沙漠研究 **21**-2, 51 - 55 (2011)
Journal of Arid Land Studies "ICAL 1/DT X"
-Refereed Article-

Effect of Climate and Soil Condition on Oil Content of *Jatropha* Plants Grown in Arid Areas of India

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Abstract: *Jatropha curcas* remains the most promising source of biofuel. It is a low growing oil-seed-bearing tree that is common in tropical and subtropical regions where the plant is often used in traditional medicine and the seed oil is used for lighting. Unlike other major biofuel crops. *Jatropha* is not a food crop and thus not compete for space suitable to agriculture. It can grow well in semi-arid regions with low nutrient requirements. The seed typically contains 35 percent oil and has properties highly suited to making biodiesel. The rooting nature of *Jatropha* allows it to reach water from deep in the soil and to extract leached mineral nutrients that are unavailable to many other plants. The surface roots assist in binding the soil and can reduce soil erosion. However, its constituents vary with soil and climatic condition to a great extent, which affects several parameters of biodiesel from *Jatropha*. Variation also occurs when marginal farming is changed to commercial farming with irrigation facility. Results obtained from analysis of various samples also indicate variation in colour and trace elements, some of which can cause corrosion of materials.

Key Words: Arid plantation, Climatic effect, *Jatropha*, Oil content

1. Introduction

Projections, based on current policies, show fossil fuels will continue to dominate the energy mix, with global energy-related CO_2 emissions in 2030 reaching 38 billion tonnes. The geographic location of new emissions will likely shift dramatically, from the industrialised countries to the developing world. Global energy-related emissions of CO_2 will rise by 1.8% per year to 2030, slightly faster than primary energy demand (IEA, 2010). Nuclear energy and solar energy can meet electricity demand to a large extent, reducing the role of fossil fuel in this sector; however, petroleum energy will remain in demand in several sectors, particularly in transportation.

Biofuels are being considered a good substitute for fossil fuels despite its 1% solar energy conversion capacity (conversion capacity of solar PV Cells are greater than 20% and is likely to increase further) because they fall in zero emission categories and meet most of the criteria in the transportation sector. Since transportation is responsible for some 30 percent of current energy usage (**Fig. 1**) and biofuels can be used in transportation with only few changes to the existing distribution infrastructure, biofuels have become an extremely important form of bioenergy. Producing liquid biofuels from food crops using conventional technology is also being pursued as a means of farm income support and for driving rural development.

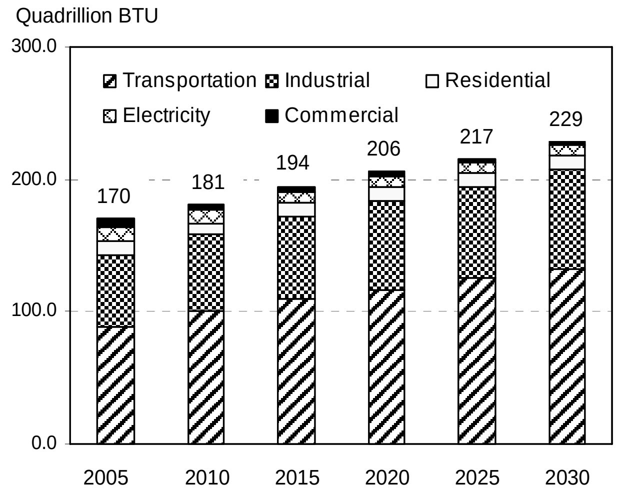

Fig. 1. Projection of liquid fuel demand in five sectors.

