mühlbauer *et al*, 1998; Jakarta Post, 2006). The plant itself can improve soil quality to be used for other crops in the future (Kumar and Sharma, 2008). While usage is still at nascent stage, numerous reports had indicated that Jatropha can be a multi-purpose plant and its full potential is far from being realized.

2.0 The Problem: Food versus Fuel Issue

Large-scale agricultural industry is responsible for the conversion of more than 95% of the world biodiesel using edible oils (Gui *et al*, 2008). An example is the use of palm oil for conversion into biodiesel. However, continuous and large-scale production of biodiesel from edible oil is not a sustainable option given the food insecurity in developing countries and regions that consistently experience food shortages or rely on food imports (Cassman & Liska, 2007). The call for efficient conversion of soil and fossil energy to produce more food crops for use as biofuel raises further ethical concerns in the form of food shortages to billions of human population. Growing crops to provide fuel squanders food resources so a possible solution is to use non-edible oil source for conversion into 'near-term alternatives to fossil fuels' such as liquid fuels (bioethanol) derived from oil palm biomass and Jatropha (biofuel, methyl ester) respectively. This paper delves into Jatropha to determine its suitability as a biofuel feedstock without the need to displace food supply.

3.0 Methodology

Development of this paper was formulated around the following areas that guide the basis of research:

- Reasons for choosing Jatropha as a crop
- Land use pattern
- Soil, water and climate conditions

This paper is broken up into three phases. The first phase covers a review of the literature, business reports and available resources on the biofuel environment. This is followed by short interviews of local producers and entrepreneurs for an insight into Jatropha processing. Subsequently, environmental issues of these non-edible plants are used for a discussion of whether it can be viably promoted for biofuel production without displacing agricultural land.

4.0 What is Jatropha?

Jatropha is native specie in northeastern South America but now abundantly found throughout tropical and subtropical regions like Africa and Asia (Jongschaap *et. al*, 2007). Jatropha is derived from the Greek word 'Jatros' means 'Doctor' and 'Trophe' mean 'food' (Kumar and Sharma, 2008). Known as *ratanjyot* and *Pongamia pinnata* in India with over 11 million ha under cultivation (Srinivasan, 2009), it is a diverse genus comprising shrubs, rhizomatous, subshrubs and herbs and botanically known as Euphorbiaceous, that includes about 175 different plants (Lakoh & Peterson, 2008). In South East Asia, Jatropha is locally called as *jarak pagar* in Malaysia (Salimon, 2008), *tubang-bakod* (Tagalog); *tuba-tuba*, **kasla** (Visayas) in Philippines (Perino, 2006), *sabuda*m (Thailand); *lohong* (Cambodia); while Indonesia has 10 different kinds of Jatropha plants namely *jarak budeg*, *nawaih nawas* (Aceh); *jarak kosta* (Sunda); *jarak gundul*, *jarak cina*, *jarak pagar* (Java); *paku kare* (Timor); and *peleng kaliki* (Bugis) (Jones and Csurhes, 2008; Jakarta Post, 2006). It is also known as physic nut (Jones and Csurhes, 2008) and is usually grown as a hedge plant. Jatropha is a succulent tree that sheds its leaves during the dry season (Salimon, 2008; Kumar and Sharma, 2008).

Jatropha is a perennial sub-tropical shrub that produces oil-rich seeds yet unique in that it thrives on semi-arid regions (La Koh & Peterson, 2008) and highly adaptable with limited nutrients (Jones and Csurhes, 2008; Salimon, 2008). Not only is it a hardy plant but also a valuable multi-purpose crop to alleviate soil degradation, desertification and deforestation (Kheira and Attan, 2008). The Jatropha tree can easily be propagated by cutting, is widely planted as a hedge to protect a field's erosion as it is not browsed by cattle (Salimon, 2008). Jatropha's unique ecological features is that it can grow even on gravely, sandy and saline soils with minimal efforts (Gui *et al*, 2008) and be sustained with minimal irrigation without yearly re-planting as it has a life cycle of 30–50 years.

5.0 Tree Description

Jatropha is a deciduous large shrub or small tree of 3 to 5m in height but under favourable conditions it can attain a height of 8 to 10m (Kumar and Sharma, 2008: Jatroleum Bioenergy). The tree has a smooth grey bark and when cut, the stems exude a whitish coloured watery latex but become brittle and brown when dry (Jones and Csurches, 2008). Its leaves are green to pale-green with a length of about 6cm and width of about 15cm

(Henning, 2004), 3 to 7 lobes with a spiral phyllotaxis, hypostomatic and stomata are of paracytic (Rubiaceous) type (Kumar and Sharma, 2008; Jatroleum Bioenergy). Insects, ants, thrips, flies and bees pollinate and to forme the flowers terminally and individually (Jones and Csurches, 2008). The petiole length is between 6 to 23 mm. Inflorescence forms in the leaf axil and yields approximately 10 or more ovoid fruits. During hot seasons, the female flower grows slightly larger and when there is an imbalance of pistillate or staminate, it produces a higher number of female flowers (Kumar and Sharma, 2008; Jatroleum Bioenergy). Fruits are produced several times during the year and production range may be also attributable to low and high rainfall areas as well as soil fertility (Jatroleum Bioenergy). A three, bivalved cocci is formed after the seed matures and the fleshy exocarp dries (Kumar and Sharma, 2008). Once ripen for picking, the capsule changes from green to yellow in 2 to 4 months (Jatroleum Bioenergy). The inner seeds are black and weigh about 727gm per 1000 seeds but averagely there are 1375 seeds/kg (Kumar and Sharma, 2008).

