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THE SEARCH FOR ALTERNATIVE ENERGY SOURCES: JATROPHA AND MORINGA SEEDS FOR BIOFUEL PRODUCTION

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ABSTRACT

Biodiesel utilization, in recent times, has become a novel issue especially because of its benefits towards mitigating global warming effect, as well as being an alternative source of energy. In the fore front of choice energy crops adopted for use are Jatropha curcas and Moringa oleifera seeds which produce about 27-40% oil and 38–40% (edible oils) respectively. Both crops exhibit numerous attributes which make them suitable as alternative energy sources. However Jatropha possesses some risk factors associated with its inherent toxic part as well as environmental hazards associated with its large scale and long term production as an alternative energy source crop. Moringa however, has one hundred percent usability, as all parts of the plant are useful without any toxic part. This review highlights some of the merits and demerits of the two crops; vis-a- viz the search for a viable and sustainable means of an alternative energy source.

Key words: Biodiesel, Alternative energy, Oil seeds, Jatropha, Moringa.

INTRODUCTION

Biofuels, simply put, are fuels that are derived from agricultural products. Biofuels are a renewable source of energy that can be used in many applications, from fueling your vehicle, to generating electricity and heating your home. Recently, biofuels have been attracting attention from various sectors. Biofuels are considered to be ‘carbon-neutral’, which simply means that the amount of carbon dioxide which is created when burned is equal to the amount of carbon dioxide used during growing (Admin, 2009). It is hoped to be a ‘green’ alternative to petroleum, which has generated a lot of interest from investors and different countries around the World. In 2007, investment into biofuels production capacity exceeded $4 billion worldwide, while in 2008, they provided 1.8% of the world's transport fuel and is growing (UNEP, 2009).

According to the International Energy Agency (IEA), biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050 (Meghan, 2011). Examples of solid biofuels include wood, sawdust, grass cuttings, domestic refuse, charcoal, agricultural waste, non-food energy crops and dried manure. One of the advantages of solid biomass fuel is that it is often a by-product, residue or waste-product of other processes, such as farming, animal husbandry and forestry. In theory this means there is no competition between fuel and food production, although this is not always the case (Wikipedia, 2011a).

Numerous studies have shown that biomass fuels have significantly less impact on the environment than fossil based fuels. A derivative of solid biofuel is biochar, which is produced by biomass pyrolysis. Bio-char made from agricultural waste can substitute for wood charcoal. This alternative is gaining ground as wood stock becomes scarce (due to massive deforestation). In eastern Democratic Republic of Congo, for example, biomass briquettes are being marketed as an alternative to charcoal in order to protect Virunga National Park from deforestation associated with charcoal production (Wikipedia, 2011a).

There are two main types of biofuels for transport: Bioethanol, which is an alcohol derivative of sugar or starch, for example from sugar beet, cane or from corn; and Biodiesel, derivative of vegetable oils, for example from rapeseed oil, jatropha, soy or palm oil. United States is the world's biggest bioethanol manufacturer, and this accounts for 99% of their biofuel for road transport. The region is, as of yet, the world's chief biodiesel creator, and prefer biodiesel than bioethanol. It is discovered that ethanol has preferably less greenhouse gas releases than petrol. Among the biofuel crops grown in Europe and the US, biodiesel is usually measured to be more energy competent than bioethanol. A few biodiesel crops, such as oilseed rape are developed with huge magnitude of fertilizers, which compensate for a lot of the green house gas reserves (www.meangreenbiofuels.com/tag/biodiesel-fuels). Fig. 1 shows a list of choice crops for biodiesel production.

A choice of crops

Biodiesel crop	**Litres of oil per hectare**
Oil palm	2, 400
Jatropha	1, 300
Rapeseed (canola)	1, 100
Sunflower	690
Soya bean	400

Fig 1: List of Agricultural Crops used for Biodiesel
Source: United Nations Development Programme/World Bank. Jatropha figure from Indian Planning Commission.