Energy market is quite large as compared to the agricultural commodities market including biofuels. Hence, the latter cannot significantly address climate change and energy security. However, the increased demand for biofuels does create a huge new market for agricultural products (IEA, 2010). Liquid biofuels generally require large-scale production and processing to be viable, although this is less true where the end product is straight vegetable oil or oil which can be processed locally for direct blending of diesel. In several cases, they don't compete for agricultural land and provide an alternative

(Received June 14th, 2011; Accepted October18th, 2011)

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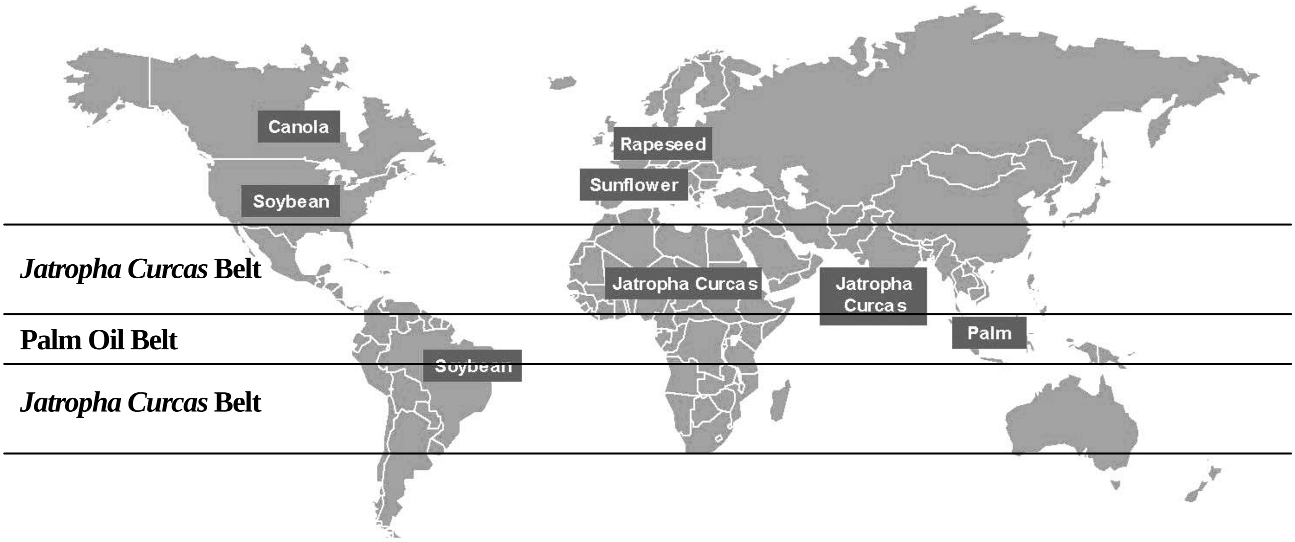

Fig. 2. Ingredients of biodiesel in various regions.

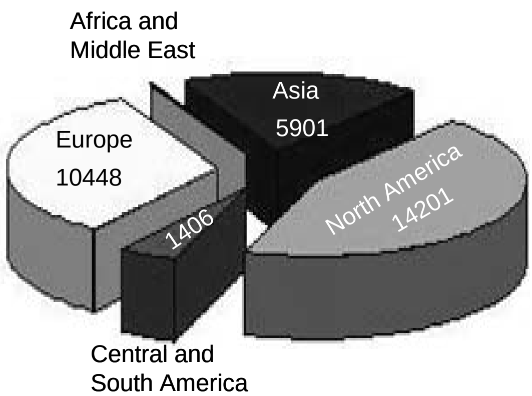

Fig. 3. Biodiesel output in 2008 (kmt/Yr).

Table 1. Waste Land suitable for *Jatropha* plantation.

S. No.	States	(million ha.)
1	M.P. & Chhattisgarh	6.62
2	Rajasthan	5.688
3	Maharashtra	4.855
4	Andhra Pradesh	4.396
5	Bihar & Jharkhand	1.86
	Total (India)	40.037

Table 2. Parameters used for GCMS analysis.