6.0 Planting and Growing Jatropha

Jatropha can be grown in drought tolerant, areas of low rainfall with a precipitation between 200mm to 500mm per year, on low-fertility marginal, degraded, fallow, waste land (Gonsalves, 2006; Kheira, 2008; Rabe, 2006). It can be used to reclaim eroded areas, grown as a boundary fence or live hedge in the arid and semi-arid areas (Gonsalves, 2006; Kheira, 2008). It can be grown along canals, roads and railway tracks, on borders of farmers' fields as a boundary fence/hedge in the arid/semi-arid areas and even on alkaline soils. Jatropha also responds to higher rainfall (up to 1200mm) particularly in hot climatic conditions such as prevailing in Nicaragua and Tanzania as well as in the tropical and sub-tropical heat and has proven to do well even in lower temperatures with light frost (Kheira, 2008). Jatropha water requirements is extremely low and handles dryness over long periods by living almost entirely off humidity in the air by shielding most of its leaves to reduce transpiration loss (Kheira, 2008). Commercially, Jatropha is easy to establish in nurseries, grows relatively quickly and is hardy particularly on well-drained soils of ph from 6 to 9 with good aeration. A plant with good characteristics needs uniform maturity that is consistent in flowering and fruiting. Jatropha seeds are easy to harvest as the plant is not very tall and are best plucked before the tropical rainy season. Jatropha is not known to be browsed by animals making it easy for larger scale management (Gonsalves, 2006; Henning, 2004). There are limited data available on seed or oil yields of Jatropha because of limited scientific work published in peer-reviewed journals. Yields vary on location, such as 1 to 2 tonnes per hectare in the first year and can go up to 10 tonnes in the fifth year (Peterson, 2008). There is talk that yields can reach 30 tonnes per hectare but that is not proven yet as ccommercial development is still at a nascent stage so there are big variations of estimates of oil yield in terms of land area ranging from a high of 2.4 tons/hectare to 1.6 tons/hectare during shorter growing seasons and/or rainfall (Kindred *et al*, 2008). For cultivation in tropical and subtropical countries, a typical oil yield is 33% (Peterson, 2008). Gonsalves (2006) suggesting that the oil yield per hectare for Jatropha is among the highest for tree-borne oil seeds with seed production ranging from about 0.4 tons per hectare per year to over 12 tons/hectare. Assuming a typical seed production of 3.75 tons/hectare with an oil yield of 30-35%, it generates a net oil yield of 1.2 tons/hectare. The Malaysian Superbulk breed is reported to produce a consistently good crop with strong yield potential (Mail, 2009). Rainfall has a direct influence on the seed yield. Kheira (2008) reported that Jatropha's optimum rainfall is between 600mm to 800mm. Rabe (2006) asserted that African plantations with 600mm rainfall per year have a seed yield of 5 tons per hectare while in some areas of India with a rainfall of 1380 mm produce good crop yields (Kheira, 2008). In Tanzania, seed with 18mm in length and 10mm width, per kg in weight corresponds to 1375 seedlings so a yield of 5 tons per hectare translates to 7 millions seedlings (Rabe, 2006). Jatropha can live up to 50 years and yield for about 30 years (Peterson, 2008). A good overview of Jatropha yield under various scenario of planting by Kindred (2008) provide us a good understanding for new and existing plantations as listed in Figure 1 below.

Figure 1: Estimated Jatropha Yield Curves 2008-2020 (Adopted from Kindred *et. al*, 2008, p.39)

Oil yield (kg oil/hectare)				
Year	**New plantations [1]**	**New plantations 1**	**Existing plantations [2]**	**Existing plantations 2**
	High yield potential [3]	**Standard yield potential [4]**	**High yield potential [5], 3**	**Standard yield potential 4**
2008	500	200	2400	1500
2009	1500	700	2410	1505
2010	2000	1300	2420	1510
2011	2300	1500	2430	1515
2012	2400	1520	2440	1520
2013	2500	1540	2450	1525
2014	2520	1550	2460	1530
2015	2540	1560	2470	1535
2016	2560	1570	2480	1540
2017	2580	1580	2490	1545
2018	2600	1590	2500	1550
2019	2620	1600	2510	1555
2020	2640	1610	2520	1560
	[6]	6	6	6

Salimon and Abdullah (2008) conducted a test on the physicochemical properties of Malaysian wild Jatropha seed oil and found it suitable for biodiesel production based on the component analysis (weight %) as found in Figures 2a,b & c.

