BIODIESEL PRODUCTION IN MEXICO FROM JATROPHA CURCAS

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ABSTRACT

Biodiesel production from vegetable oils has been severely questioned in several published works; they present economic, social and sustainability arguments to show that there are no neat advantages in the use of biofuels obtained from plants or cultivated varieties. In particular, it has been mentioned that biodiesel production competes with food production, that the overall energy efficiency of the process including the fuel burning is almost zero, that the large scale biodiesel production will require the massive destruction of rainforests and ecology at large. Without denying some of the arguments that are clearly true, in this study some arguments are presented to show that in Mexico it is technical, economic and ecologically possible to use the *Jatropha curcas*, an endemic vegetal variety in the country, to produce biofuels with some social and ecological advantages. This is accomplished by considering not only the technological aspects but also the social and ecological ones, taking for granted that a sound public policy is applied for this purpose. Some clear and immediate benefits are mentioned in connection with the ecology and the jobs arising around the biofuels industry.

Key words: Biofuels, biodiesel, Jatropha curcas, bioenergy sources, biofuels production.

INTRODUCTION

The need to develop new alternatives for liquid fossil fuels arises mainly from the increasing prices of conventional fuels, the depletion of the oil reserves of the world, the present impossibility of substituting the liquid fuels as energy sources for long distance transportation (airplanes, ships, etc.) and, last but not least, the air pollution. Several of these alternative fuels have been developed from long ago, the main being bioethanol and biodiesel, which are used mainly to replace gasoline and petroleum diesel (petrodiesel), respectively. In particular, biodiesel can be obtained from many oil-containing plants and seeds, some micro algae, and also from burned oil previously used for cooking or animal fats. Silitonga et al.[1] have reported up to 350 types of different plants that can be used for obtaining biofuels, from edible plants as soybean, oil palm, sunflower, colza, peanut, rapeseed, mustard, to non-edible varieties as jatropha, karanj and neem. After algae, the second best source of oil for biodiesel is Jatropha, due to its sustainability in the sense that it does not necessarily compete with food and can have an energy return rate larger than 5.5, that is, for each unit if energy inverted in the whole production process (planting, harvesting, transesterification) and transportation to the end user, more than 5.5 energy units are obtained.

Table 1 shows the historical evolution of prices for both petrodiesel and Jatropha diesel in Mexico. As can be seen, prices for conventional diesel have more than doubled in the last decade; on the other hand, Jatropha biodiesel prices are becoming more and more competitive as the production increases.

Table 1. Historical evolution of prices for petrodiesel and Jatropha diesel[2,3]

Price per liter in Mexican pesos		
Year	**Diesel (PEMEX)**	**Biodiesel**
2003	5.01	---
2004	5.16	---
2005	5.31	---
2006	5.70	---
2007	5.93	---
2008	7.33	---
2009	8.16	---
2010	9.12	18.32
2011	10.09	18.50
2012	10.99	16.04
2013	11.56	---

According to INEGI[4] (Instituto Nacional de Geografía e Informática), in Mexico the demand for diesel by sectors in 2010 was as follows:

Transport	591.56 Petajoules
Agriculture	106.83
Industrial	54.5
Electricity generation	14.73

As can be observed in table above, the transport sector represents the highest demand of diesel, from a total consumption of about 330,000 barrels per day (bl/d). On the other hand, Mexico has planned to incorporate gradually a certain amount of biodiesel into the conventional diesel in order to fulfill international standards to reduce air pollution. These blends are designated with the letter B followed by the percentage of biodiesel content: for example, B20 corresponds to 20% biodiesel and 80% petrodiesel; B100 corresponds to 100% biodiesel, and so for. The initial plan in Mexico is to use the blend B6.7 for transportation in 2012, and gradually (in 5 to 10 years) reach the B10, which is a concentration that still permits the normal operation of engines without major modification of engines, fuel systems or infrastructure. Obviously, the amount of biodiesel required to produce these blends (33,000 bl/d) is almost 100 times larger than the present national production. This poses the need to increase the local capabilities. An additional point to be considered: international regulations for air transportation in Europe are requiring that all airplanes landing in European airports incorporate by 2015 at least 10% of biofuels to the conventional fuel used up to now. Lack of compliance with this norms will prevent Mexican airlines from landing in European countries. It seems that present Mexican regulations for air transport have not taken into account this restrictions to the travel industry.