S. No.	Parameters	Values
1	Temperature Range	50-200 ℃
2	50RRIER	0.5 ml/min
3	Make up	29.5 ml/min
4	Split	1:50
5	Purge	10 ml/min
6	Attn	5 (3.12%)

strategy to combat desertification while providing an alternative source of energy.

2. Bio-ethanol and Biodiesel

Bio-ethanol and biodiesel are two main end products for use as liquid fuels. Bio-ethanol is produced by fermentation of sugar content in agri-produce. Sugarcane (Australia, Brazil, China, Colombia, Ethiopia, India, Mexico, Thailand), sugar beets (EU), maize (US, China), wheat (Canada, EU), cassava (Thailand) are major ingredients in the production of bio-ethanol (**Fig. 2**). There are growing concerns, however, about stress on food availability and price rise in third world countries due to diversion of edible food sources. The economics of bio-ethanol favors corn and has been a major reason for higher corn price despite continuous increase in plantation acreage. Global coarse grain stocks have been lately getting uncomfortably tight. Corn ethanol production is expected to reach 12 billion gallon in 2015 and will account for 30% of the corn crop, which may cause severe food crisis.

Biodiesel is a better substitute than bio-ethanol. Biodiesel is a monoalkyl ester of long chain fatty acids produced from the trans-esterification reaction of vegetable oil with alcohol in the presence of a catalyst (Gerpen, 2005; Lele, 2006). **Figure 3** shows the status of continental biodiesel production in 2008.

3. *Jatropha*: Source of bioenergy

Interest in *Jatropha curcas* as a source of oil for producing biodiesel has arisen as a consequence of its perceived ability to grow in semi-arid regions with low nutrient requirements and