Figure 2a: Component Analysis of Malaysian Wild Jatropha Seed Oil (Source: Salimon & Abdullah, 2008)

Component	**Weight %**
Moisture	6.2%,
Protein	18%,
Fat	38%,
Carbohydrate	17%,
Fibre	15.5%
Ash	5.3%.
Tri-glycerides of oleic acid	34-45%
Linoleic acid	31-43%
Palmitic acid	14-15%

Figure 2b: Physicochemical Characteristic of Malaysian and Nigeria J. Seed Oil (Source: Salimon & Abdullah, 2008, p.380)

Parameter	**Value Malaysia**	**Value Nigeria**
Iodine Value (mg/g)	35.85 ±1.44	105.20 ±0.70
Peroxide Value	0.66 ±0.04	-
Acid Value (mg KOH/g)	1.50 ±0.07	3.50 ±0.10
Free Fatty Acid as Oleic Acid (%)	1.03 ±0.10	1.76 ±0.10
Saponification Value (mg/g)	208.50 ±0.47	198.85 ±1.40
Moisture – Oil (%)	0.02 ±0.01	-
Viscosity	36.00	17-52
Refractive index at 28oC	1.469	1.468
Color	Golden-yellow	Light yellow
Total lipid content (%)	60.45±1.44	47.25±1.34

Figure 2c: Fatty Acids Composition of Malaysian and Nigerian J. Seed Oil (Source: Salimon & Abdullah, 2008, p.381)

	Jatropha curcas L	
Fatty Acid, %	**Malaysia**	**Nigeria**
Palmitic	13.89 + 0.06	19.50 + 0.80
Palmitoleic	0.61 0.33	-
Stearic	7.16 0.36	6.80 0.60
Oleic	46.40 0.19	41.30 1.50
Linoleic	31.96 0.20	31.40 1.20
∑ Saturated Fatty Acid	21.05	26.30
∑ Unsaturated Fatty Acid	78.95	72.70

7.0 Seed Selection

In agriculture, it is common to collect seeds from superior parent stocks in search for higher yields and environmentally durable plants. A better quality of offspring plants will result if the seeds used to produce them are collected from superior individuals, stands or orchards. However, this concept has yet to be widely explored in Jatropha practice (Luhat). An error in judgment can lead to crops with poor growth or poor fruiting. To maximise yields and quality of seeds for plantations, similar principles for collecting Jatropha seeds should be observed. Seed quality is determined by many factors, principally purity and germination. In Malaysia, The Asiatic Centre for Genome Technology Experimental Station started a 22 hectare Jatropha plot at a cost of RM130 million (USD37 million) with the assistance of US-based Synthetic Genomics Inc, to carry out in-depth genomic, physiological and biochemical analysis of the Jatropha plant with the hope of developing high yield seedlings (Ooi, 2008; Raj, 2008). The Malaysian Palm Oil Board is carrying out performance tests on Jatropha biodiesel and the Malaysian Rubber Board is engaged in seed breeding while the National Tobacco Board is investigating if Jatropha can thrive on brisly soil. Regionally, the Malaysian and Indonesian government have agreed to cooperate in the development of the Jatropha industry under the ambit of renewable energy that will cover research and development (R&D) activities related to agronomic practices, breeding of quality seeds and processing technologies (Bernama, 2008).However, many other factors such as the variety and ability to bear fruits are important considerations for seed purchase and planting. The choice of seed source is one of the most important decisions undertaken by local farmers planting Jatropha (Mail, 2009; Luhat). Using a pure line of Nicaraguan quality seeds, a Malaysia's independent researcher (E. Luhat) developed a fourth generation Jatropha plant called 'Superbulk' after spending five years of plant breeding, trial planting, tree selection, tree improvement and seed orchard establishment. Superbulk is a good phenotype or elite tree suitable for East Malaysian soil that maximises yield through induced early and heavy fruiting. Currently another test plot for 200 hybrid plants of 3 to 4 months old are being cross-bred with the toxic, non-toxic and flower types under agronomical and sivicultural practices of cropping. Current experiments include a new hybrid for a dwarf variety, a shorter height that induces more female than male flowers to ensure heavy fruiting (Luhat).

In Indonesia, three methods are used for selecting high grade of seed. For example, from selected farmers' seed stocks; secondly by cross-pollination between two subspecies of the Jatropha plant, and thirdly using genetic mutation. These methods of seed selection help to reproduce plants without losing quality in terms of tissue culture, cutting and grafting plants, and cultivation (Jakarta Post, 2006). Due to poor agriculture infrastructure, the cheapest and most feasible way for Indonesia is to use the seed production method but the Indonesian agency for National Sciences and Technology Development has yet to determined which type of Jatropha seed is considered superior as there are 10 different kinds of Jatropha plants spread over the many islands (JakartaPost, 2006).

