PROSPECT OF BIODIESEL PRODUCTION FROM JATROPHA CURCAS, A PROMISING NON EDIBLE OIL SEED IN BANGLADESH

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ABSTRACT

This paper investigates the prospect of jatropha curcas plantation in Bangladesh and making of biodiesel from jatropha. In the first part of this report prospect of jatropha cultivation is discussed and in the 2nd part of the report, making of biodiesel is done. Jatropha curcas is a renewable non-edible plant. Jatropha is a wildly growing hardy plant, in arid and semi-arid regions of the country on degraded soils having low fertility and moisture. It can be cultivated successfully in the regions having scanty to heavy rainfall even it can be cultivated even on fallow and barren lands. There is huge unused area in southern part of Bangladesh, where jatropha can be cultivated with profitable income. The seeds of jatropha contain 30-40% oil. The oil can be converted to biodiesel by the well-known transesterification process. Its oil can be used as lubricant, soap making, candle making and source of plant nutrients. The transesterification result of this report shows that about 96% biodiesel production is experienced with 20 vol% of methanol and 0.6% wt% of NaOH catalyst. The properties of biodiesel made from jatropha are much closer or even better to conventional diesel fuel. By planting of jatropha, Bangladesh can save a huge amount of importing of petroleum products from foreign countries.

Keywords: Jatropha Curcas, Transesterification process, Catalyst, Biodiesel.

1. INTRODUCTION

Jatropha curcas is unusual among tree crops. Perhaps its modular construction is its most unusual feature. Before falling to the ground the dry fruits and seeds will remain on the tree for some time, especially under dry conditions. Some benefits of jatropha oil are as follows: [1]:

(i) The oil has a very high Saponification value and is being extensively used for making soap in some countries.

(ii) The oil is used as an illuminant as it burns without emitting smoke.

(iii) The latex of Jatropha curcas (Ratanjyot) contains an alkaloid known as "jatrophine" which is believed to have anti-cancerous properties.

(iv) The bark of Jatropha curcas (Ratanjyot) yields a dark blue dye which is used for coloring cloth, fishing nets and lines.

(v) Jatropha curcas (Ratanjyot) oil cake is rich in nitrogen, phosphorous and potassium and can be used as organic manure. Jatropha leaves are used as food for the tusser silkworm.

In addition to these benefits, scientists at Perdue University in the U.S. and elsewhere are working in the extraction of usable pharmaceutical derivatives from Jatropha Curcas while others are attempting to grow non-toxic plants (Mexico). It has been found that jatropha may display certain anti-tumor and, anti -malarial properties and research is advancing related to HIV/AIDs and immune system response enhancement using jatropha. An organic fertilizer is produced by direct fermentation of jatropha seed cake. The fertilizer has a high potential for export to developed countries.

It has been found that jatropha's oil properties are the most exciting in the field of biodiesel fuel. It has been demonstrated experimentally that at same power output, jatropha curcas oil specific consumption and efficiencies are higher than those of diesel fuel. Tests conducted also showed that in comparison to various other vegetable oils including copra, palm, groundnut, cottonseed, rapeseed, soya and sunflower, biodiesel has significant potential for use as an alternative fuel in compression–ignition (diesel) engines [2-3].It has been observed that the lowest exhaust gas emissions were obtained with copra and jatropha curcas crude oil

It is technically competitive with conventional, petroleum–derived diesel fuel and requires no changes in the fuel distribution infrastructure. While some technical improvements regarding cold–flow properties, reduction of NOx exhaust emissions, and oxidative stability remain, a major hurdle towards widespread commercialization of biodiesel. For this reason, the commercialization of biodiesel is targeted towards regulated fleets, mining, and marine markets in the United States. In these markets, environmental and energy security concerns, which are subject to legislation, can override economic aspects. Vegetable oils, such as soybean oil, rapeseed oil (canola oil), and in countries with more tropical climates, tropical oils (palm oil and coconut oil) are the major sources of biodiesel. However, in recent years, animal fats and especially recycled greases and used vegetable oils have found increasing attention as sources of biodiesel. It has been found that used vegetable oils are primarily used as inexpensive feedstocks [4]. Regardless of the feedstock, transesterification reactions are carried out to produce biodiesel. Earlier during the renewed interest in vegetable oils as alternative diesel fuels, it was observed that the resulting vegetable oils (or animal fat) esters did not exhibit the operational problems, such as engine deposits, choking of injector nozzles, etc, which were associated with neat oils [5].