What is Bio-energy?

Bioenergy is energy derived from biofuels. Biofuels are fuels produced directly or indirectly from organic material – biomass – including plant materials and animal waste. Overall, bioenergy covers approximately 10% of the total world energy demand. Traditional unprocessed biomass such as fuelwood, charcoal and animal dung accounts for most of this and represents the main source of energy for a large number of people in developing countries who use it mainly for cooking and heating (FAO, 2008).

Bioenergy is mainly used in homes (80%), to a lesser extent in industry (18%), while liquid biofuels for transport still play a limited role (2%). A distinction is made between primary and secondary biofuels. In the case of primary biofuels, such as fuel wood, wood chips and pellets, organic materials are used in an unprocessed form, primarily for heating, cooking or electricity production. Secondary biofuels result from processing of biomass and include liquid biofuels such as ethanol and biodiesel that can be used in vehicles and industrial processes. Even though the production of liquid biofuels for transport has grown rapidly in recent years it currently represents only 1% of total transport fuel consumption and only 0.2 to 0.3% of total energy consumption worldwide. Currently used liquid biofuels, which include ethanol produced from crops containing sugar and starch and biodiesel from oilseeds, are referred to as *first-generation* biofuels**.** These fuels only use a portion of the energy potentially available in the biomass.

What are Second-Generation Biofuels?

Most plant matter are composed of cellulose, hemicellulose and lignin, and processes that are able to convert these components to liquid fuels are referred to as "*second-generation biofuel*" technologies. Once commercially viable, these could significantly expand the volume and variety of sources that could be used for biofuel production (FAO, 2008).

Potential cellulosic sources include municipal waste and waste products from agriculture, forestry, processing industry as well as new energy crops such as fast growing trees and grasses. As a result second generation biofuel production could present major advantages in terms of environmental sustainability and reduced competition for land with food and feed production. It could also offer advantages in terms of greenhouse gas emissions. In the search for some of these new energy crops such as fast growing trees and shrubs, two formidable crops Jatropha and Moringa spp. have been discovered.

Facts about Jatropha

Jatropha is a genus of approximately 175 succulent plants, shrubs and trees (some are deciduous, like *Jatropha curcas*), from the family Euphorbiaceae. The name is derived from the Greek words ἰατρός (iatros), meaning "physician," and τροφή (trophe), meaning "nutrition," hence the common name physic nut. Mature plants produce separate male and female flowers. As with most members of the family Euphorbiaceae; Jatropha contains compounds that are highly toxic (Wikipedia, 2011b).

Jatropha curcas has been cited as one of the best candidates for future biodiesel production (Goldman, 2007). It is resistant to drought and pests, and produces seeds containing 27-40% oil (Achten *et al.*, 2007), averaging 34.4% (Wikipedia, 2011a). The remaining press cake of jatropha seeds after oil extraction could also be considered for energy production. However, despite their abundance and use as oil and reclamation plants, none of the Jatropha species have been properly domesticated and, as a result, their productivity is variable, and the long-term impact of their large-scale use on soil quality and the environment is unknown (WAC, 2007). The potential broad spectrum antimicrobial activity of *J. curcas* has also been demonstrated (Igbinosa *et al.* (2009).

According to REUK (2011), Jatropha is seen by many to be the perfect biodiesel crop since it can be grown in very poor soils actually generating top soil as it grows, is drought and pest resilient, and it has seeds with up to 40% oil content. Other facts and figures about Jatropha relating to its growth as an oil product are that:

- it grows well on low fertility soils however increased yields can be obtained using a fertilizer containing small amounts of magnesium, sulphur, and calcium.
- Jatropha can be intercropped with many cash crops such as coffee, sugar, fruits and vegetables with the Jatropha offering both fertilizer and protection against livestock.
- Jatropha needs at least 600mm of rain annually to thrive however it can survive three years of drought by dropping its leaves.
- Jatropha is excellent at preventing soil erosion, and the leaves it drops act as a wonderful soil enriching mulch.
- Jatropha prefers alkaline soils.
- Jatropha oil can be used as a kerosene substitute for heating and lamps.
- Jatropha oil burns with a clear smokeless flame.