8.0 Irrigation

Jatropha needs a minimum rainfall of 500–600mm for fruiting, but relies on local ground water for up to two years to survive under severe drought conditions and re-grows when rain occurs (Kheira, 2008). As a commercial crop, weekly irrigation is preferable while a 7–15 day interval is a must to prevent wilting. Drip irrigation is not an option since as it can induce vegetative growth. Jatropha can bloom and produce fruit all year long in equatorial regions where moisture is unlimited. Kheira (2008) tried to establish a relationship between dry climate and oil yield under extreme drought in which the plant will shed leaves in an attempt to conserve moisture, thereby causing decreased growth.

9.0 Food versus Fuel

Conversion of plant starch, sugars, oils, and animal fats into an energy source that can be used in combustion engines is known as first-generation biofuels (Naylor *et al*, 2007). Dufey (2006) argued that greater demands for biofuels would lead to land being drawn away from other purposes including food production. This competition for land and water resources would lead to food shortages and higher food prices for consumers that otherwise could be used for cultivating edible crops (Clements, 2008).

In light of the earth's carrying capacity, Pimentel *et al*. (1999) had suggested humans should voluntarily limit their population growth instead of being controlled by natural resources. He reasoned that a rising global population would put the world's food systems under new stresses through increased scarcity of land and water resources. A crop must meet its fundamental need but must be compatible with both society's needs and the natural ecosystem (Giampietro and Pimentel, 1993). However, under-investment in agricultural science and technology (S&T) over the past decades exerted pressure for quick commercial alternatives to feed the world's poor (Von Braun, 2007). On the one hand, food production is still essential to the economy of all nations so the prime resources of agriculture (land, water, energy, and biological resources) function interdependently to make up for a partial shortage in one or more of the others. For example, irrigation can convert desert land into agricultural production but the lure of alternative energy in the form of Biofuels from agricultural resources is diverting poor nation's economic interest to conflicting priority in terms of food versus fuel.

Von Braun (2007) had undertaken a country assessment of 5 million people to demonstrate that large land and water resources, the same as those used for food production, determine the economic viability of biofuel production. This scenario was left unchanged since 1993 when Giampietro and Pimentel called for "renewed respect for natural systems that support agriculture and for population policies in line with the earth's ability to produce food on a sustainable basis" (p1). Back then, 'monocultures (single fast growing crop for maximum use of the land)' are the preferred means to provide high yields and returns such as corn, soya but it brought along negative environmental impacts of soil erosion, reduced biodiversity, chemical contamination through fertilizers and pesticides, and mining of groundwater. Basically, it was all about energy society, either as food for humans (endosomatic or metabolic energy) or for burning as gasoline in a tractor (exosomatic energy) (Giampietro & Pimentel, 1993). Using these as a backdrop on Von Braun (2007) assessment of arable land for biofuel production, it is quite obvious that the ratio of land balance does not support a country like Malaysia in growing a crop entirely for fuel use in contrast to Indonesia, Thailand and the Philippines.

10.0 Jatropha versus Palm Oil

Due to the demands of differing soil conditions, Jatropha and the oil palm tree are found to survive in different locations so that biofuel formers in South East Asia prefer to differentiate the location as being the Jatropha belt or the Oil Palm belt as suggested by Figures 3 & 4.

Figure 3: An Overview of Jatropha and Oil Palm Planting Belts (Source: Jongschaap *et al* (2007, p.1)

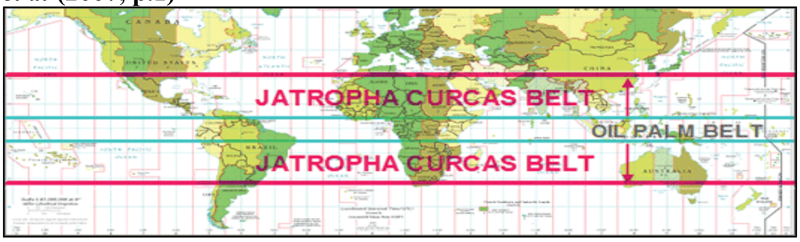

Figure 4: Oil Palm and Jatropha Compared (Source: Peterson (2008);*Yusoff (2006);Ooi (2008); #Kheira (2008);♦Jongschaap (2007); ^Poh (2003); ***Jatropha -Curcas Plantation Estimate: Including Labor Provided Land Is Cleared; 500litres of Biodiesel (USD500) + 100litres Glycerine (USD200) + 400kg Seed Cake Biomass (USD50) =USD750; 1ton = 1000litres; USD500 x 2 = USD1000**
^ RM2, 371/3.8=USD624)

	OIL PALM	JATROPHA
♦Water efficiency use	3.95-4.42 mmol CO2 mmol H2O.	3.68 and 2.52 mmol CO2mmol H2O
Flower to ripe fruiWt	18-36 mths	2-4 mths
Seedlings nursery	9-12 mths	ready to plant in 3 mths
Life span	25-30 yrs	perennial 30-40 yrs