2. OBJECTIVE AND PURPOSE OF THE WORK

The objectives of the proposed project cover the followings:

1. Reducing import of petroleum, particularly automotive diesel oil
2. Improving the security of biodiesel supply
3. Creating employment opportunities
4. Increasing foreign earnings (supposed it can be exported)
5. Supporting equal plantation development, particularly for the southern part of Bangladesh.
6. To create awareness among the farmers about the use of non-edible oils for meeting the energy requirements
7. To provide financial support to encourage farmers to set up bio-oil gensets.

The purposes of the proposed project are to focus mainly on gradual development of plots and cultivation of Jatropha curcas on the areas, where food cultivation is not done. It is specially emphasized to develop uncultivated huge area in the southern part Bangladesh to cultivate jatropha. Also there is huge prospect of cultivating jatropha on the side of railway tracks.

3. REASONS FOR JATROPHA CULTIVATION

1. Easy to cultivate
2. No Fencing is required since the crop is non-browseable by animals
5. Short gestation period & easy harvesting
6. Grow even on marginal/saline/acidic/alkaline soils and sloppy lands.
7. Develop without much care and irrigation.
8. Suit even dry-land farming and survive drought.
9. Provide live hedge for farms to arrest the menace of stray cattle.
10. Generate rural employment for cultivation, seed collection and processing.
11. Need hardly any application of pesticide.
12. Improve soil fertility throughout their life-cycle.
13. Provide fuel wood after 50 years' life-span.
13. Possess medicinal as well as other multiple uses.
14. Create green cover for long term ecological benefits.
15. Enhance energy security for the country.

4. PROSPECT OF JATROPHA CULTIVATION IN BANGLADESH

In Bangladesh, jatropha curcas can be cultivated in all over the country and is generally grown as a live fence for protection of agricultural fields against damage by livestock as it is unpalatable to cattle.

The agro climatic conditions prevailing in Bangladesh are conducive for jatropha cultivation. A feasibility analysis of jatropha cultivation can be done on a pilot scale over various regions in the country, where climatic and agricultural conditions are suitable for this crop. The primary focus of this project would be the cultivation of jatropha to get jatropha seeds and jatropha oil as final output.

Jatropha is a small tree or shrub with smooth gray bark, which exudes whitish colored, watery latex when cut. Normally, it grows between three and five meters in height, but can attain a height of up to eight or ten meters under favorable conditions.

Jatropha curcas grows almost anywhere, even on gravelly, sandy and saline soils. It can thrive on the poor soils. It grows even in the crevices of rocks. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. On heavy soils, root formation is reduced. Jatropha is a highly adaptable species, but its strength as a crop comes from its ability to grow on very poor and dry sites. The leaves shed during winter months. The organic matter from shed leaves enhance earth-worm activity in the soil around the root-zone of the plants, which improves the fertility of the soil. It is reported [6] that jatropha can grow on 0-500 meters above sea level. The mean annual temperature ranges from 20-28ºC and annual rainfall is 300-1000 mm or more. Jatropha has the ability to withstand extreme drought and light frost condition.

Jatropha plantation [7] can be done at a spacing of 2x2 m in a pit filled with soil and the soil can be mixed with organic manure. Approximately 2500 plants per hectare with the spacing mentioned above are needed. Direct seeding is good if good quality seeds available. It is recommended that transplantation of precultivated plants is feasible when good length, age and type are available. Plant propagation is mainly based on rainfall conditions. Cultivation method depends on the basis of maximum survival rates. Seeds are collected when capsules split are opened. Fresh seeds improve germination. With good moisture, germination takes about 10 days. After splitting seed shell, radicula emerged and 4 small peripheral roots are formed. After development of 1st leaf, cotyledons become wither and fall off.

The length of petiole ranges from 6 to 23 mm. The inflorescence is formed in the leaf axil. Flowers are formed terminally, individually.

Generally jatropha fruits are produced in winter when the shrub is leafless. It may produce several crops during the year if soil moisture is good and temperatures are sufficiently high. Each inflorescence yields a bunch of approximately 10 or more ovoid fruits. A three, bi-valved cocci is formed after the seeds become mature and the fleshy exocarp are dried.