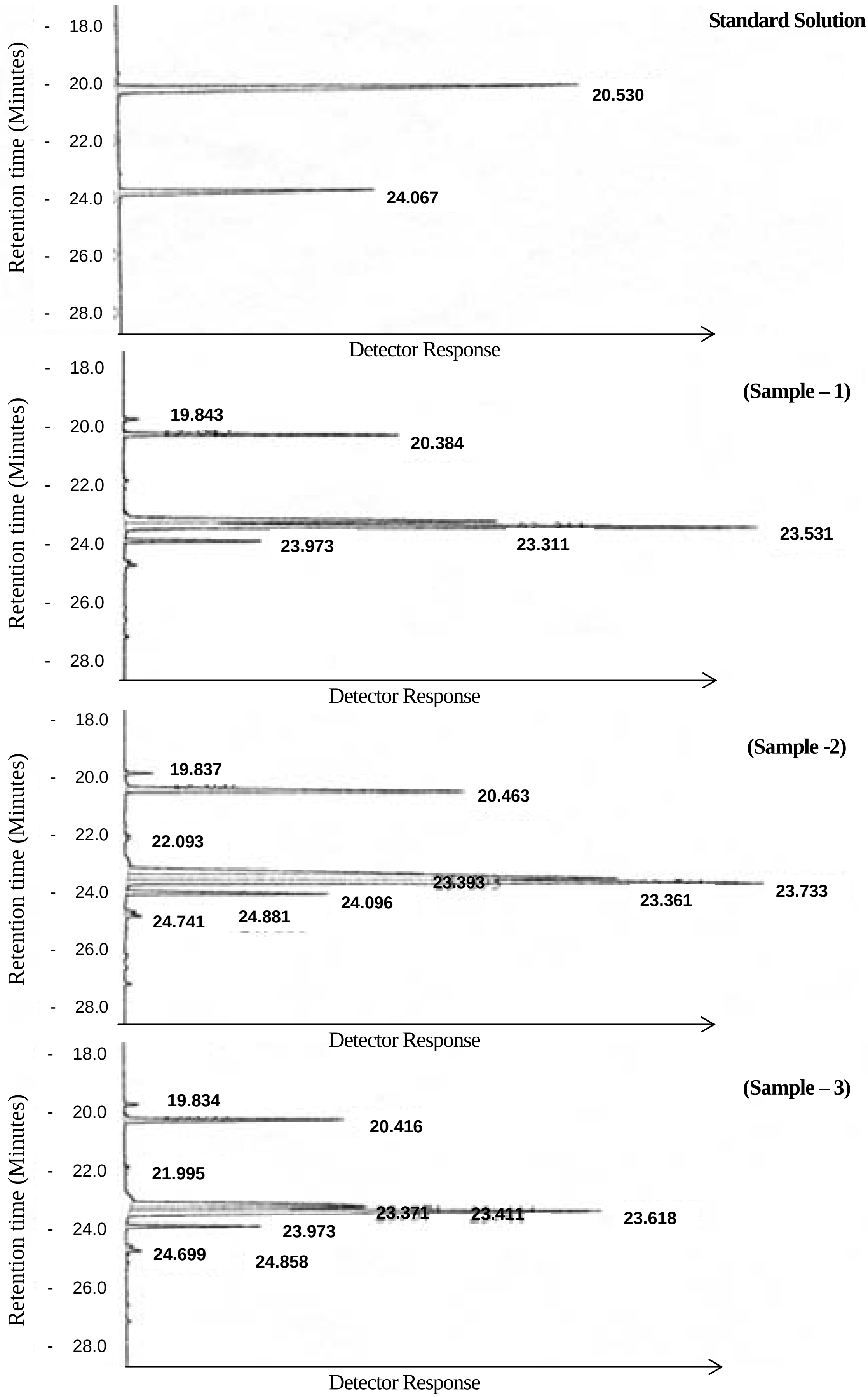

Fig. 4. Standard GCMS of methyl ester and of three samples of *Jatropha* oil.

little management (Prueksakorn and Gheewala, 2006; Kureel, 2006). The seed typically contains 35 percent oil which has properties highly suited to biodiesel production (Vijay *et al*., 2004). It is a low growing oil-seed-bearing tree that is common in tropical and subtropical regions where the plant is often used in traditional medicine and the seed oil is sometimes used for lighting (Sirisomboon, 2007). The tree is occasionally grown as a live fence for excluding livestock and for demarcating property. The rooting nature of *Jatropha* allows it to reach water from deep in the soil and to extract leached mineral nutrients that are unavailable to many other plants. The surface roots assist in binding the soil and can reduce soil erosion. In 2008, *Jatropha* was planted on an estimated 900, 000 ha globally – 760,000 ha (85 percent) in Asia, followed by 120 000 ha in Africa and 20 000 ha in Latin America (Brittaine. and Lutaladio, 2010). By 2015, forecasts suggest that *Jatropha* will be planted on 12.8 million ha. In India, waste land suitable for *Jatropha* plantation is estimated to be over 40 million hectare. **Table 1** shows land availability in five states of India, where *Jatropha* plantation will not compete with agriculture.

4. Methodology

Samples were collected from several sites in India with diverse climatic conditions, soil types and plantation (marginal, irrigated and non-irrigated farming), to investigate the effect on C16 and C18 compounds in *Jatropha* oil. Oil was extracted by standard process of esterification and analysed with Gas Chromatograph Mass Spectrometer (GCMS). Chromato -graphic data represents detector response against retention time. The spectrum of peaks for the samples represents the analytes present in a sample eluting from the column at different times. Retention time can be used to identify analytes and the pattern of peaks can identify complex mixtures of analytes. The area under a peak is proportional to the amount of analyte present in the chromatogram. By calculating the area of the peak using the mathematical function of integration, the concentration of an analyte in the original sample can be determined. The follwing parameters were selected in the final experiment (**Table 2**).