Seedlings to ripe fruit	30-36 months	10-14 months
Collection of fruits	heavy bunches and loose fruit	light fruitlets and no loose fruit
Planting density/ha	148 palms/ha	2000-2,500 plants/ha
Density per stand*	0.0068 ha	0.25ha
Fruit/tree*, shrub#	150kg/ffb	318gm
Fruit/ha	4.2tons ^	794kg
Oil yield/ha**	4 tons	1 tons
Planting cost/ha (exclude land cost)	USD624 ^	USD1000***
Oil price/ton	USD670 (i)	USD750***
Biofuel/ton	USD1000	USD1000***
Soil conditions	Inland and mangrove	Semi arid land; ph 6-9

Jatropha is better favoured than palm oil for its cold filter plugging point (CFPP) value, making it a better option for use in cold climates (Peterson, 2008). For tropical climate, Jatropha still needs to be refined for biofuel conversion. Oil palm will lead in terms of yield and economics for commercial needs but Jatropha needs less energy and input, as much of it grows on marginal land. However, landowners tend to plant oil palm for good land (Peterson, 2007).

11.0 Jatropha in South East Asia

Regionally, Thailand and Indonesia is more into Jatropha cultivation while some reports had identified small scale cultivation in Myanmar and Laos. The Malaysian government has no immediate plan to divert national resources to Jatropha as this might disrupt the palm oil plantation equilibrium. At present, Malaysia is concentrating on increasing the yield per hectare of Crude Palm Oil due to the disadvantage of not having vast plantation land like Indonesia (Peterson 2008). Malaysia's plantation culture is keener on R & D, consequently is the last country in the South East Asian region to jump onto the Jatropha bandwagon (Peterson, 2008). Most Malaysian companies involved in Jatropha do not own plantations but are more into R & D and commercialisation of biodiesel. The plan is to grow Jatropha elsewhere like in China, India or Indonesia as these countries provide a ready potential market (Ark Bio; Khoo, 2008). Consequently, China, India, Indonesia, Cambodia and Thailand are all ahead of Malaysia right from the upstream to the downstream, even coming up with the various by-products that include soap, pig feed and medicinal drugs to treat some cancer. There is no estimate on how much Jatropha is being planted or cultivated in Sarawak but anecdotal evidence suggests the trend is accelerating (Mail, 2009).

11.1 Malaysia

Malaysia has about of 1.5 million hectares of marginal land and the take-up rate for growing Jatropha is rising albeit on a gradual curve. Going by the oil palm experience, Malaysia's expertise is more inclined towards plantation management. Malaysia cannot afford to destroy the rainforest as there is still a lot of poor land between 30 degree North and 30 degree South (Peterson, 2007). ARK Bio Sdn Bhd is the biotechnology arm of Cosmo Biofuels Sdn Bhd that focuses on the development of improved genetic material and mass propagation of planting material for Jatropha, other oil seed plants and organisms which can be utilised as feedstock for the biofuel industry. It also has collaboration with research institutes on agronomy, plant nutrition, and farm mechanization, among others. Cosmo meanwhile is engaged in establishing Jatropha plantations, biodiesel downstream processing and trading activities in the Asia Pacific region. Together with its strategic partners, Cosmo has upstream projects in Thailand, Cambodia, Vietnam, Indonesia, the Philippines and China. Jatroleum was established in 2006 with a pilot plantation in Kuala Pilah. It is also involved in a 10,000-hectare plantation in Cambodia with a non-governmental organisation to train farmers in Jatropha cultivation. In 2008, the company embarked on a pilot project of 1,000 hectares in China's eastern Fujian province, which is ready to be cultivated on a commercial basis. According to a news report, the company hopes to tap China's burgeoning biodiesel market. NSP specializes in providing plantation advisory services. The company credits its strong business growth to its distinctive management practices that stress on continuous improvement in yields. It has a team of in-house planters that conduct analysis and studies with the objective of ensuring that best practices for sustainable agriculture are adhered to. BioNas is a wholly owned by BATC Development Bhd is a stockist engaged in the trading of Jatropha seedlings and oil for bulk shipment. They assist local farmers to venture in Jatropha planting and had a guaranteed buy back price scheme of RM850 per tonne. Using Phenotype of Jatropha developed by the the Luhat Technology Institute, Passion Masters will embark on a Jatropha plantation and processing facility in the Sarawak Corridor of Renewable Energy. They had identified locations in Belawai, Jerijeh, Tanjung Manis and the Rajang area in Mukah division for cultivation of the Jatropha Superbulk variety covering 809 hectares. Jatropha Superbulk would be the main feedstock for a biofuel processing facility in Tanjung Manis. As of the first quarter of 2009, the nursery in Jerijeh will provide two million seedlings for planting (Mail, 2009; Luhat).