The seeds become mature when the capsule changes its color from green to yellow. Flowering occurs during the wet season and two flowering peaks are often seen. In permanently humid regions, flowering occurs throughout the year. Early growth is fast and with good rainfall conditions nursery plants may bear fruits after the first rainy season, while direct sown plants after the second rainy season. The flowers are pollinated by insects especially honey bees.

The jatropha fruits and seeds are shown in Figure 1. In Bangladesh there is 0.32 million hectare [8] unused land. Jatropha plantation can be done in such a huge area. The expected jatropha oil from such land is as follows:

Plants needed per hectare: 2500
Seeds expected from each plant: 2.5 kg
Therefore, expected jatropha oil is about 2.00 ton per hectare per year (considering 38% conversion from seed to jatropha oil). Biodiesel from jatropha oil: 1.92 ton to (considering 96% conversion from jatropha oil to biodiesel).

So, in 0.32 million hectare land the amount of biodiesel production will be 0.62 million ton per year. Bangladesh imports 2.4 million ton diesel each year [9]. If jatropha plantation is successful in Bangladesh, the country saves a huge amount of currency, which needed for importing diesel fuel. The country can reduce importing (0.62 x 100)/2.4 = 25% diesel fuel from foreign countries.

5. PROCESSES INVOLVED IN THE PRODUCTION OF BIO-DIESEL

1. Preparation of nurseries
2. Plantation
3. Seed collection
4. Oil extraction
5. Transesterification
6. Blending with conventional diesel fuel
7. Characterization of biodiesel
8. Institutional arrangements.

5.1 TRANSESTERIFICATION PROCESS

Transesterification or alcoholysis is the displacement of alcohol from an ester by another in a process similar to hydrolysis, except than alcohol is used instead of water [10]. This process has been widely used to reduce the high viscosity of

Fig 1: Jatropha fruits and seeds

triglycerides. The basic reaction is one of transesterification in which the triglyceride molecule reacts with methanol (or ethanol) to form three ester molecules and one glycerol molecule. The details of transesterification reaction are shown in equations (1-3). The transesterification reaction is represented by the general equation as shown in Figure 2.

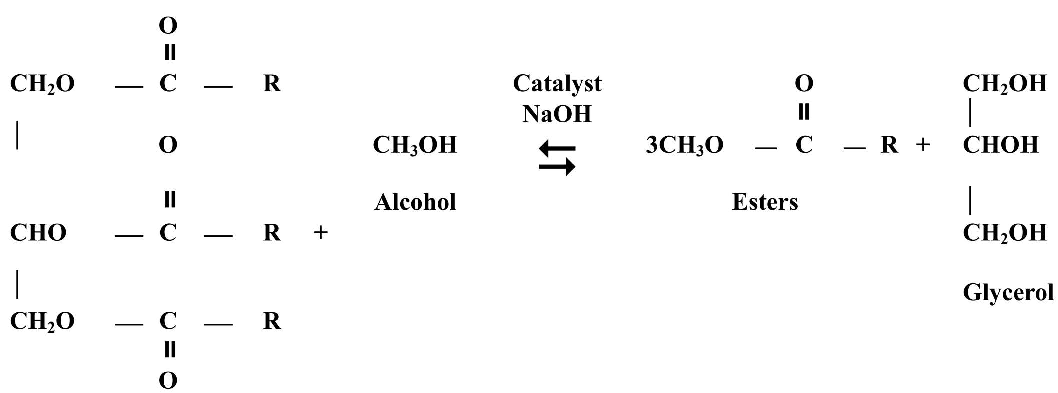
Triglyceride + Methanol → Diglcyeride + Ester---- (1)
Diglyceride + Methanol → Monoglyceride + Ester- (2)
Monoglyceride + Methanol → Glycerol + Ester-- (3)

The only by-product of transesterification is glycerol. All reactions are reversible so it is necessary to have a significant excess of methanol. A catalyst is required, normally sodium hydroxide or sodium methoxide though other base and acid catalysts are sometimes used. In this report NaOH is used as catalyst. The product (methyl ester) is separated from the glycerol by gravity separation. Some processes flash off the methanol before separation. Methanol must be removed from the product to increase flash point and cetane number. Recovery is also essential for economic reasons. Methanol is removed by flash or water washing or a combination of the two. In this work methanol is removed by water washing system.