5. Results and Discussion

Results of GCMS analysis for three samples are shown in **Figure 4**. Due to background noise (not shown here), the value of peak cannot be used to show the relative strength. They are only indicative of the presence of various constituents in *Jatropha* oil. Presence of C16 and C18 compounds are identified with the help of standard curves of Methyl Palmitate and Methyl Stearate. The area under the curve represents

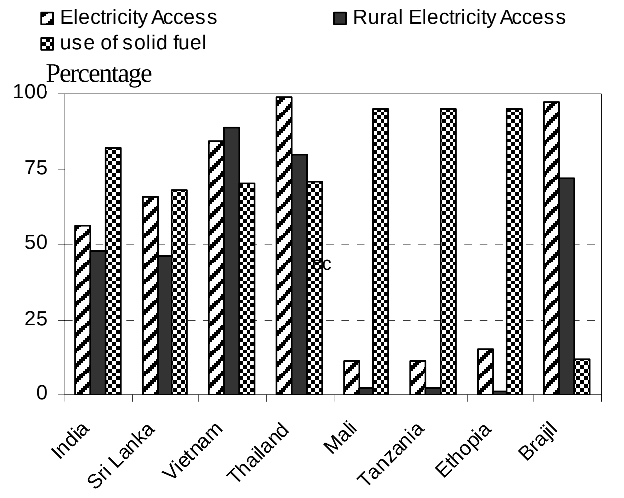

Fig. 5. Status of electricity in countries where *Jatropha* can be grown.

their relative strength as compared to each other.

The CCMS curve shows wide variation in its constituents. However, the main components remain C16 and C18, which changed with variation in other parameters. Though it is very difficult to quantify and correlate oil in seeds with other parameters, it is possible to ascertain the best relative condition.

The overall oil content also varied. A relative analysis of samples showed variation of oil content from 25% to 41%. Dry farming suits *Jatropha* plantation best as, oil content and C18 to C16 ratio, both increased. C16 remained almost constant but the ratio varied from 5.5 to 5.9 as computed from chromatogram. The ratio between is calculated by computing the area under the curve representing C16 and C18 peaks. The instrument used combines gas chromatograph and the mass spectrometer. With an increase in C18 fraction, the colour of jatropha oil also changed from dark brown to relatively light brown.

Although *Jatropha* is adapted to low fertility sites and alkaline soils, better yields can be obtained on poor quality soils if fertilizers containing small amounts of calcium, magnesium, and sulfur are used. Mycorrhizal associations have also been observed with *Jatropha* and increased the plant's growth under conditions where phosphate is limiting. 1 kg of farmyard manure and 100 g of Neem waste for every seedling in farming conditions provided better oil output than in commercial farms. Crop density also affects the oil output of the plant. Under farming conditions, 2,500 trees per hectare provides better quantity of oil per seeds, while for commercial farming the average plantation of 4,000 trees increases oil output per hectare (Lele, 2006). Preliminary investigation indicates that the fruit size in plants increases by partial root drying mechanism. A methodology to parametrie and use the mechanism for higher oil yield in *Jatropha* seeds is under investigation.

6. Conclusion

The key factors that can influence the oil yield of *Jatropha curcas* are: climate, quality of the soil, irrigation, weeding, use of fertilizer, crop density, genotype, use of pesticide and inter-cropping. It can withstand severe heat. It does well in warmer areas. During winter season, it will drop its leaves. It can withstand light frost but not for prolonged periods. The oil content is highest in sandy, well-drained soils. It can withstand very poor soils and saline conditions. Organic fertilizers provide higher yield. It needs rainfall as low as 250 mm a year. However, oil content is better in case of 600 - 1,300 mm rainfall. Under irrigation 1,500 mm is optimum. 4,000 trees per hectare is best for commercial irrigated farming while 2,500 trees are best for unmanaged and marginal farming. Given the state of electric supply in rural areas in developing countries (**Fig. 5**), potential of *Jatropha* as poor man's energy source is simply incomparable.

Acknowledgement

Authors are grateful to New Energy Foundation, Asia Biomass office for providing financial support and other facilities to the research work.

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