11.2 Indonesia

Indonesian researchers believed they have neglected the potential of Jatropha but due to rising oil prices globally in recent years, the government is looking at it again for improved use (Jakarta Post, 2006). To date, Jatropha are unsystematically cultivated by small farmers on arid land without having to irrigate or use more fertile plots on which other cash crops could be planted (Jakarta Post, 2006). There is no proven model in terms of land size for cultivation, but Indonesian typical size is between 5 and 10 hectares. Biomac Corporation Sdn Bhd asserts that it makes sense to grow in Indonesia, among the hardcore-poor farmers to enjoy the economic benefits despite its smaller yield (Peterson, 2008). It is a smallholder crop as it has huge labour requirements and the management of it has yet to be in place. It is no surprise that large listed entities have not gone into Jatropha cultivation, as few companies are willing to put capital into it in one go. Biomac Corporation, a Malaysian company, is currently looking at planting 30,000 hectares of Jatropha in East Java by setting up a biodiesel plant with a capacity of 100,000 tonnes a year starting with the basic production of 5,000 litres of oil per day (Peterson, 2008). Jatropha plantations are sporadically found in West Nusa Tenggara, East Nusa Tenggara, West Java, Lampung and Sulawesi but size of cultivation is not systematically documented. Further government-supported research is underway at the Agriculture Ministry, the Agency for the Assessment and Application of Technology, the National Nuclear Power Agency, and the Agro Industry Center. A private company, PT Sawu, is looking out for good plant characteristic that can maximize cultivation per acre and its fruit carries a large percentage of oil. Local government agencies are expecting the national scale planting to create job opportunities and reduce the level of poverty (Jakarta Post, 2006).

11.3 Philippines

Currently, Jatropha occupies a total area of 360 ha in the Philippines: 200 ha in General Santos; 27 ha in Camarines Sur; 120 ha in Fort Magsaysay, Nueva Ecija; 5 ha in 98 Dacong Cogon, Negros Occidental; and small plantations in Quezon Province (Milbrandt and Overend, 2008). The Department of Science and Technology (DOST) plans to make Jatropha a success in its biofuel industry using 2 million ha of unproductive and idle land suitable for cultivating the country's next golden crop (Milbrandt and Overend, 2008). It started in 2006 when the Government initiated an update on RISE (Research Information Series on Ecosystems on Jatropha) with provision of more relevant information about this species to helping investors establish Jatropha plantations (Perino, 2006).

11.4 Thailand

Thailand is just entering its initial phases of Jatropha cultivation. Although oilseed is yet to be cultivated on a large scale, the nation is determined to use her experience on alternative energy source like molasses and cassava ethanol as a major feedstock, for the Jatropha biodiesel program (Gonsalves, 2006). With the support of Thai edible ethanol community, Bioenergy Development Co. Ltd (BEDC) is promoting cultivation of Jatropha under contract farming scheme along with off-take buy-back at variable prices according to feedstock of combined vegetable oil prices. BEDC is establishing their own plantations in Kumpong Spue (Cambodia) 3000 ha, and in Boekeo (Laos) 4000 ha and Vientiane (Laos) 8000 ha. BEDC has a pilot oil mill in Thailand to process Jatropha seeds in to crude Jatropha oil (CJO) for supply to biofuel developer in Germany, Japan and Terasol who supplies CJO to UOP jet fuel R&D. BEDC is commercialising oil mill with a capacity of 150 tons/day to be commissioned later in 2009 (Suann, 2009).

11.5 Myanmar

Myanmar Agri-Tech Ltd is involved in production, processing and marketing of Jatropha seeds in Myanmar as biofuel crop. This company has 100,000 acres of Jatropha plantation at Maw Tin. Subsequent plan is to collaborate with Enertech Korea to refine biofuel using JCO for certification by Korean Institute of Petroleum Quality, to complete the supply chain from seed to oil (Suann, 2009).

12.0 Economic Need for Biofuel

Bioenergy feedstocks, it remains at the core of any biofuels venture (Figure 5) and most nations embarked on a biofuel driven model more for economic development need (Rajagopal, 2008) in competition for other land uses, such as production of food or other crops even at the concept stage itself.

Figure 5: Production of Major Biofeedstocks (Source: Naylor *et al*, 2007, p.36)

Agricultural production of the five major feedstocks and biofuel energy yields in 2005										
Biofuel type	Bio-ethanol						Biodiesel			
Biofuel crop	Maize		Sugarcane		Cassava		Soybean		Oil palm	
Country; top 2 crop producers	USA	China	Brazil	India	Nigeria	Brazil	USA	Brazil	Malaysia	Indonesia
Total production million tons	280	133	420	232	42	26	83	50	76	64
% world production	40	19	33	18	20	12	39	24	44	37
Average crop yield, '03-'05 tons/ha	9.4	5.0	73.9	60.7	10.8	13.6	2.7	2.4	20.6	17.8