Boocock et. al [11} detailed a procedure for the esterification of oils to methyl esters in which a 6:1 molar ratio of methanol to oil (1:6.25 volumetric ratio) is combined with 1% NaOH (by weight of oil). The mixture was to be agitated and kept at a constant temperature of 60°C for one hour. This procedure is modified in the present work varying the volumetric ratio of methanol to jatropha oil and agitating at 60°C for 1 hour. The reaction time is increased to permit increased conversion of triglycerides, and to hopefully improve the quality of biodiesel prepared from lower grade raw materials. In this modified work, first, methanol percentages are varied keeping NaOH percentages as constant for maximum biodiesel production. Thus optimum methanol percentage is realized. Next keeping the optimized methanol percentage as constant, it is varied the percentage of NaOH for maximum biodiesel production. In this way, methanol and NaOH percentages are optimized for maximum biodiesel production. This standard procedure is generally used in the preparation of methyl esters from all of the feedstocks, regardless of the type of fat or oil used as the feedstock or the degree of refinement. It is realized that modifications of the standard procedure will be required to maximize the yields of methyl esters from each feedstock, but this will be the subject of later work. The properties of conventional diesel fuel and biodiesel made from jatropha are shown in Table 1.

Table 1:

Properties	**Jatropha biodiesel**	**Ordinary diesel**
Density [gm/cc]	0.87	0.86
Kinematic viscosity [cSt]@30ºC	4.50	4.00
Heating value [MJ/kg]	39.5	44
Cetane number	51.5	48
Ester content [%]	96	--



Glyceride

Fig 2: Transesterification reaction

6. RESULTS AND DISCUSSIONS

6.1 Effect of Methanol Percentages on (Methyl Ester) Biodiesel Production

Figure 3 shows the effect of methanol (CH_3OH) percentages on biodiesel production. The volume percentage of methanol is varied from 15 to 20 keeping the weight percentage of catalyst (NaOH) constant at 0.5. It can be seen from the Figure that with the increase in reaction temperature up to 55ºC, biodiesel production increases and then decreases for all methanol percentages. It is found that maximum 96% methyl ester (biodiesel) is obtained with 20 vol% methanol. Decrease in biodiesel production with further increases in reaction temperature after 55ºC, may be associated with the methanol evaporation. Thus it is concluded that 20 vol% of methanol is optimum for maximum biodiesel production.

6.2 Effect of Catalyst (Naoh) Percentages on Biodiesel Production

Figure 4 shows the effect of catalyst (NaOH) percentages on biodiesel production. The weight percentage of catalyst (NaOH) is varied from 0.5 to 0.7. Here the volume percentage of methanol is kept constant as 20 vol%, which is optimized earlier. It can be seen from the Figure that with the increase in reaction temperature up to 55ºC, biodiesel production increases for all catalyst (NaOH) percentages and then decrease. It is found that maximum 95% methyl ester (biodiesel) production is obtained at 0.6 wt-% of catalyst (NaOH) percentage. Increasing the reaction temperature beyond 55ºC, biodiesel production decreases which may be due to evaporation of methanol at higher temperature. Therefore, it can be

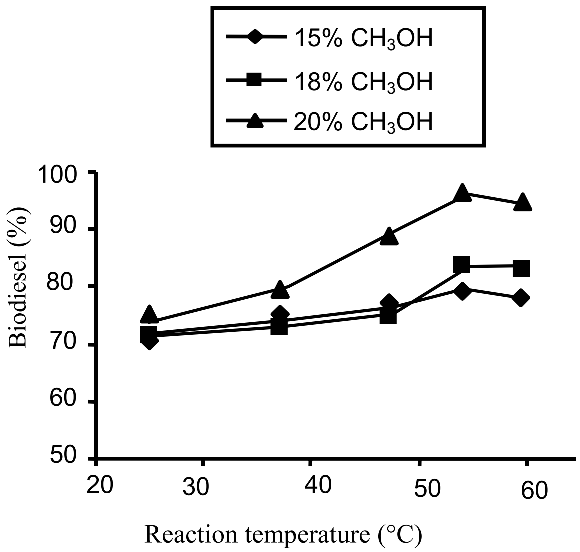


Fig 3: Effect of methanol (CH_3OH) percentage on biodiesel production (NaOH = 0.5 wt %)