In order to stimulate and regulate the production of biofuels in Mexico, in 2008 was published the Ley de Promoción y Desarrollo de los Bioenergéticos (LPDB, Promotion and Development of Bioenergetics Law). This law is aimed to promote and regulate the production, commercialization and efficient use of bioenergetics, in an effort to reactivate agricultural production, create new jobs, rise the quality of life in rural areas, increase energy security and reduce contamination.

Under this law, some private and public enterprises have emerged into the biofuels market to take advantage of the high potential that the country has in connection to the biofuels production.

JATROPHA IN THE MEXICAN CONTEXT

Jatropha is an endemic plant in our country; it grows in tropical and subtropical climates and likes heat, but it can also be found in cold places and can withstand light frost. It grows in sandy soils and is also suitable to prevent soil erosion and shifting of sand dunes.

There exist several varieties of Jatropha, but the most widely used for biodiesel production is Jatropha curcas. Jatropha oil is considered to be sustainable in the sense that its production does not compete with food production and can survive and sustain in unfertile land or even stony soil. Jatropha can be intercropped with many other crops as coffee, sugar, fruits and vegetables, offering both fertilizers and protection against livestock. Almost any land in Mexico can be planted with Jatropha, and in order not to reduce the land needed for food, forests and livestock, the unfertile zones can be used for its production. In connection to this point it is important to apply the proper regulations contained in the "Programa de Producción Sustentable de Insumos para Bioenergéticos y de Desarrollo Científico y Tecnológico".

Table 2. Requirements and rendition of Jatropha[1,5]

Parameters	Quantity needed or produced
Area per plant	2m x 2m
Liters of water/plant	1 per day or every 15 days[1]
Temperature	20-26 °C or higher
Time required for initial production	1 year after plantation
Oil content	28-40% on the average[2]
Amount extracted by pressing	75%
Amount extracted by pressing[3]	96%
SFA (saturated fatty acids)	21%
UFA (unsaturated fatty acids)	79%
Seeds per plant	3.5 Kg
Productivity life per plant	30-40 years
Plants per hectare	2,200
Biodiesel per hectare	17 barrels/ha/year

1 600 mm of rain per year for the typical plant; some varieties can stand 3 years without rain.

2 Typical annual productivity of a Jatropha plant after 5 years planted.

3 By using solvents (a more contaminating process) or heating (more energy demand).

Jatropha oil

One of the major advantages of Jatropha biodiesel is the fact that it can be used in existing engines and fuel injection equipment with little impact to operating performance. The fuel consumption, horsepower and torque are similar to those of petrodiesel.

Table 3. A comparison between properties of petroleum diesel and Jatropha biodiesel[1,5]

Properties	Petroleum diesel	Jatropha biodiesel
Viscosity mm^2/s at 40°C	4.84	4.59[1]
Density g/cm^3	0.83	0.94
Gross caloric content (MJ/Kg)	46.22	44.88
Flash Point °C	71	182
Combustion Temp. (°C)	76	190
Color	Dark brown	Light amber
Sulfur content (% mass)	2-5 %	<0.0002 %

Jatropha biodiesel and ecology

The use of Jatropha biodiesel in a conventional diesel engine results in a substantial reduction of unburned hydrocarbons[5], carbon monoxide and particulate matter compared to emissions from diesel fuel. In addition, the exhaust emissions of sulfur oxides and sulfates (major components of acid rain) are essentially eliminated compared to common diesel.[6] The yellowish atmospheric blanket that can be seen in many cities is due mainly to the sulfur content of fuels. In addition, the overall ozone forming potential of the hydrocarbon exhaust emissions from biodiesel is nearly 50% less than that measured for diesel fuel.