Conversion yield Liters/tons (a)	399	399	74.5	74.5	137	137	205	205	230	230
Biofuel yield in gigajoules/ha (b)	3751	1995	4522	4522	1480	1863	552	491	4736	4092
Energy yield in gigajoules/ha (c)	79.1	41.1	95.4	95.4	31.2	39.3	18.2	16.1	156	135
2005 petroleum (d) replacement , % of petroleum use	2.0	2.4	1.8	1.8	-	-	0.1	-	-	-

a) Calculated, 20 percent of harvested mass of crude oil, 1:1 conversion of crude palm oil to biodiesel. Palm oil density is 0.87 kilograms per liter;
b) Biofuel yield = crop yield x conversion yield;
c) Gross energy yields; lower heating value of ethanol 21.1 mega joules per liter or biodiesel 32.9 mega joules per liter x conversion yield x crop yield;
d) Biofuel production capacity converted to energy-equivalents of gasoline (or diesel).

Peterson (2008) reported that Jatropha seeds were priced at a range of US$100 and US$150/tons while the summer oil price was US$550/tons. Traders were expecting the crude Jatropha oil price to be priced at 30% lower than palm oil due to the availability of other feedstock such as algae. Malaysia's biofuel market is expected to be worth around US$4.5 billion annually, driven by the price of palm biodiesel which is at about US$700 per metric tonne (MT). The local version of biodiesel is called Envo Diesel, a blend of 5% processed palm oil and 95% petroleum diesel. Jatropha oil can be mixed with pure diesel as a component of biodiesel alternative fuel. In Indonesia, a liter of the Jatropha oil cost less than a liter of diesel oil at about Rp 2,250 (US$0.25; rupiah9000/US$1) and Jakarta Post (2006) reported that Jatropha oil yield higher profits per hectare than crude palm oil or sugar cane. However, Jatropha oil price is not expected to overtake than that of palm oil asserts Kumaraguru Veerasamy, Director (Chemicals, Materials, Food) at Frost & Sullivan Asia Pacific (Peterson, 2007). Crude Jatropha oil were sold at a discounted price of RM1, 000 (US$286)/tons, which is 45% less than the palm oil traded price. Consistent demand for a biodiesel conforming to the cold filter plugging point (CFPP) in European Union countries will push crude Jatropha oil demand up (Peterson, 2007). Being a new entry to the host of commodity oils, the major issue about Jatropha is its lack of market mechanism found in exchanges like Chicago, Rotterdam and Kuala Lumpur. In consequence over the uncertainty, the market is only prepared to pay US$150/tons (US$1= RM3.18) and 7,000 rupiah/litre (US$0.77; rupiah9000/US$1 and rupiah 100=RM0.37) for Indonesian biofuel pricing (Peterson, 2008).

13.0 Reasons for Choosing Jatropha as a Crop

We have to look at things on the energy front when sources of energy comes to a critical level but given that so little is known about Jatropha, the present attitude promulgates it as a viable and sustainable feedstock for biodiesel in contrast with other food-based crops like palm oil and soybean oil (Peterson, 2007). With basic mechanisation infrastructure, the Jatropha crop can be flexible in terms of harvesting productivity making it a good smallholder crop. However, as pure pressed oil (PPO), its usable resource is only 14% but there is a large market for seedcakes and biomass for the balance 86% (Hani, 2009). Jatropha projects are very location specific and experiences in India and Africa have been varied in terms of viability (Rajagopal, 2008) with some suggesting low capital investment but Peterson (2007) asserted that it is possible to have an end-to-end mill for less than US$150,000 with a plantation backing. Planters look at the capacity of the crop to establish yield in determining its viability. Annually, a hectare of Jatropha generates 8 to 9 tons of seeds/year with a contribution of US$900/ton/year and produces 3 tons of oil (Peterson, 2008). This is a huge improvement compared to oil palm with 1ton of oil per acre back in 1976.

14.0 Drawbacks of Jatropha

Jatropha has its fair share of drawbacks despite being a hardy plant with limited requirements for survival. For one, there is a problem of inconsistent fruit maturity causing it to ripen unevenly. It also requires a lot of manpower for harvesting as the seeds need to be collected every day (Peterson, 2008). As a monocrop, Jatropha can be a poisonous weed and is harmful for soil posing negative effects on flora and fauna including pigeon pea crop while the fumes of seed oil could also be unsafe for inhaling because villagers use the oil fumes as an insect repellent (IANS, 2008). Secondly, Jatropha has been reported to displace crop meant for animal grazing (beef production) in Queensland rural areas (Jones and Csurches, 2008). Preventing large-scale monoculture from replacing valuable biodiversity would mandate the practice of crop mixing, rotation schemes to scale down the magnitude of cultivation. Jatropha is less prone to pest damage however there are emerging problem as monocrop cultivation due to infestation by the scutellarid bug, Scutellera nobilis Fabr. causing flower fall, fruit abortion and malformation of seeds. The Pempelia morosali*,* causes damage by webbing and feeding on inflorescences and also is a capsule-borer while 85% of it can be parasitized by dipteran. Occurrence of natural predators are also found such as the spider, Stegodyphus sp. (Eresidae: Arachnida) webs these bugs while the barkeating caterpillar, Stomphastis (Acrocercops) thraustica Meyerick, the blister miner, the semilooper Achaea janata and to a small extent, the flower beetle Oxycetonia versicolor (Shankar and Dhyani, 2006). Perino (2006) reported other known organisms causing diseases of Jatropha are Clitocybe tabescens (root rot), tabescens (root rot), Colletotrichum gloesporioides (leaf spot) and Phakopsora jatrophicola (rust). In Malaysia, a scutellid bugs from the genus Scutellera and Calidea drege*i* (an African scutellerine) was found attacking a nursery Jatropha. The crop was planted about a year ago and the nymphs are seen to be attacking the maturing fruits, threatening commercial size cultivation. Similar problems were also reported in India (*Croton* sparsiflorus*)*, Australia (scutellarid).