- Jatropha seedlings yield seeds in the first year after plantation.
- After the first five years, the typical annual yield of a jatropha tree is 3.5kg of beans.
- Jatropha trees are productive for up to 30-40 years.
- 2, 200 trees can be planted per hectare (approx 1,000 per acre).
- 1 hectare should yield around 7 tonnes of seeds per year.
- The oil pressed from 4kg of seeds is needed to make 1 litre of biodiesel.
- 91%+ of the oil can be extracted with cold pressing.
- 1 hectare should yield around 2.2-2.7 tonnes of oil. Press cake (seedcake) is left after the oil is pressed from the seeds. This can be composted and used as a high grade nitrogen rich organic fertilizer (*green manure*). The remaining oil can be used to make skin friendly soap.
- One job is created for each 4 hectares of jatropha plantation.

The black seeds of *Jatropha curcas*
(Candace Feit for The New York Times)

Lex Worrall, the chief executive, Helius Energy, a British company developing the use of jatropha as an alternative to fossil fuels states that, “Every hectare can produce 2.7 tonnes of oil and about 4 tonnes of biomass. Every 8,000 hectares of the plant can run a 1.5 megawatt station, enough to power 2,500 homes.” (The Times, 2007). Scientists say that it can grow in the poorest wasteland, generating topsoil and helping to stall erosion, but also absorbing carbon dioxide as it grows, thus making it carbon-neutral even when burnt. A jatropha bush can live for up to 50 years, producing oil in its second year of growth, and survive up to three years of consecutive drought.

In some countries biodiesel is less expensive than conventional diesel. Biodiesel is the most common biofuel in Europe. It is produced from oils or fats using transesterification and is a liquid similar in composition to fossil/mineral diesel. Chemically, it consists mostly of fatty acid methyl (or ethyl) esters (FAMEs). Feedstocks for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropha, mahua, mustard, flax, sunflower, palm oil, hemp, field pennycress, pongamia pinnata and algae. Figure 2 shows the EU and other member states biodiesel production over a decade (Wikipedia, 2011b).

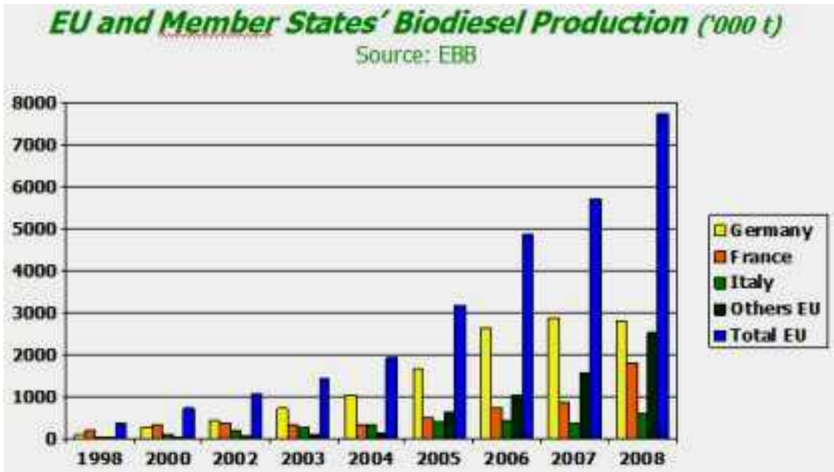

Fig. 2 EU and Member State Biodiesel Production (in metric tons)
Source: European Biodiesel Board, 2009 * Total EU27 biodiesel production for 2008 was over 7.7 million metric tonnes, an increase of 35.7% from the 2007 figures.