A 2002 study on biodiesel impacts on exhaust emissions[6] concluded that biodiesel in general reduces net carbon dioxide emissions by 78% compared to petrodiesel. This is due to biodiesel's closed carbon cycle. The CO_2 released into the atmosphere when biodiesel is burned is recycled by growing plants, which are later processed into fuel. This study also confirms that biodiesel exhaust has a less harmful impact on human health than petrodiesel. Pure biodiesel emissions have decreased levels of polycyclic aromatic hydrocarbons and nitrated compounds that have been identified as potential cancer causing compounds. Also, particulate matter, an emission linked to asthma and other diseases, is reduced by about 47%, and carbon monoxide, a poisonous gas, is reduced by about 48%.

Additional points in favor of Jatropha biodiesel

1. Jatropha production does not compete with food production because the seed contains substances that are toxic and improper for human consumption.
2. Jatropha can live in very poor soils, sand and even stony land.
3. Least amount of water needed. The fallen leaves are a good organic fertilizer.
4. Prevents soil erosion and the displacement of sand dunes.
5. The press cake after oil extraction can be used as biomass feedstock to power electricity plants, or used as fertilizer (it contains nitrogen, phosphorus and potassium).
6. The Jatropha oil has good physicochemical properties and its characteristics as a fuel are comparable to that of conventional diesel.
7. Transesterification process catalyzed by vegetable oils is quicker than that catalyzed by acids.
8. Jatropha biodiesel mix easily with petrodiesel.
9. Biodiesel performance in existing engines is similar or even better than fossil diesel performance.
10. The high flash point and high combustion temperature of biodiesel makes it safer for transportation, storage and handling.
11. Kinematic viscosity and cetane index of biodiesel complies with the ASTM standards.

Jatropha byproducts:

a. The bark contains a bluish tint that can be used as colorant in the textile industry.
b. The leaves have been employed as anti-inflammatory in medicine.

Socio-economic benefits

Production of biodiesel from Jatropha under proper regulations will allow the country to create green jobs in rural areas and at the same time rise the income of the farmers who produce the crops. At the national level, biofuels production will generate more industries, new technologies, more working and research groups, new jobs and new markets. Instead of importing diesel, the country can reach energy security and even be a neat exporter of biofuels. But a careful public policy is needed to avoid that biofuels production put in serious risk the food production capacity of the country or the biological diversity and the ecology. Not all oil-producing plants are equally convenient for biodiesel production. As mentioned before, for Mexico there is only one alternative better than Jatropha, and this is based on the Algae.

DISCUSSION & CONCLUSIONS

The daily demand of diesel in Mexico is about 330,000 barrels. In order to produce the blend B10 it would be necessary to produce 33,000 barrels of Jatropha biodiesel per day or 12,045,000 barrels per year. This would require, according the productivity given in Table 2 for cultivated Jatropha:

$$12,045,000/17 = 708,529.41 \text{ ha},$$

3.6% of the Mexican territory. Taking half this productivity for poor lands, the result would be 1,417,058.8 ha. of non-cultivated land, what amounts to 7.2% of the total land area of Mexico. This seems to be a very large area, but some recent studies on agroecological zonification[7,8] shows that in Mexico there exist more than 6 million hectares with medium and high potential for Jatropha production. There are at least 2.2 million hectares with high potential (altitudes between 0 and 1,200 meters above sea level; temperatures from 18 to 28 °C, slope from 0 to 20%, and rains between 600 mm. and 1,200 mm. per year) in the states of Sinaloa (557,600 ha.), Tamaulipas (317,690 ha.), Guerrero (282,158 ha.), Chiapas (230,273 ha.), Michoacán (197,288 ha.). Other states like Veracruz, Yucatán, Colima, Oaxaca, Nuevo León y Campeche have more than 100,000 ha. each with similar characteristics. At the time being, there are many private and public enterprises in Mexico trying to create a powerful industry of biofuels to meet the national demand and export remainings, but by now the production is only about 1% of the volume needed for B10.

Mexico has the natural resources, the trained people, the research and development capacity to be an important producer of biofuels. It seems that the only ingredient missing is a clear understanding of the whole problem on behalf of the government and the political will to create a concerted national program in which all present dispersed efforts obey a unique objective.

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