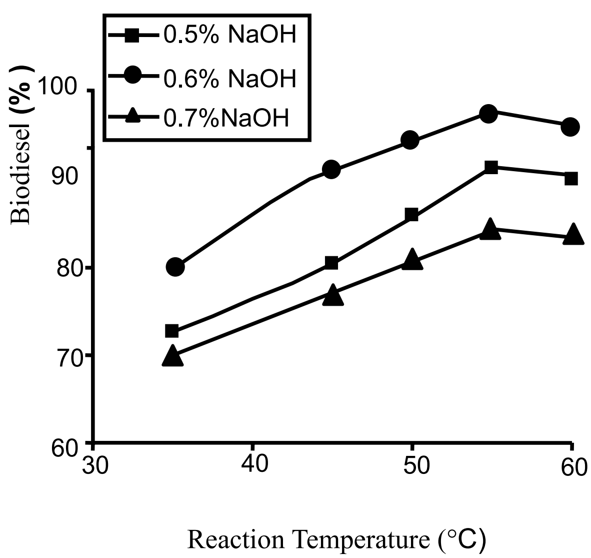


Fig 4: Effect of catalyst (NaOH) percentages on biodiesel production (methanol = 20 vol %)

concluded that 20 vol% methanol and 0.6 wt% NaOH are the best for maximum biodiesel production

6.3 Effect of Reaction Time on Biodiesel Production

Figure 5 shows the effect of reaction time on biodiesel production. The volumetric percentage of methanol is kept at 20, while the catalyst weight percentage is set to 0.6 (both optimized earlier). It is evident from the Figure that with the increase in reaction time, the biodiesel production increases up to 6 hours and then decreases. This is due to the fact that the tendency of soap formation increases with increase in reaction time. It is found that for 6 hours the maximum biodiesel production is 96%. When the

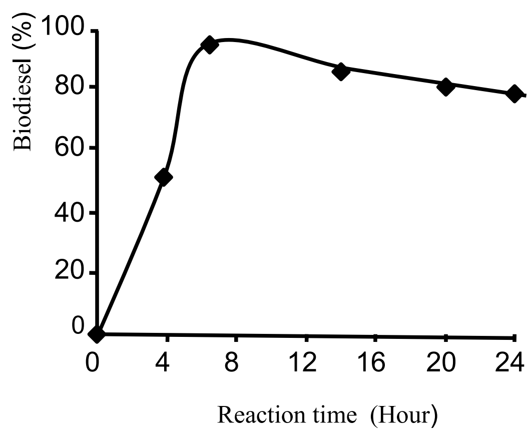


Fig 5: Effect of reaction time on biodiesel production (CH_3OH = 20%, NaOH=0.6%).

mixture of jatropha oil, methanol and catalyst is kept for 24 hours, the biodiesel production is reduced to 80%. Most recently, a novel technology is invented for producing biodiesel from waste, cooking grease, recycled vegetable oils and agricultural seeds in a much faster, simpler and as much less as expensive way [12-13].

7. CONCLUSIONS

In this report prospect of jatropha curcas cultivation is discussed. Biodiesel is produced with jatropha oil. The properties of jatropha biodiesel is determined and compared with those of conventional diesel fuel. The results of this work may be summarized as follows:

1. Jatropha curcas is cultivated in Bangladesh as live fence by the village poor. It can be cultivated even on arid, barren and fallow lands. There are hills in southern part of Bangladesh. If jatropha is cultivated on such hills or other barren or uncultivated lands, Bangladesh can save a huge currency importing petro-diesel. If jatropha is cultivated on uncultivated land Bangladesh can reduce mporting 25% petro diesel from foreign countries.
2. It can generate rural employment for cultivation, seed collection and processing.
3. Jatropha seed is crushed for oil. 35% oil is obtained by crushing of jatropha seed in a conventional mustard seed crushing machine.
4. Biodiesel is produced by the transesterification process using methanol and NaOH.
5. Maximum 96% jatropha ester (biodiesel) is obtained at a temperature of 55ºC by well known transesterification method.
6. Characterization of biodiesel is done. The properties of biodiesel are closer or even better than those of conventional diesel fuel. Thus, biodiesel from jatropha curcas may be used as alternative diesel fuel in Bangladesh.

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