Facts about Moringa

Moringa is the sole genus in the flowering plant family Moringaceae. The 13 species it contains are from tropical and subtropical climates and range in size from tiny herbs to massive trees. The generic names are derived from the Tamil word *murunggai* or the Malayalam word *muringa*, both of which refer to *Moringa oleifera* (Quattrocchi, 2000). The most widely known species is *Moringa oleifera*, a multi-purpose tree native to the foothills of the Himalayas in northwestern India and cultivated throughout the tropics (Janick and Robert, 2008). *M. stenopetala*, an African species, is also widely grown, but to a much lesser extent than *M. oleifera*.

Benefits of Moringa Leaf

- Increases the Natural Defenses of the body
- Provides nourishment to the eyes and the brain.
- Promotes metabolism with bio-available ingredients
- Promotes the Cell structure of the body
- Promotes natural Serum cholesterol
- Lowers the appearance of wrinkles and fine lines.
- Promotes the normal functioning of the liver and the kidney.
- Beautifies the skin
- Promotes energy
- Promotes proper digestion
- Acts as an antioxidant

- Takes care of the immune system of the body
- Promotes healthy circulatory system
- It is an anti-inflammatory
- Gives a feeling of general wellness.
- Moringa leaves have the calcium equivalent of 4 glasses of milk, the vitamin C content of 7 oranges, potassium of 3 bananas, 3 times the iron of spinach, 4 times the amount of vitamin A in carrot, and 2 times the protein in milk.
- Moringa also helps to purify water, a cheaper alternative to mechanical filtration.

According to Anon. (2006), Moringa leaf boosts your energy in a natural manner, and is a remarkable source of nutrition. This energy promotion does not happen because of sugar, so it lasts for a long time. Individuals ingesting it say that their ulcers are healed, tumors restricted, there are reduction in the arthritis pains and inflammations, controlled blood pressure, the skin problems are restored, and finally they have stronger defenses against diseases. Another property of the Moringa leaf is its soothing ability, because of which it can lower the blood pressure and promotes good sleep. It can also purify water since it has a detoxifying effect. Also a coagulant agent, Moringa can attach itself to hazardous bacteria and other materials, a process that is surmised to occur in the body too. The happy outcome is more sustained energy without any over-activity, balanced hormone and gland system, controlled blood pressure, and a rested nervous system. The leaves are highly nutritious, being a significant source of beta-carotene, Vitamin C, protein, iron, and potassium (BBC News, 2009). The leaves are cooked and used like spinach. In addition to being used fresh as a substitute for spinach, its leaves are commonly dried and crushed into a powder, and used in soups and sauces. The tree is a good source for calcium and phosphorus. In Siddha medicines, these drumstick seeds are used as a sexual virility drug for treating erectile dysfunction in men and also in women for prolonging sexual activity.

The Moringa seeds yield 38–40% edible oil (called ben oil from the high concentration of behenic acid contained in the oil). The refined oil is clear and odorless and resists rancidity at least as well as any other botanical oil. The seed cake remaining after oil extraction may be used as a fertilizer or as a flocculent to purify water (Lea, 2010).

The Choice for Biofuel: *Jatropha* or *Moringa*

Jatropha was the toast in biofuel oil industry until moringa was discovered as better source (Admin, 2010). As the Philippines sought better ways to use its resources in combating climate change, a Filipino biotechnology company based in the U.S. tapped a wonder plant in the country (*Moringa oleifera* Lamk), as a source of biofuel. The choice of moringa oil as a source of biofuel over jatropha stems from the fact that moringa is 100 percent usable; all parts are biodegradable. Jatropha however has a toxic part, which, once its oil is extracted, the left-over part becomes a nuclear waste according to findings (www.ezine.Articles.com/?Malunggays-Moringa-Oil-Seen-as-Biofuel-Source&id=1103764).