15.0 Soil, Water and Climate Conditions

From a commercial perspective, Jatropha would need a higher level of water usage so it may push for development of large-scale irrigation to enable multiple harvests that may cause long-term impacts on ground water resources. As water resources may be a limiting factor for commercial Jatropha development, there is a need to evaluate large-scale projects in ecologically fragile zones (Rajagopal, 2008). Claims about Jatropha's ability to bind soil need further research in different growing regions because large-scale land clearance may have negative impact on soil quality (Rajagopal, 2008). Soil erosion is a major environmental threat to the sustainability and productive capacity of agriculture over the 40 years. Pimentel et al (1995) asserts, 'nearly one third of the world arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year' and with the increase in world population's food demand, will see a decline in per capita food productivity. However, experiences across the developing world have been quite varied reflecting complexities in local practices, soil, water and climatic factors (Rajagopal, 2008). With the growing interest in Jatropha, these projects are no longer conceptualised entirely for soil erosion control but rather for the purpose of economic and social benefits. Most projects are now characterised by new agronomical and technological challenges posed by new production and conversion processes with the adoption of new rural business models and emergence of environmental issues impacting the long-term sustainability. After all, Jatropha is a hardy plant with low water efficiency use of 3.68 and 2.52 mmol of CO_2 mmol H_2O respectively as compared to oil palm of 3.95-4.42 mmol of CO_2 mmol H_2O (Jongschaap, 2007). It grows on well-drained alkaline soils with good aeration but root formation is reduced in heavy soils (Kumar and Sharma, 2008). Limited fertilizers containing small amounts of calcium, magnesium, sulfur and phosphate, can aid the growth significantly (Muhlbauer *et al*, 1998).

16.0 Conclusion

Benefits of Jatropha have been debated informally within the agricultural fraternity and plantation forums in recent years but most initiatives are in the confines of commercial planting for biofuel rather than for landscaping to control soil erosion. By end 2008, the early stage Jatropha projects would have attained maturity of 5-6 years (Rajagopal, 2008). In countries where Jatropha projects are being planned there are a variety of types of Jatropha plants, with different oil content, yields, maturity periods, resistance to drought and pests, and rainfall requirements. This paper highlights that most of the Jatropha projects in South East Asia have issue with limitations of arable land that are diverted for biofuel use taking up resources and land that otherwise could have other sustainable uses. However, Pyakuryal (2008) suggested that the adoption of Green Technology such as biofuel, biogas, biomass, bio transgenics, organic farming, integrated pest management (IPM), agro forestry can increase agricultural output without depleting presently available resources beyond the point of recovery. To protect biodiversity and prevent deforestation, Matthews (2007) suggested a ‘Biopact’ between countries in the Northern and Southern hemispheres to emulate the propagating success of Brazil with ethanol production, since the Southern hemisphere has available land, climate and crops such as Jatropha. Once mutual consensus about biofuels issues associated with water usage run-off, herbicides, pesticides, soil degradation and land energetics are addressed, the conundrum of the countries’ confused agriculture and energy policies will be broken. (Mathews, 2007). On the other hand, Naylor *et al* (2007) asserts that energy markets could determine agricultural commodities value and help to reverse the long-term trend of declining real prices for the global biofuels market.

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[1] New plantations using improved germplasm from genetic and agronomic improvement. Yields are lower in year 1-6 since yield of plantation is low in early years.

[2] Existing plantations – assumes yield improvements from advances in agronomy, and assuming no physical, labor related, transport or geographical limitations to crop management or importing chemical inputs (fertilizer and pesticides).

[3] High yields potential sites in equatorial regions with year round production, high rainfall, adequate nutrients and remaining frost-free.

[4] Yield potential sites in non-equatorial regions with seasonal production, adequate rainfall and nutrients and remaining frost-free. v) Existing oil yield estimate for high yield potential plantations (2400 kg/ha).

[5] Existing oil yield estimate for high yield potential plantations (2400 kg/ha).

[6] To overcome uncertainty over nutrient requirements of Jatropha, the plan is to use residue (cake) from a central crushing facility for burning for N, P and K.