The North American Biofuels Inc. (NABI) is currently growing moringa in 500,000-hectare farmland to meet the demands of NABI as possible raw material for biodiesel production, having authenticated that it has passed the biofuels standards. Currently, there are 165 marketing companies in the U.S. for biodiesel using soybean oil as raw material. It is expected that in the next 50 years, Japan and Korea will be the biggest markets of Moringa oil for their automobiles that will use biodiesel. With moringa as a biofuel source in the Philippines, the country may in some way help other countries reduce the impact of global warming by sharing the benefits of Moringa oil. According to Ben Macintyre (The Times, 2007), Jatropha found a strong supporter in Sir Nicholas Stern, the government economist who emphasized the dangers of global warming and advised South Africa to "look for biofuel technologies that can be grown on marginal land, perhaps jatropha". However, there are fears that this could result in increasing the risk of famine, since in areas dependent on subsistence farming, it could force out food crops.

Some countries are also cautious for other reasons: last year Western Australia banned the plant as invasive and highly toxic to people and animals. Climate change experts in Kenya argue that there is need for further studies to back the emphasis on the plant's potential to solve all energy challenges, while growing on little water, yet producing a lot of biofuel. According to them, "Energy is not created from nothing". With the planned cultivation of 50,000 hectares of jatropha at the Kenyan Coast by an Italian firm, questions concerning the sustenance of biodiversity in these areas have been raised (The East African, 2010).

According to executive director of Nature Kenya, Paul Matiku, large-scale cutting of Dakatcha woodland to pave way for the plantation will damage its capability as a water catchment area and lessen its ability to protect soil erosion. He adds that loss of the woodland would also sound a death knell to some rare bird and animal species that should be conserved as tourists' attraction; this would spell doom for the tourism industry. The deprivation of economic and social gains to the local community is also imminent. Contrary to previous findings, all current initiatives to set up jatropha plantations in arid and semi-arid Kenya have failed because of the enormous amounts of water and soil nutrients required by the plant. Also, Matiku said that jatropha is not well suited to absorb carbon dioxide from the atmosphere.

Indeed, it appears that the many positive claims for the plant are not based on mature project experiences. The Times (2007) had argued that, on a modest scale, jatropha cultivation can help with soil-water conservation, soil reclamation and erosion control, and be used for living fences, firewood, green manure, lighting fuel, local soap production, insecticides and medicinal applications. However, they conclude that claims of high oil yields in combination with low nutrient requirements (soil fertility), lower water use, low labour inputs, the non-existence of competition with food production and tolerance to pests and diseases are unsupported by scientific evidence. The most critical gaps are the lack of improved varieties and available seed. Jatropha has not yet been domesticated as a crop with reliable performance (www.greenfacts.org/en/biofuels/figtableboxes/jatropha-crop.htm).

Jatropha oil is lauded as being sustainable, and that its production would not compete with food production, but the jatropha plant needs water like every other crop to grow. This fact could create competition for water between the jatropha and other edible food crops. In fact, jatropha requires five times as much water per unit of energy as sugarcane and corn (*GBC*, 2009; Mckenna, 2009).

CONCLUSION

Although biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050, the International Energy Agency said, at the meeting requested by G8 energy ministers that, "…..displacing 27% of transportation fuels -- particularly diesel, kerosene and jet fuel -- by 2050 would cut greenhouse gas emissions by 2.1 billion tons/year". It cautioned that the levels can only be achieved if conventional technologies become more efficient at converting crops, algae and other organic material into energy. Reaching the 2050 goal would require the production of 65 exajoules of feedstock grown on about 100 million hectares (about 247 million acres), the report said. Another 80 exajoules of biomass would be needed to generate heat and power for production.

"This poses a considerable challenge given competition for land and feedstocks from rapidly growing demand for food and fibre," the report said. "However, with a sound policy framework in place, it should be possible to provide the required 145 exajoules of total biomass for biofuels, heat and electricity from residues and wastes, along with sustainably grown energy crops", like Jatropha, but most especially, Moringa. Biodiesel utilization may not be the panacea for lower oil prices, but it is hopefully a bridge towards becoming a little bit more dependent on ourselves rather than others

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